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Sciences de l'homme et de la societé (ED-SHS)

Spécialité de doctorat : Sciences Économiques

Par

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Sustainability assessment of the university buildings: an application of a multi-criteria and participative tool to help the decision-making process

Thèse présentée et soutenue à Guyancourt, le 27 novembre 2017 :

Composition du Jury :

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ÉCOLE DOCTORALE
Sciences de l'homme et de la société (SHS)

Titre : L'évaluation de la durabilité des bâtiments universitaires : une application d'un outil multi-critères et participatif pour soutenir le processus de prise de décision

Mots clés : Bâtiments universitaires ; Durabilité ; Délibération ; Participation ; Prise de décision

Résumé : Les bâtiments universitaires en France ont énormément de défis pour atteindre aux exigences de transition écologique pour la croissance verte. En même temps sont des éléments clés pour la propagation des objectives du développent durable à l'échelle du bâtiment, du campus universitaire et de la ville. Les universités sont des institutions capables de promouvoir des changements dans la société, mais aussi sont des institutions qui ont besoin de changer. En d'autres termes, avant d'être un modèle pour la société, les universités devraient mettre en œuvre un comportement durable favorisant des pratiques durables dans le campus. Il est possible d'affirmer que la consommation énergétique, les émissions de CO2 et le manque d'intégration avec la ville sont les problèmes majeurs auxquels font face les universités françaises. Actuellement, l'implantation de stratégies pour améliorer la performance de durabilité dans les bâtiments font face à de nombreux défis, parmi eux le manque d'expérience et d'information pour soutenir la prise de décision. Un outil participatif d'aide à la décision a été développé et testé pour mesurer la performance des stratégies de la rénovation du bâtiment Aile Sud de la Bergerie Nationale. La performance des stratégies de la rénovation du bâtiment Aile Sud a été évalué et des solutions pour améliorer sa performance ont été suggérées dans une approche d'amélioration continue.

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ÉCOLE DOCTORALE
Sciences de l'homme et de la société (SHS)

Title: Sustainability assessment of the university buildings: an application of a multi-criteria and participative tool to help the decision-making process

Keywords: University buildings; Sustainability; Deliberation; Participation; Decision-making

Abstract: In France, the university buildings have significant challenges to meet the environmental transition requirements for green growth. At the same time, they are key elements for the spread of the sustainable development objectives at the building, the university campus, and the city scale. Universities are institutions capable of promoting changes in society, but also are institutions that need to be changed. In other words, before being a model for society, universities should implement sustainable behavior through the promotion of sustainable practices on campus. It is possible to say that energy consumption, CO2 emissions and lack of integration with the city are the major problems faced by French universities. Nowadays, the sustainable strategies implementation to improve buildings performance faces many challenges, including the lack of experience and information to support decision-making. A participatory tool for support decision-making was developed and tested to measure the performance of the 'Aile Sud' building renovation strategies in the Bergerie Nationale. The performance of the 'Aile Sud' building renovation strategies was assessed, and some recommendations for performance improvement were suggested in a continuous improvement approach.

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LIST OF ACRONYMS

AACSB: Association to Advance Collegiate Schools of Business

AASHE: Association for the Advancement of Sustainability in Higher Education

ADEME: *Agence de l'Environnement et de la Maîtrise de l'Énergie* (Agency for the Environment and Energy Management)

AFNOR: *Association Française de Normalisation*

AHELO: Assessment of Higher Education Learning Outcomes

AHP: Analytical Hierarchy Process

AISHE: Auditing Instrument for Sustainability in Higher Education

ANABF: *Association Nationale des Architecte des Bâtiments de France* (National Association of Architects of Buildings of France)

ANR: *Agence Nationale de la Recherche* (National Research Agency)

ARWU: Academic Ranking of World Universities

AR5: Fifth Assessment Report

AU: Architecture and Urban Planning

BBC: *Bâtiment Basse Consommation* (Low energy building)

BEMs: Building Energy Managements Systems

BEPAC: Building and Environmental Performance Assessment Criteria

BEPAS: *Bâtiment à Energie Passive* (Passive House)

BEPOS: *Bâtiment à Energie Positive* (Positive Energy Building)

BIPV: Building-Integrated Photovoltaic

BMS: Building Management System

BN: *Bergerie Nationale*

BRE: Building Research Establishment

BREEAM: Building Research Establishment Environmental Assessment Method

BSR: Business for Social Responsibility

B4U: Benchmark for You

CASBEE: Comprehensive Assessment System for Buildings Environmental Efficiency

CBA: Cost-Benefit Analysis

CCPY: *Communauté de Communes Plaines et Forêts d'Yvelines* (Community of Plains and Forests of Yvelines)

CDHO: Dutch Committee on Sustainability in Higher Education

CEREMA : *Centre d'Études et d'Expertise sur les Risques, L'Environnement, la Mobilité et l'Aménagement* (Center for Studies and Expertise on Risks, Environment, Mobility and Development)

CERTU: *Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques* (Center for Studies on Networks, Transport, Urban Planning and Public Buildings)

CEZ: *Centre d'Enseignement Zootechnique* (Zootechnical Education Center)

CGE: *Conférence des Grandes Écoles* (Conference of Grandes Écoles)

CIAM: *Congrès international d'architecture moderne* (International Congresses of Modern Architecture)

CITE : *Crédit d'impôt pour la Transition Energétique* (Energy Transition Tax Credit)

CIUP: *Cité Internationale Universitaire* (International University City)

COMUE : *Communauté d'universités et Établissements* (Community of Universities and Institutions)
COP: *Conférence des Parties* (Conference of the Parties)
CPU: *Conférence des Présidents d'Université* (Conference of the of the University Presidents)
CSPS : *Coordonnateur en matière de Sécurité et de Protection de la Santé* (Health and Safety Coordinator)
CSR : Corporate Social Responsibility
C3ED : *Centre d'Économie et Éthique pour l'Environnement et le Développement* (Center for Economics and Ethics for Environment and Development)
C4U: Construction for You
C&DW: Construction and Demolition Waste
DATAR : *Délégation interministérielle à l'aménagement du territoire et à l'attractivité régionale* (Interministerial Delegation of Land Planning and Regional Attractiveness)
DM: Deliberation Matrix
DRSA: Dominance-based Rough Set Approach
DST: Deliberation Support Tools
EAUC: Environmental Association for Universities and Colleges
EC: European Commission
EEC: European Economic Community
EIA: Environmental Impact Assessment
EIT: Institute of Innovation and Technology
ELECTRE: Elimination and Choice Expressing the Reality
EPA: Environmental Protection Agency
EPN: *Établissement Public National* (National Public Institution)
EQB: Environmental Quality of the Building
EQUIS: European Quality Improvement System
ERC: Extended Responsibilities and Competences
EU: European Union
EVVADES: *Outil d'auto-Evaluation du Développement Durable dans l'Enseignement Supérieur*
GB: Green Building
GBR: Green Buildings Rating
GCY: General Council of the Yvelines
GHG: Greenhouse Gas
GNP: Gross National Product
GSHP: Ground Source Heat Pump Systems
GSR: Global Social Responsibility
GR: Green Revolution
GRI: Global Reporting Initiative
HE: Higher Education
HIA: Health Impact Assessment
HQE: *Haute Qualité Environnementale* (High Environmental Quality)
HVAC: Heating, Ventilation and Air-Conditioning
IAQ: Indoor Air Quality

IAU : *Institut d'aménagement et d'urbanisme de la région Île-de-France* (Institute of Planning and Development of the Île-de-France Region)

IEA: International Energy Agency

IEEP: International Environmental Education Program

IEQ: Indoor Environmental Quality

IISD: International Institute for Sustainable Development

IMF: International Monetary Fund

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organization for Standardization

IUCN: International Union for Conservation of Nature

KDM: KerBabel™ Deliberation Matrix

KGBCC: Korea's Green Building Certification Criteria

KIC: Knowledge and Innovation Communities

KIK: Kerbabel™ Indicators Kiosks

KPI: Key Performance Indicators

KRR: Kerbabel Representation Rack

K4U: Kerbabel For You

LA21: Local Agenda 21

LCA: Life Cycle Analysis

LCI: Life Cycle Inventory

LCIA: Life Cycle Impact Assessment

LEED: Leadership in Energy and Environmental Design

LIFE: Learning in Future Environments

LOF: *Loi d'Orientation Foncière*

LRU: Liberties and Responsibilities of Universities

MAUT: Multi-Attribute Utility Theory

MESR: *Ministère de l'Education Nationale, de l'Enseignement supérieur et de la Recherche* (Ministry of Education, Higher Education and Research)

NGO: Non-governmental organization

MCDA: Multi-Criteria Analysis Decision Analysis

MDGs: Millennium Development Goals

MEDDE: *Ministère de l'Ecologie, du Développement durable et de l'Énergie* (Ministry of Ecology, Sustainable Development and Energy)

MEDDTL *: Ministère l'Écologie, du Développement durable, des Transports et du Logement* (Ministry of Ecology, Sustainable Development, Transport and Housing)

MEEM: *Ministère de l'Environnement, de l'Énergie et de la Mer* (Ministry of the Environment, Energy and the Sea)

MESR: *Ministère de l'Education Nationale, de l'Enseignement supérieur et de la Recherche* (Ministry of National Education, Higher Education and Research)

MLH: *Ministre du Logement et de l'Habitat Durable* (Minister of Housing and Sustainable Building)

OECD: Organisation for Economic Co-operation and Development

OMS: Operational Management System

OPC: *Ordonnancement, Pilotage et Coordination* (Scheduling, Management and Coordination)

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PADOG: *Plan d'Organization Générale de la Région Parisienne* (Parisian General Organization Plan)
PCET: *Plan Climat-Énergie Territorial* (Plan of Climate, Air, and Energy)
PISA: Programme for International Student Assessment
PLU: *Plan Local d'Urbanisme* (Local Urban Plan)
PNSE: *Plans Nationaux Santé Environnement* (National Environmental Health Plan)
POE: Post Occupancy Evaluation
PPP: Promote Public-Private Partnership
PRES: Pôle de Recherche et d'Enseignement Supérieur
PROMETHEE: Preference Ranking Organization Method for Enrichment of Evaluations
PV : Photovoltaic System
REEDS : *Centre International de Recherches en Économie-écologie, Éco-innovation et ingénierie du Développement Soutenable* (International Centre for Research in Ecological Economics, Eco-Innovation and Tool Development for Sustainability)
SA: Sustainability Assessment
SB: Sustainable Buildings
SCOT: *Schéma de cohérence territoriale* (Territorial Coherence Strategy)
SCP: Sustainable Cities Programme
SD: Sustainable Development
SDGs: Sustainable Development Goals
SDU: *Schéma de Développement Universitaire* (Strategy of the University Development)
SEA: Strategic Environmental Assessment
SQY: *Saint-Quentin-en-Yvelines*
SR: Social Responsibility
SRCAE : *Schéma Régional du Climat, de l'Air et de l'Énergie* (Regional Strategy Plan of Climate, Air, and Energy)
SRCE: *Schéma Régional de Cohérence Écologique* (Regional Strategy Plan of Ecological Coherence)
SRU : *Solidarité et Renouvellement Urbain* Law (Solidarity and Urban Renovation Law)
STARS: Sustainability Tracking, Assessment and Rating
RT: *Réglementation Thermique* (Thermal Regulation)
TBL: Triple Bottom Line
THE: Times Higher Education
UCLG: United Cities and Local Governments
UGO: *Unite Géographique et/ou Organisationnelle* (Geographic and/or Organisational Unit)
UIT: University Institutes of Technology
ULSF: University Leaders for A Sustainable Future
UN: United Nations
UNCED: United Nations Conference on Environment and Development
UNCHS: United Nations Centre for Human Settlements
UNCSD: United Nations Conference on Sustainable Development
UNESCO: United Nations Educational, Scientific and Cultural Organization
UNEP: United Nations Environment Programme
UNFCCC: United Nations Framework Convention on Climate Change
UN-HABITAT: United Nations Human Settlements Programme

USGBC: U.S. Green Building Council
USR: University Social Responsibility
UVSQ: *Université de Versailles Saint-Quentin-en-Yvelines*
U2000: *Université* 2000
U3M: *Université du Troisième Millénair*e (University of the Third Millennium)
VAT: Value-Added Tax
VOC: Volatile Organic Compounds
WBCSD: World Business Council for Sustainable Development
WCED: World Commission on Environment and Development
WCS: World Conservation Strategy
WEEE: Waste Electrical and Electronic Equipment
WSSD: World Summit on Sustainable Development
WWF: World Wildlife Fund
ZAPA: *Zone d'actions prioritaires pour l'air* (Priority Action Area for Air)
ZEB: Zero Energy Buildings
ZNIEFF: *Zone Naturelle d'Intérêt Écologique, Faunistique et Floristique* (Natural zone of ecological interest, fauna and flora)
ZPS: *Zone de Protection Spéciale* (Special Protection Areas)
ZSC: *Zone Spéciale de Conservation* (Special Areas of Conservation)

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GENERAL INTRODUCTION

RESEARCH CONTEXT

The projected estimate of population growth contained in the 'World Population Prospects Report' of the United Nations (Melorose et al., 2015), states that by 2050 the human population would reach 9.7 billion people, and by 2100, 11.2 billion. The rapid urbanization following this population increase will bring several challenges in the spatial distribution of individuals and resources, as well as in the use and exploitation of land (UN-HABITAT, 2017).

One consequence of the urban population increase is that the construction of new buildings will require a significant input of resources; more energy, material, and water consumption. Moreover, new constructions will produce significant quantities of waste, GHG emissions, and environmental impacts, affecting directly human health and well-being.

Currently, the building sector is the largest energy consuming industry globally. In developed countries, buildings consume, on average, one-third of the total primary energy consumption (Álvarez et al., 2009). Energy demanded by the industry could rise 50% in 2050 if society continues with the same energy consumption trend in the construction sector. In this environment, the Paris Agreement attempts to limit the world's temperature rises to 2°C and recommends an estimated of 77% reduction in total CO2 emissions in the buildings sector (UN, 2016; UNFCCC, 2015).

In this context, buildings could help to generate safer and more resilient cities of tomorrow; sustainable cities fostering social and economic development through an environmental management and urban governance. Furthermore, the sustainable development (SD) principles adoption (e.g., intergeneration and intra-generation equity, environmental protection, partnership, transparency, accountability, decentralization principles, and others) might assist the cities in this 'new urbanization' process.

The implementation of the SD principles is still a challenge, but also an opportunity to decelerate the climate change effects. When questioned if the global climate agreement is ever going to be possible, Christiana Figueres (2016) answered that impossible is not a fact, is an attitude. Changing the attitude about climate change is about modifying patterns, and victory cannot be achieved without optimism. Transformational optimism should be the fundamental belief adopted by the world community to adapt our carbonized economies in the face of our challenging environment. For instance:

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- Increasing investments in clean technologies, such as solar panel plants that might provide energy to entire cities, and can create positive effects on the mobility and the green buildings;
- The shift in the economic equation that can account for the climate change costs, and look for economic advantages and intrinsic benefits in the new situation;
- The rise in the active participation of all sectors of economy;
- National benefits from action;
- A common direction of the social challenges insured by the Sustainable Development Goals (UN, 2012), that establish a national priority for mobilization of stakeholders and resources toward a common goal.

Education has a major role in the transformation of the society, as it has become a strategy for promoting the sustainable development (Sauvé et al., 2007). Training and research activities have the ability to bring about changes in behavior and lifestyles of society, but also are essential for disseminating knowledge (UNESCO, 1997).

In this sense, universities provide leadership to society by shaping the thinking and training of decision-makers. Higher educational institutions are aware that these leaders' decisions engage the future of humanity on ecological, economic and social aspects (CPU, 2012).

The universities contributions to the SD can be divided into three main areas:

(1) through their mission, that encompasses teaching and research activities;

(2) by social anchorage, through activities, by the establishment of partnership and entrepreneurship, and urban dynamics, through the engagement in the local community and the contributions of the living environment;

(3) by their internal operations, that encompasses socio and environmental responsibilities related to the quality of life, work conditions inside the campus, and governance with participation, consultation and responsible steering (Bouckaert, 2016).

Through their campus structure, universities could provide the best possible living and working conditions. Furthermore, the universities should meet the social and environmental responsibilities that arise from their existence as a societal institution. As universities are active contributors to society, they must participate in the sustainability of their environmental development at the risk of compromising their future (*Ibid*., 2016).

The physical structure of the university campus is a fragment of the city. Hence, parking lots, green areas, and buildings are primary urban elements that compose the campuses. The new universities architecture are designed as a mesh of tridimensional connections between the teachers, students and researchers to diffuse, produce and share knowledge inside and outside of the building (Compain Gajac, 2014). Many of these new universities have been greening their campus by constructing new low energy buildings to reach environmental certifications (e.g., LEEDS, HQE). However, often they neglect the potential energy savings in renovating existing buildings, while at the same time this would promote their historical and cultural value.

The massive arrival of a university-age generation associated with the higher education democratization, after the Second World War period, motivated the construction of new building. Nowadays, the buildings constructed during the first boom period (i.e., the 1960s and 1970s), corresponding to 40% of the university asset in France, which represents 18 million m² (CPU, 2014).

Modern Architecture much influenced these buildings design especially due to the combination to promptly build substantial buildings, made with prefabricated structures, with a low price to answer the demand and constraints of this period. Even with the obstacles faced during the Reconstruction Period, these buildings represent a significant historical architecture and functional diversity

Applying current standards, the general situation of these buildings is degraded, outdated, with the lack of maintenance and high energy consumption (CPU, 2014). These conditions and consumption of these buildings put into question the environmental and social responsibilities of the universities to which they belong.

A study from the General Direction of High Education concluded that 15% of the French university buildings are not adequate for research and teaching activities (Campus Responsables, 2013). They cannot face up to the new digital pedagogical design's challenges. Energy consumption and CO2 emissions of these buildings are, respectively, three times and two times higher than the limits established by the Grenelle Environmental Law (Caisse de Dépôts and CPU, 2010).

Renovating these existing buildings would not only reduce the adverse effects of the energy consumption and the GHG emissions but could also be used as an opportunity to enhance indoor air quality and the general well-being of staff of students using the campus. It is, above all, an opportunity for the universities to affirm their position as an important societal institution addressing not only local social and environmental responsibilities but contributing globally as a strong actor for a societal change.

The literature review presents many beneficial outcomes for improving sustainability performance in university buildings (e.g., environmental, economic, and health and community benefits). However, it also highlights many barriers, such as the lack of previous experience and information, awareness, cooperation between the project stakeholders; the risks inherent in technology, and the use of cutting edge materials. (Gan et al., 2015; Häkkinen and Belloni, 2011).

The existing buildings are crucial elements of a university campus because they host research and teaching activities. The renovation process of these buildings might assist in the reduced consumption of natural resources, reduced output of waste and pollution, and at the same time promote the health and well-being of its occupant's. Nonetheless, considering the existing barriers, it is possible to conclude that it is necessary to settle an approach to support and clarify the decision-making process of the university building renovation.

Our hypothesis here is that an evaluation process can be helpful to analyze past actions, detailing the results achieved and identifying potential deficiencies to correct then and draw potentially useful lessons for future projects. In other words, it can be advantageous to help the decision makers (e.g., designers, owners, investors) in making more informed decisions.

The current environmental sustainability assessment and rating of buildings (e.g., LEED, HQE, BREEAM, CASBEE, and others) have many limitations. They promote a '*building-centric*' approach that considers just the built environment as an object of evaluation, rather than evaluating and examining the complexity of building urban relationships as a necessary element in favor of the sustainability (Mateus and Bragança, 2011; Richardson and Cashmore, 2011).

The existing rating systems, evaluate buildings by their certification professionals and do not engage another participant with interest in the assessment. This limitation restricts the overall building assessment to purely quantitative indicators and neglects the human experience.

Sustainability assessment should explore ways to reinforce legitimacy and relevance, engaging the building user's, team project's actors, and owners. Integrating all participants experiences of the buildings into a broader analysis of the structures would build deeper foundations to the assessment system and is essential for greater inclusivity among the building's community.

The major challenge of a renovation project is dealing with the uncertainty and risk due to lack of information. Hence, decision support tools must provide enough information. We suggest that a multi-criteria tool is appropriate to furnish all this information to provide as much certainty as is practical.

This thesis aims to answer, « What method best promotes sustainable development in the building and renovation of a university campus? »

Given this main concern, other questions might be raised:

- Why does the issue of sustainable development arise nowadays?
- How can sustainable development be applied to the planning of urban buildings, including universities campuses?
- What are the challenges of urbanization faced by both the construction sector and the university campus?
- How can we evaluate the performance of the strategy of the university building renovation process?
- What are the contributions and limitations of the existing methods of building and university assessment?
- How can a new tool contribute to the decision making of a university building renovation process?
- What are the performance issues of a university building renovation process?

THESIS GOALS

Initially, this work set two main goals:

- To establish a tool for the performance assessment of the university buildings with regards to sustainable development by integrating the various phases of the renovation life cycle and the external relations between the building and the city, and the internal relationship between the building on its campus.
- Secondly, to apply this new method to a case study, thereby analyzing the performance strategy of a university building renovation in order to identify the main contributors to the case study to the SD and the main possibilities for improvement.

METHODOLOGY

To answer the questions that we determined previously, we will use the INTEGRAAL framework developed at the International Center REEDS which is consisted by six steps:

Step 1. Identifying the problem

We will describe the field of study selected and the case study. Data collection and analysis, and interviews with the stakeholders will be employed to investigate the case study.

Step 2. Structuring the problem

We will determine the key actors and stakeholder's groups within our case study. A literature review will be conducted in the sustainability, cities, building as universities subjects. After determining a preliminary list of the sustainable performance issues of a renovation process of a university building, we will analyze the pertinence of the performance issues.

We will categorize the actors and the performance issues through an interactive process of documenting and evaluating the problems studied, based on the consultation of the actors concerned.

Step 3. Representing the system

The literature review will be used here to make an inventory of tools and data available for representing the system of analysis of the performance renovation process of the university buildings. The indicators and tools will be inserted in an online platform called EPLANETe, that was also developed at the Centre International REEDS. This modeling system will assist us in the representation of our tool in a digital platform.

Step 4. Evaluating and Deliberating

In this step, we will use an expert system and an evaluation section with the project's actors to assess the case study. The EPLANETe will be used to insert values and generate a final spider diagram.

Step 5. Analyzing and Communicating

An extensive analysis of the results will be performed to provide interpretation of the results. We will analyze results from a global view of each category, and we will use the indicator's values to provide an explanation, in addition to the actor's statement.

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Step 6. Reflecting on outcomes

We will consider the results of the evaluation process and the case study results. This Step represents a data analysis for clarification and verification.

THESIS PLAN

This thesis work comprises three parts. The first part (Chapters I and II) consists of presenting the main challenges and drivers for achieving sustainability in buildings, cities, and inside the university campus.

The second part (Chapters III and IV) presents the contributions and limitations of the existing methods for buildings, universities and urban innovations evaluations. It demonstrates the importance of a participative multi-criteria evaluation for the sustainability of university buildings. Furthermore, it proposes a methodology for the construction of a new tool for the assessment of the selected case study: the *'Aile Sud'* building – a building with a historical value situated inside the Bergerie Nationale in Rambouillet that was renovated to become an International Research Center of the University of Versailles Saint-Quentin-en-Yvelines.

The third and last part, presents the practical experience of the new tool, in other words, the practical approach validation with the *'Aile Sud'* building where the results are exposed and analyzed. A reflection on the outcomes provides renovation strategies performance of the '*Aile Sud'* building and the new tool theoretical validation.

Chapter I: Architecture and urban planning regarding sustainability

This chapter aims to present the sustainable development aspects, in what they represent for the cities and buildings progress, and how towns and buildings have adapted to contribute to a low-carbon, resilient economy. The idea is to present the current framework for cities and building and to focus on the sustainable campus in Chapter II.

Initially, we will present the origins of the SD concept exploring the Conservation and Environmental Movements emergency in consequence of the criticism about the industrial model during the Industrial Revolution, and post First and Second Wars. Likewise, we will show how the 'Limits of Growth' report contributed to the appearance of Neo-Malthusian theories and 'zero growth' solutions for the society. Also, we will present the eco-development concept, which supports integrating the holistic environment into development, and the contributions of the Stockholm Conference and the Brundtland Report. Principles, SD dimensions, the SD concept interpretations and views, and the main SD models and representation will be introduced.

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We will then study how urban planning and architecture apply the SD concept. We will come out with the urban planning background, from the 19th century and the middle ages, until the 21st century which the development of the first environmental urban policies, to understand the roots of the cities' problems. Then we will present the main definitions about sustainable urbanism and its contributions and challenges.

Finally, we will change the analysis scale and present how the buildings can be a communal asset and, at the same time, an opportunity to promote SD locally. For this, we will clarify key aspects of sustainable buildings, the main drivers and barriers; and concentrate on the increase in energy performance by active and passive techniques that are the main goal of ZEB, BBC, Passive Houses and BEPOS projects.

Chapter II: The case of the sustainable campus

The main purpose of Chapter II is to take up the influences experienced by universities regarding their architecture, governance, and relations with the cities, in the sense that, we need to know the past to understand the present situation.

Firstly, we will focus on the historical manifestations of the French university campus, as the first 'boom' period due to the democratization of the higher education, the second 'boom' period, the modernization programs, and the operation campus.

After the presentation of the historical context, we will determine the relationship between the university campus and the city in three particular cases according to their location: in old cities centers universities, in peripheral universities and universities located neither in urban peripheral neither city centers. We will also highlight the importance of spatial scale and mobility.

As universities constitute a complex of buildings, we will provide an analysis of universities architectures, from modernism, brutalism, and contemporary to energy efficient buildings as an architecture trend for the universities of tomorrow. However, as universities have a crucial role in society, in being responsible for the transfer of knowledge, we will present the main agendas of higher education on the way to a holistic approach to the idea of sustainability.

We will conclude the chapter presenting our most important concerns about the sustainable campus, regarding energy efficiency and the greenhouse gas emissions, and the strategic plans that have been employed by universities. When universities determine their strategic plans for greening the campus, they are trying to meet their social responsibilities. We will present the several ways that university contributes to the SD, and we will focus on how they are improving their infrastructure.

Chapter III: A participative multi-criteria evaluation for the sustainability of university buildings

We will open this chapter presenting the UVSQ, its implementation in the Bergerie Nationale in Rambouillet, and the renovation design and planning process of the *'Aile Sud'* building to receive the REEDS Center.

After that, we will explain the general context of an evaluation and present the fundamental elements and objectives of evaluation, including the methods employed, in order to emphasize the multi-criteria and the decision-making support systems.

We will be proceeding with an analysis of the existing approaches and tools for assessing buildings, universities and urban innovations. We will present the main contributions and limitations of each method to open a discussion on the concept of evaluation of sustainability in the university buildings where a participative and integrative approach will be proposed. We will introduce the INTEGRAAL methodology approach and the EPLANETe system.

Chapter IV: Defining an evaluation approach for the performance strategy of university building's renovation

This chapter's main objective is the definition of an assessment approach for the performance strategy of a university building's renovation that we will be calling C4U.

Firstly, we will identify the problem that we want to solve. We will focus on the French university asset as our field of study, due to the high energy consumption, CO2 emissions and the lack of integration with the city; the Aile Sud' building as our case study; and the need for a new evaluation tool, as was already approached in Chapter III.

In a second moment, we will identify the performance issues to evaluate sustainability in the university buildings., with the support of the literature review and the actor's validation, and we will define the stakeholder's group and the actor's categories related to our case study.

Lastly, with the support of the INTEGRAAL framework and the EPLANETe system, we will identify and utilize indicators to represent our system and to evaluate our case study.

Chapter V: Practical experience and validation of C4U tool

The Chapter V aims to evaluate of the 'Aile Sud' building using the indicators selected and provide a theoretical and practical approach to validate of the C4U tool.

At first, we will evaluate the case study giving values to qualitative and quantitative indicators in an expert system but also in a deliberation section with the actors. Then, results will be analyzed by category (i.e., People, Planet, Profit, Process, and Propagation) and sub-goals to identify drivers and barriers of the renovation project of the 'Aile Sud' building. Lastly, we will reflect on the outcomes of the assessment regarding our case study but also the C4U tool.

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FIRST PART

HOW THE SUSTAINABLE DEVELOPMENT CAN BE APPLIED IN THE URBAN PLANNING, IN THE ARCHITECTURE AND IN THE UNIVERSITY CAMPUS?

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Chapter I. Architecture and urban planning with regard to sustainability

1 INTRODUCTION

This first chapter has as the main goal to present the sustainable development aspects and what does it imply for the development of new cities and buildings. Initially, we will present the origins of the modern sustainable development concept and the historical sustainability background.

The increasing levels of smoke pollution in the atmosphere during the Industrial Revolution resulted in many the criticism about the industrial model. The environmental movement emerged as a political, social and scientific response to the critical situation to address the environmental issues of the cities.

The 'Limits of Growth' report raised the uncertainty about the human future and highlighted the world population growth’s effects. The Neo-Malthusian theories defended a society 'zero growth' as a solution for reaching a global equilibrium of natural resources.

The first Earth image, in 1972, marked an important moment for the humanity and brought attention to the environmental conservationism of the natural systems. A new alliance between 'environment' and 'development' was perceived with the eco-development emergence. The Stockholm Conference and the Brundtland Report contributed to the elaboration of a sustainable development concept, and to understand the main transformation that this concept implies for the humanity. The Rio 92 established the main endeavors to change global priorities toward sustainable development through the Agenda 21.

The main challenge identified is to bring the SD concept to the practice. Models and representations have an important role in the definition of the most important aspects, and the relation between these aspects. For instance, it is possible to mention the Triple-bottom-lines, the SD hierarchy viewed from the Passet's eco-ecological model, and the Daly's triangle of equity, economy, and environment.

This work introduces the sustainability in the urban planning due to the importance of the cities for the social and economic development, but also because of the significant environmental impacts. The adverse environmental impacts of the urban agglomerations have been questioned since the Industrial Revolution. The Industrial Revolution boosted the population growth in cities, as London and Paris, what conducted the society to reflect on the issues of the Industrial period and increase the doubts about the future.

The 'progressist' and 'culturalist' models marked the 19th century with their utopian models of the future. In France, the world wars had a major role in transforming the cities. Many urban planning regulations and manifests appeared to boost the urban reconstruction, for instance the Athens Charter which was the modern urbanism manifest of the 20th century.

The Reconstruction period, after the Second World War, gave free rein to the new modern cities design. From the 1960 and 1970, a significant number of new buildings were erected, sometimes with a restricted time for planning and designing. New cities, as Cergy-Pontoise, Evry, Saint-Quentin en Yvelines, Marne-la-Vallée, and Sénart were born. These cities should absorb the new population and improve the living conditions in the Parisian Region.

In the 21st century, new environmental urban policies influenced the cities' urban planning. The SRU Law and the Grenelle Environment led to the development of eco-cities and sustainable cities concept. The main challenges for reaching a sustainable urbanism will be mentioned in the Chapter.

Improving sustainability in buildings is a critical approach toward sustainable cities, especially due to the high buildings energy consumption and GHG emissions. We will clarify the sustainable building concept and the main ecological, economic and social aspects of the whole building life cycle. Energy efficiency in buildings is the focus of many regulations and laws in France and Europe, as for instance the RT 2012.

Inside the French scenario, we will present the active and passive techniques and existing policies for improving the buildings energy performance. For example, the Energy Efficiency Directive established a set of measures to help the EU countries to reach their 20% energy efficiency target by 2020. This goal contributes to the emergence of ZEB, BBC, Passive Houses and BEPOS concept of energy efficient buildings. We will then present the existing barriers and drivers for implementing sustainability in the construction sector.

2 SUSTAINABLE DEVELOPMENT: THE BIRTH OF A CONCEPT

The sustainable development concept was gradually built over the years to answer to the society 's needs to conceive solutions to decrease the economic development impacts face to the population growth. Inside this historical background, two major moments can be highlighted: the Industrial Revolution and the Second World War.

Many theories emerged from the projections about an uncertain scenario of a future with not enough food, energy, water to everyone, or lack of urban space and materials to build new buildings. Some movements took a side in the population growth limitation, and some movements developed a paradigm for a sustainable development of society, ensuring in this way the needs of the current and future generations.

2.1 Criticism of the industrial model: the natural resources conservation, and the environmental movements

More than two centuries passed since Thomas Mathus (1798) brought attention for the mismatch between the rapid population growth and the not so fast increase of the subsistence means. Malthus estimated that the humanity would face famine and starvation unless births were controlled.

A significant population growth and urbanization process marked the Pré-Industrial Revolution in England. However, the transformations in the productive industrial system were not enough to follow the increasing needs of the population that was growing, resulting in the imbalance previewed by Malthus.

The Industrial Revolution[1] was a transition to new manufacturing processes, followed by a technological progress that affected the way that society exploited resources in a production cycle. This period entailed significant changes in the labor conditions, in the social structure[2], in the working conditions, in the cities organizations, and it resulted in environmental consequences.

Since the late 18th century, the modern cities growth led to a massive urbanization with no precedents and the new cities appearance. The population numbers changed quite significantly. For instance, in London population went from 864.845 inhabitants in 1801, to 1.873.676 in 1841, and 4.232.118 in 1891. In less than one century the London's population almost quintupled (Choay, 1965).

New ways of production and transport emerged and gave rise to new urban functions[3] (Choay, 1965). Progressively, cities of the 19th century were taking shape, adapting to the new societal needs. Industry production increased trying to supply the growing population demands, which resulted in the

[1] This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, improved efficiency of water power, the increasing use of steam power, the development of machine tools and the rise of the factory system.

[2] Concerning the social structure, the Industrial Revolution witnessed the triumph of a middle class of industrialists and businessmen over a landed class of nobility and gentry. Ordinary working people found increased opportunities for employment in the new mills and factories, but these were often under strict working conditions with long hours of labor dominated by a pace set by machines.

[3] In Paris, for instance, this is the moment that new roads, new trains stations, new urban equipment were built (Choay, 1965).

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appearance of more factories and the concomitant immense growth in the coal consumption, increasing the smoke pollution in the atmosphere. The industrial capitalism was characterized by a complex division of labor between and within work process and the routine of work tasks (McLean and McMillan, 2009).

The transition to new manufacturing processes, the population growth, the cities expansion, and the rise in the industrial production, finally established the global predominance of the capitalist production mode. The capitalist industrialization provoked the development of the profit and economic domination paradigm model. Southern countries were transformed by the powerful and seemingly indomitable interests of North (Redclift and Springett, 2015).

All this scenario gave birth to the Conservation Movement. The movement believed that human activities damaged the environment and there was an obligation to maintain the environment for future generations. They affirmed that scientific empirically based methods should be applied to ensure that this duty will be carried out.

In the 20th century, the First and the Second Wars, accelerated the global industrialization. Even though industrialization was not answering all the human needs, it was becoming a threat to the human health, the economy and the environment (Nicol, 2007). After the Second War, in 1948, a group of Swiss naturalists founded the International Union for Conservation of Nature (IUCN) to encourage international cooperation in the nature protection, to promote national and international action, and to compile, analyze and distribute information (IUCN, 2012).

As the environmental impacts were significant and ecological discourses broke geographic barriers, the Northern countries started to influence the South countries increase and development. According to Redclift and Springett (2015):

> *"The new scientific and industrial revolution of the 20th century meant that Northern power would go to impact on developing nations under the guise of 'development' and 'aid" (…) "the second World War resulted in extended ways of exercise power over people and nature through the globalization of economy, strengthened by the creation of Northern dominated global structures such as the World Bank, the International Monetary Fund (IMF) and the World Trade"* (Redclift and Springett, 2015, pg.14).

During this period, many manifestations and new organizations took place against the globalization power, the market capitalism and their environmental impacts (Redclift and Springett, 2015). The

Conservation Foundation, a precursor of the WWF (World Wildlife Fund), was founded in 1947 by Fairfield Osborn to support the capitalism-friendly ecological practices

After 1950, biologists and conservationists condemned certain waste accumulation, the pollution of the river, lakes eutrophication, fog and some other phenomena that threaten natural equilibrium, starting the Ecologist Movement or the Environment Movement. It is possible to highlight here notable works of Rachel Carlson[4], that denounced the industries effects on the natural world with her book 'Silent Spring,' and Barry Commoner, author of 'The Closing Circle' (1971) where he identifies the four simple 'laws' of ecology (Nicol, 2007). Beyond that, Alfred Sauvy[5] denounced social inequality and used for the first time the expression 'Third World' to designate those countries that are least developed (Sauvy, 1952).

At the same time, many economists were concerned about the problem of allocating investments in so-called underdeveloped countries and about the hunger in the world (Nicol, 2007). Furthermore, concerns about environmental degradation and environmental conditions for the next generations were growing. In 1954, René Dumont[6] denounced the rural development implications and its ecological footprint on his book *'Économie Agricole dans le Monde'*[7] (Séjeau, 2014).

On the one hand, the Conservation Movement concentrated attentions in analyzing the human activities' effects on the environment. On the contrary, the Environmental Movement brought attention to the population growth and questioned the 'traditional' economic development. The Ecological Movement stated the outcomes of the industrial and economic capitalism and called into question the dominant political conception. This dominant political approach believes that economic growth itself left unfettered, will help to resolve environmental and social problems (Redclift and Springett, 2015).

The Environmental Movement itself become engulfed in the predominating environmental management paradigm and finished for losing some of the moral leadership it once symbolized. This

[4] Rachel Carlson's work inspired a grassroots environmental movement that led to the creation of the U.S. Environmental Protection Agency (EPA).

[5] At his article 'Three worlds and one planet', Alfred Sauvy stated the coexistence between the capitalism oriental and communist world during the Cold War, and the exclusion of a 'Third War': "... *finally, this Third World ignored, exploited, despised like the Third Estate, also wants to be something*" (In French: *"...enfin ce Tiers Monde ignoré, exploité, méprisé comme le Tiers Etat, veut, lui aussi, être quelque chose"*.)

[6] Concerned about soil degradation, he believes that humanity should keep the Fertility of the soil for the next generations.

[7] René DUMONT, Économie agricole dans le monde, Paris, Institut d'études politiques, 1947, 311 p.

can be noticed in the foundation of the Club of Rome[8], in 1968, and in the publication of the report 'Limits of Growth' that was concerned with exposing the scarcity problems as a result of the exponential population growth (Redclift and Springett, 2015).

2.2 Neo-Malthusian theory and transition' from population growth to a global equilibrium

The 'Limits of Growth' analyzed five main elements: population, food production, industrialization, pollution, and non-renewable natural resources consumption. The report affirmed that the world population has been growing exponentially since 1650. The main explanation for the population growth is the regularization in the fertility and mortality rate after the Industrial Revolution (i.e., a birth rate exceeded the death rate). Beyond that, it is possible to mention the increase of the life expectancy in consequence of the modern medicine, public health techniques, new growing methods and distributed foods.

Physical and social human necessities were identified as significant ‘ingredients’ that might assist in sustaining the world economy and population growth. Physical human necessities can support all physiological and industrial activity (e.g., food, raw materials, fossil, fuels). Social needs help to create social value and opportunities for people to occupy an active and efficient role in the society (e.g., peace, social stability, education, employment).

According to the report, the population growth rose the demand for food and expanded the future food production. Hence, the population growth depends on the nonrenewable resources availability. The nonrenewable resources future availability depend on how society will lead decisions ahead through policies implementation to decrease consumption resources in the present.

World industrial production showed a clear exponential increase due to the augmentation of the industrial capital, for instance, factories, trucks, tool, machines, and investments. This production model resulted in changes in the natural environment. Adverse effects in nature, like pollution, were exponentially increasing, notably, carbon dioxide, thermal energy, and radioactive wastes. The report concluded that the limits of growth of this planet would be reached in the next one hundred years (Meadows et al.,1972).

[8] The Club of Rome is a global nonprofit organization that deals with a variety of international issues, including the world economic system, climate change, and environmental degradation.

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The Club of Rome's Report highlighted the natural resources shortage due to overexploitation. The Neo-Malthusian[9] solution, evocated by the authors, proposed the stabilization in the economic process through the population control and resources conservation. Inside the Neo-Malthusian principles, this characterized an indispensable operation to ensure the continuity of the human activities without sudden change. The ‘Limits of Growth' report promoted an idea of 'zero growth'[10], and also a 'transition' from economic growth to a global equilibrium.

For the Neo-Malthusians, the main barriers were to promote changes in the human values and the morality ideas. Garry Hardin (1968) argued that society has a view of the population problem. In his essays 'Tragedy of the Commons', he stated that most of the people were not able to abandon their conveniences and privileges over the population problem. He contested that the natural tendency of individuals is to put 'private' interests before the 'collective' ones.

Paul Ehrlich (1968) pointed on 'The Population Bomb' the importance of the demographic issues as an inductor of starvation and natural resources scarcity. He considered that in the short term it was not possible to change the production and consumption mode. Redclift (1987) presented the Neo-Malthusian objections from a geopolitical point of view. He assumed that the Northern countries have the interest in drawing attention to the resources scarcities, once this scarcity might compromise their economic development.

The Neo-Malthusian received criticism from writers who claim that the Malthusian warnings were exaggerated and premature. Malthus believed that due to the overpopulation, we were already condemned to the disaster by the natural systems overexploitation or resources depletion. Indeed, Neo-Malthusian theory excluded planet dynamism, which is represented by the possibility of cultivating natural capital and regenerated agriculture (Sachs, 1997).

The Green Revolution (GR)[11] took place between the 1930s and the late 1960s. It increased substantially global agricultural production, particularly in developing countries. The GR had as the main goal to save a billion people from starvation by developing new technologies to transform agriculture around the world, and by increasing world grain production. The GR played a major role in

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[9] With the same essence of Malthusianism, the Neo-Malthusianism is convinced "that population cannot exceed resources without famine or disease providing natural checks on population growth" (Redclift, 1989, pg.9).

[10] "A finite world can support only a finite population; therefore, population growth must eventually equal zero" (Hardin, 1968, pg.27).

[11] Led by Norman Borlaug, the "Father of the Green Revolution", involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers.

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the Neo-Malthusian theories, in the sense that, substantial increases in the food production could allow the continued population growth. GR suffered many criticisms due to (Shiva, 1991; Redclift, 1987):

- Changes in the population food diet: the agriculture usually incorporates polycultures, and during the GR the cereal grains monocultures predominated and caused people malnutrition;
- Geopolitical aspects: providing food for the population in developing countries could bring social stability and would weaken the fomenting of communist insurgency;
- Socioeconomic impacts: the transition from traditional agriculture to GR agriculture required the purchase of inputs and led to the widespread establishment of rural credit institutions. Smaller farmers often went into debt and in some cases, lose their lands;
- Environmental impacts: GR affected biodiversity. In Asia, for example, the ecological effects include irrigation water salinization, pollution effects of chemical sprays and the increasing resistance12 of pest species to insecticides;
- Health impacts: The consumption of the pesticides increased the likelihood of cancer in some of the rural villages.

The new agricultural production technologies implementation had severe impacts in the Latin American, Africa, and India. Existing environmentally sustainable systems mutated toward greater specialization, but also in economic dependency (Redclift, 1987).

2.3 The eco-development emergence: a new alliance between environment and development

The humanity became aware of the environmental concerns with the disclosure of the first Earth's images from space. In 1968, Apollo 8 sent the first live televised pictures of Earth. In 1972, the Apollo 13 took the famous 'The Blue Marble' photograph that became a symbol of the environmental activism movement.

The perception of the dichotomy between 'environmental' and 'development' issues became a growing concern. The enhance in the global awareness impacted the international environmental

[12] The "miracle" seeds of the Green Revolution have thus become mechanisms for developing new pests and creating new diseases.

discourse, leading global society to the United Nations Conference on the Human Environment, held in Stockholm (1972), and, after that to the Brundtland Report publication (1987).

Followed by the 'Founex Report'[13], the Stockholm Conference was consisted by consecutive meetings that agreed upon a Declaration containing 26 common principles. The Stockholm Declaration aimed to inspire and guide global population concerning the environment preservation and the human environment enhancement (UN, 1972).

After effectuating a general overview in the Stockholm Declaration, many differences can be found in comparison with the other manifestations presented before. Essentially, the protection and improvement of the human environment is an urgent issue not just for some countries and cultures, but for the whole world. The collective efforts for the human environment preservation and improvement are global. Hence, every country must be engaged in a distinct way, targeting new goals to benefit the people now and for the posterity. In this sense, all citizens, communities, and companies are responsible for sharing common efforts.

As affirmed previously, the Neo-Malthusians believe that population growth present problems for the environment preservation, however, it is not the main reason for environmental impacts. The root of the problem can be found in the man's actions. The man can transform his surroundings, bring people the benefits of development and the opportunity to enhance their life quality. Consequently, the man can provoke incalculable harm to human beings and the human environment, through wrong or negligent actions.

The most important lesson from the Stockholm Declaration is the divergence on environmental problems and efforts required for developing and developed countries (UN, 1972).

> *"In the developing countries, most of the environmental problems are caused by under-development. Millions continue to live far below the minimum levels required for a decent human existence (...) Therefore, the developing countries must direct their efforts to development, bearing in mind their priorities and the need to safeguard and improve the environment. (...) In the industrialized countries, environmental problems are generally related to industrialization and technological development"* (UN, Stockholm Declaration, Proclamation 1, 1972).

[13] Played a critical role in laying the ground work for the 1972 Conference. Founex was the first paper to identify key environment-development objectives and relationships.

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The divergence in their roles was also affirmed by Maurice Strong[14] (cited by Sachs, 1997). He stated that the Northern countries should reduce their resources consumption and that the Southern countries must fight against poverty. Developing countries are most vulnerable to social and environmental issues and need to have an adequate institutional support (Kates et al., 2001). Figure 1 presents the sustainability science within a divided North-south world.

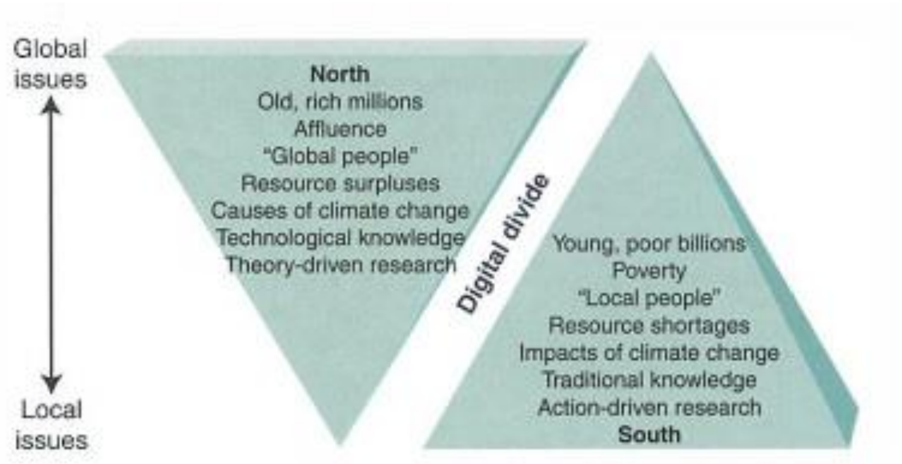

Figure 1. Sustainability science inside a divided world. Source: Kates et al. (2001).

In this sense, economic and social development is essential for certifying a favorable living and working environment for humanity and creating conditions on earth that are imperative for the improvement of the life quality (UN, 1972).

Stockholm Conference launched not just a hope message but also clarified the need for an essential concept based on three fundamental criteria: social justice, ecological prudence, and economic efficiency. Hence, 'eco-development' idea has gained value. UNEP (1975) defined this approach with a highlight in the natural resources use.

> *"Eco-development refers to development at regional and local levels, consistent with the potentials of the area involved, with attention given to the adequate and rational use of natural resources, technological styles and organizational forms that respect the natural ecosystems and local social and cultural patterns"* (UNEP, 1975).

[14] He had also an important role when leading the Stockholm Conference as Secretary-General of the Conference.

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Ignacy Sachs developed the primary conceptual basis of eco-development in his book *'Initiation à l'écodéveloppement .'* According to him, the main principles of the eco-development are (Sachs, 1981):

- Priority on the reaching social purposes;
- Autonomy valorization;
- Ecology prudence;
- Voluntary acceptation of an ecological restriction based on the principle of searching the social development;
- Construction of an economy adapted to human needs and environmental potential and limits.

During the Stockholm Conference 'Blueprint for Survival' (i.e., special edition of The Ecologist) was launched. The 'Blueprint for Survival,' stated a need for a change in the modern way of life. It denounced that the industrial expansion worldwide was not sustainable. Edward Goldsmith and Robert Allen contested about a radically restructured society as a unique way to prevent what the breakdown of society and the permanent disruption of the life-support systems (i.e., ecosystem and social system) on this planet (Goldsmith and Allen, 1972).

2.4 What does a sustainable development imply for the human progress?

Concerns about the environmental problems in developing countries were increasing. Between 1979 and 1980, the United Nations Environment Programme (UNEP)[15], in cooperation with the United Nations (UN), organized many events to explore the link between the environment and the development. In 1980 both organisms, aligned with the WWF and the IUCN, published the World Conservation Strategy where the concept of sustainability brought attention.

The World Conservation Strategy (WCS) had three main goals: the maintenance of essential ecological processes and life-support systems, the genetic diversity preservation, and the assurance of the ecosystems and species sustainable use. The main reasons to achieve these goals are because the planet's capacity to support people is being irreversibly reduced in both developing and developed countries. Hundreds of millions of rural populations in the developing countries are compelled to destroy the resources necessary to save them from poverty and starvation. The main consequences

[15] The UNEP is an agency of United Nations founded in 5 June of 1972. The agency coordinates United Nations environmental activities, assisting developing countries in implementing environmentally sound policies and practices.

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of this situation are the growth in the energy price, and the reduction of the major industries' resource base (IUCN, 1980).

The report highlighted that subsistence communities needed to be better equipped to use resources sustainably. More attention must be given to the ecosystems management, for instance, the agriculture, as the global population is increasingly dependent on these environmental resources.

The disruption of the traditional agriculture patterns started in the Green Revolution. It considerably affected and damaged the ecosystems. In many places, insecticides destroyed fish stocks in paddy fields, resulting in a serious loss of the biosphere and dietary consequences in the population (Redclift, 1987).

In the view of the WCS, the population must conserve living resources for sustainable development. The importance of the Earth's nature complexity and the human relationship with biosphere are crucial points to understand the development expected in the society and its engagements in conservation strategies. Hence, 'development' and 'conservation' received definitions.

Development is defined as "*the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life*." Conservation is characterized as *"the management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generations while maintaining its potential to meet the needs and aspirations of future generations"* (IUCN, 1980, pg.16).

Both development and conservation are for people. The development aims to accomplish the human goals largely through the biosphere use. Conservation seeks to ensure that such biosphere use can continue presently and in the future. Development is necessary for humanity but should involve social, ecological and economic factors. The idea is not to stop the development. The objective is to persuade many development practitioners, especially in developing countries, that conservation is essential in the sense that resource limitation is a reality.

The WCS aimed to help human society to understand the changes required to achieve this sustainable development (SD). However, doubts and concerns related to the effects sustainability for humanity development persisted. Pearce at al. (1989) highlighted that the WCS failed in integrating economically with the environment.

This scenario, aligned with the lack of results in countries efforts to reduce their environmental impacts and their failure to relate these problems to development issues, boosted the foundation of the World Commission on Environment and Development (WCED), or Brundtland Commission in 1984. In 1987, the WCED Commission published the 'Our Common Future' Report or Brundtland Report, a global agenda for change.

The Brundtland Report defined a long-term program for a mutual action for the coming decades. The main goals were basically (UN, 1987):

- To recommend long-term environmental strategies to reach SD by the year 2000 and beyond;
- To suggest cooperation among developing countries and between countries at the various economic and social development levels;
- To recognize modalities and means that international community can deal more efficiently with environmental concerns;
- Moreover, to assist in the definition of shared perceptions of the long-term environmental issues and the appropriate efforts needed to deal successfully with protecting and enhancing the environment. The word community needed a long-term agenda for action during the coming decades, with inspirational goals.

Furthermore, the Brundtland Report identified the main common challenges regarding population and human resources, food security, species and ecosystems, energy, industry and urban planning. The Report highlighted that all these topics are interrelated. New policies that sustain and expand the environmental resource base must be created to approach all these topics to build a new era of economic growth.

The report did not intend to retard the economic growth, even if it brings risks of environmental damage and puts pressure on environmental resources. Indeed, the WCED Commission considered that the concept of SD would guide policy makers to ensure that growing economies remain firmly attached to their ecological roots. These roots must be protected and encouraged so that they may support growth over the long term.

Without strengthening this new era of growth, developing countries would not be able to fight against problems of poverty and underdevelopment. Furthermore, economic development will be unsustainable if it will raise vulnerability to crises (*Ibid.*, 1987). The definition of the term SD most common quoted, finally gained shape in Chapter 2 of the Brundtland Report (*Ibid.*, 1987):

> *"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it*

two key concepts: the concept of 'needs'[16]*, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs"* (*Ibid*., 1987, Chapter 2).

The Brundtland Commission insists on treating the environment as being something beyond physicality, going beyond that traditional lines of thinking, to include social[17] and political atmospheres. It also emphasizes the development as being a shared commitment, including developing and developed countries, of what they can do to ameliorate their common situation. (*Ibid.*, 1987).

The three pillars of SD were defined as being the economic growth, the environmental protection, and the social equality. They represent the main common endeavors to all the countries.The SD's pillars cannot be solved isolated. Multidisciplinary actions are necessary for a short and long term.

Some authors criticized the idea of a qualitative sustainable growing because they believed that this concept is contradictory, in the measure that the quantitative material production should be extremely reduced to respect the Earth's physical limits and to reduce the pollution. Sachs (1997) believes that a semantic misunderstanding causes this contradiction. Qualitative sustainable growing would not be a risk because even if it implies in material production, it also involves energy and natural resources efficiency, and waste and pollution reduction.

Leaving aside the semantic disputes and optimism or pessimism degree, the necessity to reduce overconsumption of industrialized countries is urgent. Environmental goals cannot be contrary to the economic goals. Indeed, economic systems are dependent on natural systems that make planet's life possible. It is essential to change our way of thinking since the complementarity between natural capital and human capital are evident. In this sense, technical solutions isolated are not enough adequated to the transition toward the SD (*Ibid*., 1997).

The 'Our Common Future' publication and the work of the World Commission on Environment and Development, laid the groundwork for the convening of the 1992 Earth Summit or United Nations

[16] Human needs here are constituted by the essential needs of vast numbers of people. In developing countries, these essential needs are related with food, clothing, shelter, jobs, and this basic needs are not being met. Beyond their basic needs these people have legitimate aspirations for an improved quality of life (UN,1987).

[17] The social dimension of the environmental approach can be interpreted here as the inequality in people's access to resources (UN, 1987).

Conference on Environment and Development (UNCED). The Earth Summit resulted in the Rio Declaration on Environment and Development and the Agenda 21 adoption.

2.5 Endeavors to change global priorities toward a sustainable development

Rio Declaration had as the main goal the reaffirmation of the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 1972. Beyond that, it established a new trend for an equitable global partnership by a new cooperation levels among States, society's key sectors, and people. Furthermore, the declaration highlighted the relation between the development and the environment. It stated that "*the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations*" (UN, 1992, Principle 3).

The Declaration emphasized the connection between environmental protection and SD. The Principle 4 (*Ibid.*, 1992) stated that "*to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it*".

Global action based on partnership and cooperation between states are indicated as an important environmental protection strategy to achieve the SD (*Ibid*., 1992).

> *"States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation*" (*Ibid.,* 1992, Principle 7).

Not just the States, but all the concerned citizens must handle environmental issues with the access to information by public authorities (*Ibid*., 1992).

> *"...each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes"* (*Ibid*., 1992, Principle 10).

Even if all the States have common responsibilities, those are not the same to everyone. A distinction between responsibilities of developed and developing economies should be considered (*Ibid*., 1992).

> *"States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view*

of the pressures their societies place on the global environment and of the technologies and financial resources they command" (*Ibid.*, 1992, Principle7).

Inside this context, the *"special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority"* (*Ibid.*, 1992, Principle 5). Poverty eradication called attention *"as an indispensable requirement for sustainable development, to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world"* (*Ibid.*, 1992, Principle 5).

A common goal is established for all countries to achieve SD in the Principle 8:

> *"To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies" (Ibid., 1992, Principle 8).*

The Agenda 21 is a voluntary action plan of the UN about the SD that can be executed on a local, national and global level for the present and the 21st century. The 40 chapters of the Agenda 21 are divided into four sections: social and economic dimensions, conservation and resources management, strengthening the role of the main groups, and means of implementation.

The Agenda promotes actions in several areas, as the fight against poverty, the human health, the deforestation, the desertification, the biodiversity conservation, the land resources, the sustainable agriculture promotion, the issue of waste, and others. It reflects an international consensus and political commitment at the highest level of development and environment collaboration (UN, 1992).

The Preamble of the Agenda 21 describes the main challenges that humanity is facing regarding social inequality and environmental degradation:

> *"We are confronted with a perpetuation of disparities between and within nations, a worsening poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being" (Ibid., 1992, Preamble).*

The document also stated the improvements achieved regarding SD transition with the Rio Earth Summit:

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"(...) the integration of environment and development concerns and great attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prospectus future" (Ibid, 1992, Preamble).

For the first time in history, States had to adopt significant commitments on the economic level. The conventions signed in Rio (e.g., Convention on Biological Diversity, United Nations Framework Convention on Climate Change - UNFCCC - and United Nations Convention to Combat Desertification) can be determinate as the starting point for many other actions in most of the signatory countries, as the Kyoto Protocol[18] and the Paris Agreement[19]. Many other transformations took place. The industrial sector started to invest in clean technologies, the non-governmental organizations grew up, and the global citizens were increasingly more attached to environmental protection and social progress (Nicol, 2007).

The Rio Earth Summit had a significant impact on the scientific world where climate and environment reports were published. However, Cooper and Vargas (2004) and Sachs (1997) stated that 5 years after the Rio Conference, during the Rio +5 assessment[20], the overall trends for SD were worse than they were in 1992. In other words, the progress toward SD was too slow. Governments were still incapable of agreeing with a common and concrete program to address social and environmental issues.

Later on, the World Summit on Sustainable Development (WSSD) or Johannesburg 2002, and the United Nations Conference on Sustainable Development (UNCSD) or Rio +20, had as the main role to make a balance of countries engagement related to the Stockholm and Rio Declarations. The main goal was to analyze the progress achieved and identify many barriers for the sustainable development transition in different society sectors.

In 2020, the WSSD promoted the integration of the SD's three pillars - economic development, social development and economic development - and determined this relation as being interdependent and mutually reinforcing components (Cooper and Vargas, 2004). Key results of the WSSD include the Johannesburg Declaration and almost 300 international partnership initiatives meant to help in the achievement of the Millennium Development Goals (MDGs).

[18] The UNFCCC, a climate-change agreement, that led to the Kyoto Protocol - an international treaty which extends the UNFCCC that commits State Parties to reduce GHG emissions - that was adopted in Kyoto, on 11 December 1997.

[19] The Paris Agreement is an agreement within the UNFCCC dealing with greenhouse gases emissions mitigation, adaptation and finance.

[20] Special Section of the General Assembly of UN that meet in New York in June 1997.

The MDGs were the eight global development goals for the year 2015. These goals were established following the Millennium Summit of the United Nations in 2000 and were presented in the Millennium Declaration. The eight chapters of the Millennium Declaration are the Values and Principle; Peace, Security and Disarmament; Development and Poverty Eradication; Protecting our Common Environment; Human Rights, Democracy and Good Governance; Protecting the Vulnerable; Meeting the Special Needs of Africa; and Strengthening the United Nations (UN, 2000).

The Rio+20 Conference was held in Rio 20 years after the Earth Summit of 1992. It was centered around the Agenda 21, and it was particularly marked by many absences passing the subliminal message that the global heads-of-state (e.g., Barack Obama, Angela Merkel, David Cameron, Vladimir Putin) was not worried about SD challenges. Many critics claimed that the summit was overshadowed by the deepening global financial crisis.

The UN wanted at the beginning of the conference to endorse a 'UN green economy roadmap' with environmental goals, targets, and deadlines. Notwithstanding, the developing countries preferred to set a new SD goals to improve environmental protection, food and power guarantee to the poorest, and alleviate poverty[21]. It was chosen to avoid talking about business responsibility to respect human rights in the place they operate, and about the right obligations of business and international institutions (Vidal, 2012; Egeland and Evans, 2012).

Rio Earth 2012 Summit resulted in a document called 'The Future We Want,' organized in six chapters: Our Common Vision, Renewing Political Commitment, Green Economy in the context of sustainable development and poverty eradication, Institutional Framework for Sustainable Development, Framework for Action and Follow-up, and Means of Implementation. It received many criticisms as well, especially from the NGO's, as WWF International and Care International.

'The Future We Want' report mentioned the importance on reaching the sustainable goals stated by the Millennium Development Goals. Governments expressed their commitment to full and timely achievement (UN,2012):

> *"We underscore that the Millennium Development Goals are a useful tool in focusing achievement of specific development gains as part of a broad development vision and framework for the development activities of the United Nations, for national priority-setting*

[21] The process for drafting the Rio+20 declaration was as failed act as the outcome. The Brazilian hosts decreed that all text had to be agreed before the arrival of government ministers for the final three days. When the deadline was approaching, government ministers simply deleted those sections causing controversy and, in addition, they replaced them with weak compromise text (Egeland and Evans, 2012).

and for mobilization of stakeholders and resources toward common goals" (UN, Paragraph 245, pg.63, 2012).

As stated in Paragraph 249 (UN, Paragraph 245, pg.64, 2012), "the process needs to be coordinated and coherent with the processes to consider the post-2015 development agenda". Following the recommendation, the Sustainable Development Goals (SDGs) were signed to replace the MDGs in 2016. The SDGs is officially known as 'Transforming our world: the 2030 Agenda for Sustainable Development' and determines 17 SDGs to transform the world over the next fifteen years (UN, 2015a):

- Goal 1: End poverty in all its forms everywhere;
- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- Goal 3: Ensure healthy lives and promote well-being for all at all ages;
- Goal 4: Ensure inclusive and quality education for all and promote lifelong learning;
- Goal 5: Achieve gender equality and empower all women and girls;
- Goal 6: Ensure access to water and sanitation for all;
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all;
- Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all;
- Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation;
- Goal 10: Reduce inequality within and among countries;
- Goal 11: Make cities inclusive, safe, resilient and sustainable;
- Goal 12: Ensure sustainable consumption and production patterns;
- Goal 13: Take urgent action to combat climate change and its impacts;
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources;
- Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss;
- Goal 16: Promote just, peaceful and inclusive societies;
- Goal 17: Revitalize the global partnership for sustainable development.

The Paris Agreement negotiated during the 2015 United Nations Climate Change Conference, COP 21 or CMP 11 that was held in Paris, represented the governments' efforts to deal with the climate change. The Paris Agreement brings all nations into a common effort to combat climate change. At the same time, it encourages countries to develop adaptation actions, to foster climate resilience, and to reduce the GHG emissions, starting in 2020. The central goal is to strengthen the world's response to the threat of climate change by maintaining a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels. Also, it is necessary to pursue efforts to limit the temperature augmentation even further to 1.5 degrees Celsius (UNFCCC, 2015).

Paris Agreement opened for signature in April 2016. Until June 2017, 195 UNFCCC members have signed the agreement, 153 of which have ratified it. The agreement will enter force when joined by at least 55 countries which together represent at least 55 percent of GHG emissions. Beyond the global warming contention, the Paris Agreement desires the fossil fuels disinvestment and the carbon neutrality.

All this global context that started in 2002 is part of the third pressure wave[22] for change which is much influenced by the globalization. The focus of this wave is to grow the perception that SD will demand profound transformations in the companies' governance and the whole mechanism of globalization, giving focus to the civil society and government (Elkington, 1994). Modifications in the ethical value systems are indispensable to achieve changes in the human systems. Transformations in the society's acceptable behaviors about the social and environmental crisis are expected (Kirkby et al., 1995).

3 PRINCIPLES, CONCEPTUALIZATION, AND DIMENSIONS OF SUSTAINABLE DEVELOPMENT

3.1 Framework of the declared principles of SD

After analyzing all the Reports, the Declarations, the conferences, and the events, it is possible to elaborate actions, plans, and principles that are essential for to the SD transition. Cooper and Vargas identified the nineteen declared principles of SD (Cooper and Vargas, 2004; HABITAT, 2001; Mensah and Castro, 2004; UN, 1992; UN, 1994; UN, 1995; UNEP, 1997).

- Change principle: Is based on the simple reality that the current trends of living and development worldwide are not sustainable on any of the three dimensions. A global change

22 According to Elkington (1994), the first wave of pressure brought an understanding about the limits of natural resources and the environmental impacts, and the second, brought a global realization that new ways of production technologies and products are needed.

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in the priority concerns and the use of policy instrument overtime is needed, and a sense of urgency is lacking;

- Environmental protection principle: Humanity is, directly and indirectly, responsible for substantial environmental impacts. The abuse of the biosphere locally produces impacts that do not respect national boundaries inside a globalization reality;
- Balance and integration principle: The achievement of the SD demands the balanced integration between the economic, social and environmental aspects;
- Human-centered development principle: As was stated in the Rio Declaration, humanity is the center of SD concerns;
- Right to development, but with an obligation of mutual respect principle: Consists in the development considering the transboundary issues;
- Intergeneration and intra generation equity principle: Intergeneration equity principles is consisted in providing the same natural capital for the present and future generations. Intra generation is more based in providing the same natural capital for all worldwide groups, including disadvantaged groups, such as ethnocultural minorities, indigenous people, and others;
- Equality principle: It is the principle that determinates that all people are valuable, no matter the race, gender, religion, color, cultural heritage, and physical conditions.
- Decentralization principle: Is based on the idea of promoting decentralization through local democratic authorities;
- Partnership principle: It relates partnership and participation as important democratic and efficient approaches;
- Transparency and accountability principle: Participation cannot work as a key for without transparency and accountability;
- Family principle: Recognizing the family as the basic unit of society means that proposed actions should consider the impact on families in different cultural, political and social systems;
- Livable community people: Integrating family in the discussion is essential. However, families live in communities that affect the quality of their lives and must be considered in the SD commitments;
- Education principle: In every context, whether urban or rural, everyone must have access to education. Education is defined as a mechanism to achieve a sustainable lifestyle in livable communities;

- Health and wellness principle: As people are the center of SD concerns, likewise, their health and wellness, to be able to have a productive life in harmony with the environment. Public access to basic health care should be insured and reduce health threats. Moreover, the fight against diseases as HIV must be propagated;
- Poverty eradication principle: Planned actions should give priority to the benefit of the poorest members of the community;
- Culture-sensitive principle: Planned actions must allow countries with culture clashes to accommodate the commitments to their cultural scenario;
- Scope, scale and wealth principle: Wealth nations should cooperate in a spirit of global partnership the least developed countries;
- Market principle: It is based on the idea that market should force offer tools useful to the goals of a determined policy cultural conditions. These tools should fit with the other principles, but also with the social and environmental aspects of SD;
- The role of law principle: It consists in dissolving disputes among nations peacefully and within the rule a stable, just and equitable system of law.

3.2 Exploring SD contradictions and view from diverse perspectives

The Brundtland Report that brought attention to integrate SD into the national and international political agenda with the definition given by the WCED Commission. The UNCED, in 1992, turned this term a subject of discussion launching 'Our Common Future' Declaration as a guide to assist the development transition in the various sectors of the economy. 'Our Common Future' desperately searched for an alternative to help and restore the equilibrium among economic, environmental and social aspects of society (Lozano, 2008).

While the acceptance of the SD definition given by the WCED appeared to be higher than the eco-development principles, some criticism appeared and conducted us to a reflection. Has the SD Brundtland Report concept been allowing the world to advance with more clarity and understand than before? Has the Brundtland Report concept been inspiring more sustainable actions inside organizations? Has the SD Brundtland Report been answering to everyone needs?

Redclift (1987) alleged that the idea of SD is full of contradictions:

> *"The idea of sustainability is derived from science, but at the same time highlights the limitation of science. It is used to carry moral, human, imperatives, but at the same time acquires*

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legitimacy from identifying biospheric 'imperatives' beyond human societies" (Redclift, 1993, pg.3).

Furthermore, it is contested that the Brundtland Report's definition *"development that meets the needs of the present without compromising the ability of future generations to meet their needs"* (UN, 1987) connects the concept of 'needs' with the context of 'development.', leaving space for ambiguity. Notwithstanding, 'needs' can be understood from a relativist position since 'needs' can be defined depending who is defining, and every society defines 'needs' in its way (Redclift, 1993; Wackernagel and Rees, 1996). Pearce et al. (1989) suggested to substitute 'needs' for 'necessary conditions' for SD and defined those circumstances as constancy of the natural capital stock, such as oil, ground surface waters and their quality, soil quality, land and water biomass, and waste absorption capacity of receiving environment.

Many environmentalists do not appreciate the SD term since it suggests giving permission to economic growth and is often switched to sustainable growth[23] with any fundamental challenge. Brundtland report's definition allows capitalism to proceed to put forward economic growth as a solution to poverty (Rees, 1998). The conflicts between ecological equilibrium and economic development were still not resolved, in the same way as the links bounded by the state of economic welfare and environmental degradation (Holmberg and Sandbrook, 1992).

During the last years, SD was the central subject of local, national and international events, debates, and conferences, and all this criticism gave place to the emergence of distinct SD concepts in the sense that distinctive opinions emerged as well. For Pearce et al. (1989, pg.1), *"it is difficult to be against SD. It sounds like something we should all approve of, like 'motherhood and apple pie.' However, what constitutes development or progress, for one person may not be development or progress for another".* In this sense, Perce et al. (1989) conduct us to accept that the existence of several concepts for SD is normal, basically because SD depends on stakeholders' involvement that has various opinions.

As there is no single unified theory of SD, around seventy definitions of SD variants of the Brundtland's report definition are in circulation. In common, all these theories believe that future well-being is determined by what happens to wealth over time (Holmberg and Sandbrook, 1992; Atkinson et al., 1999; Kirkby et al., 1995).

[23] For Daly (1990), any economic growth can be defined as sustainable in a long term.

Munro (1995), advocated that "*SD is a complex of activities that can be expected to improve the human condition in such a manner that the improvement can be maintained*". Redclift (1987, pg.10) used some antagonism to defend that *"SD it is to be an alternative to unsustainable development, should imply a break with the linear model of growth and accumulation that ultimately serves to undermine the planet's life support syst*ems."

Pearce et al. (1989) brought attention to the important distinction between three concepts: economic growth, sustainable economic growth, and SD.

> *"Economic growth means real Gross National Product (GNP) per capita is increasing over time. Sustainable economic growth means that real GNP per capita is increasing over time and the increase is not threatened by 'feedback' from either biophysical impacts or social implications. SD means that per capita utility or well-being is growing over time"* (Pearce et al., 1989, pg.33).

Hence, real income per capita and quality of environment contribute to this well-being or satisfaction, hence to the SD.

Pearce at al. (1998) emphasizes that the 'future generations' factor, imposed by the Brundtland Report, is another essential feature of SD. The authors determined that, concerning the conservation of natural capital, SD need to be partly about intergenerational equity.

In this sense, maintaining the life chances of future generations requires the preservation and protection of natural resources and policies that ensure that future generations are considered in sharing in an equity and proportionate share of net benefits that accrue, especially when resource stocks are depleted or depleted (Howarth, 2007). It is, therefore, a question of ensuring the management of economic and ecological resources to fulfill two complementary functions: on the one hand, maintaining ecological services for human welfare and on the contrary, Ensuring economic well-being through the production of goods and services (S. Faucheux and O'Connor, 2002).

Barbier (1987) suggested that SD should be understood as an interaction between three systems, the biological, economic and social systems. He believes that the main goal of sustainable economic development is to enlarge the goals across all these systems over an adaptive process of trade-offs. He defended an adaptation of this concept to the Third World.

The Third World had been directly concerned with increasing the material standard of living of the poor at the base level, which regarding quantitative indicators can be measured by sanitation access, water supply, health care, educational services, food availability, real income, and others. Minimizing the absolute poverty of the Third World is a strategy to minimize resource depletion, environmental degradation, social instability and cultural disruption (Barbier, 1987).

3.3 Models and representations of SD

There is no consensus on the precise meaning of sustainability. However, we determine three basic fundamental concepts to achieve SD: accepting to live with some limits of the earth's capacity to maintain life; recognizing the interconnections among economy, environment, and society; and maintaining an equitable distribution of resources and opportunities for our and future generations (Mensah and Castro, 2004).

To better consider the underlying complexity sustainability, Munasinghe (2001) creates a general schematization which consists in presenting a triangle who's the summits represent the SD dimensions. In this logic, the economy is managed mainly to improve human well-being, through an increase in the consumption of goods and services (Figure 2).

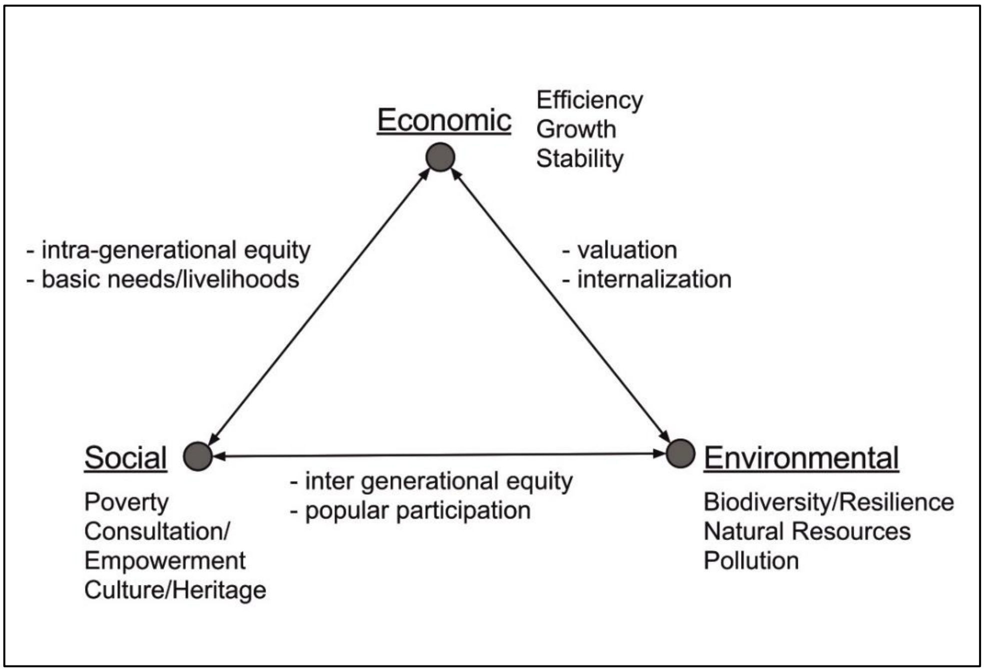

Figure 2. Munasinghe's approach to SD. Source: Adapted from Munasinghe (2001).

The environmental domain focuses on the protection and resilience of ecosystems and biodiversity. Finally, the social system seeks to enrich human relationships and to allow the attainment of the individual as well as collective aspirations (Munasinghe, 2010).

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The most obvious SD model, the TBL framework helps businesses and non-profit organizations who have committed themselves to SD values, to take a long-term perspective and thus evaluate the future consequences of their decisions (Slaper and Hall, 2011). SD is the goal to be achieved, and sustainability is the process to achieve SD (Sartori et al., 2014). In this context, we can affirm that sustainability contributes to economic growth based on social justice and efficiency on the use of natural resources (Lozano, 2006).

TBL agenda might help sustainable capitalism transition to a new paradigm. This transition needs changes in the 21st century that are listed in Table 1, are denominated by Elkington as the 'Seven Revolutions' (Elkington, 1994; Elkington, 1997). TBL will hence assist on the concretization of these revolutions.

Table 1. Seven Revolutions in the 21st century to make the shift between the old and new paradigm. Source: Elkington (1997).

SEVEN REVOLUTIONS	OLD PARADIGM	NEW PARADIGM
Markets	Compliance	Competition
Values	Hard	Soft
Transparency	Closed	Open
Life-cycle-technology	Product	Function
Partnership	Subversion	Symbiosis
Time	Wider	Longer
Corporate governance	Exclusive	Inclusive

Regarding the various 'bottom-lines,' the economic dimension deals with the flow of money, environmental aspect, represents measurements of natural resources and reflects potential influences on its viability. The social dimension invokes measurements of education, equity and access to social resources, health, well-being, quality of life, and social capital. Indicators measure these dimensions, and many of the data are collected at the state and national levels, along with community levels with stakeholder participation (Slaper and Hall, 2011). The concept of TBL demands that the CSR depend on the stakeholders. Stakeholders are anyone that is influenced by the actions of the organization (Elkington, 1997).

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Two main points of disagreement emerged over the years. The first point of disagreement concerns the questioning of the exclusivity of the three pillars - 'social,' 'environment' and 'economic' as fundamental elements of sustainability. Many authors suggested the existence of a fourth dimension.

Brodhag (2000) and Le Goff (2009) appointed 'governance' as the fourth pillar of SD concept. Brodhag (2000) alerts for the importance to mobilize information to assist the decision-making process since information is a major element of governance. Le Goff (2009) affirms that governance intends to turn public action clearer and societies more governable by the decentralization of decisions and the involvement of the community's actors.

Libaert (2000) proposed 'communication' as being the fourth pillar of SD due to the essential role of communication for the SD. For him, communication organizes the relationship between companies' stakeholders through the dialogue and listening. For Antoine (2006) and UNESCO (2011), 'culture' is the fourth pillar of SD. Recognizing the cultural importance for the SD is the same that protecting the identity of a region, a country, and an ethnic group. It is recognition that each one carries within its aspirations and values[24].

O'Connor (2007) determined a political sphere as the fourth sphere that has the arbiter objective of negotiating about the several claims made by the actors of the social and economic sphere for themselves and regarding the other sphere.

Sachs (1997) did not propose one additional dimension to the TBL. Indeed he believes that for planning society development, it is necessary to take into consideration five aspects of sustainability: social, economic, ecological, spatial, and culture.

- Social sustainability: this term covers the implementation of a development process characterized by a distinct growth and encouraged by another society's vision. The goal is to build a civilization based on a more equitable sharing to improve access to wealth substantially, and to reduce the standard life gap between the wealthy and the have-nots;
- Economic sustainability: it depends on a better division and management of resources, and a constant flow of private and public investments. Moreover, it is necessary to evaluate the economic efficiency in macro-social terms rather than only through the microeconomic criteria of the company profit;

[24] UNESCO affirms (2010, page 6) "that culture in all its diversity is needed to respond to the current challenges of humankind".

- Ecological sustainability: it can be improved by limiting fossil fuels consumption and other non-renewable resources, intensifying the research of new clean and efficient technologies for the urban space, improving rural and industrial development; promoting the auto-limitation of natural consummation for rich countries, and defining policies and rules to adequate environmental protection;
- Spatial sustainability: it is necessary to ensure a better balance between the cities and the countryside to avoid excessive concentration of metropolis, and a better spatial distribution of human settlements and economic activities;
- Cultural sustainability: it is essential to promote change in the cultural continuity, translating the normative eco-development concept into a plurality of local solutions, specific to each ecosystem, to each cultural context and each site;

Some contradiction regarding the governance dimension was noticed. The importance of governance, previously mentioned in the Rio Summit was highlighted by some authors that questioned if 'governance' should be placed as an isolated dimension or if its values should be integrated transversally in the three pillars (Bouckaert, 2016). The second disagreement point lies in the relation between the three sustainability pillars. The Venn diagram (Figure 3), characterizes the conventional sustainability illustration. In this approach, the intersection represents the three spheres sustainability.

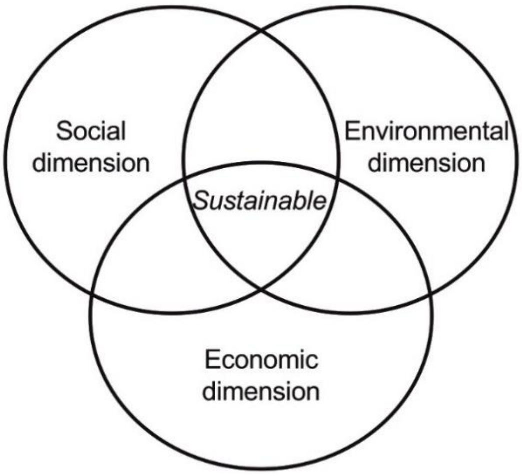

Figure 3. SD as the intersection between the three spheres. Source: Adapted from Lozano (2008)

Another model of sustainability emphasizes the environment as the basis of all activity from society and economy. This approach uses a hierarchical concept between the three spheres to show the dependency of socioeconomic systems from the environmental systems (Figure 4). This SD appreciation that has many interests by the interdependency between human societies, ecosystems, space and time is the basis of the ecological economics or bioeconomic studies.

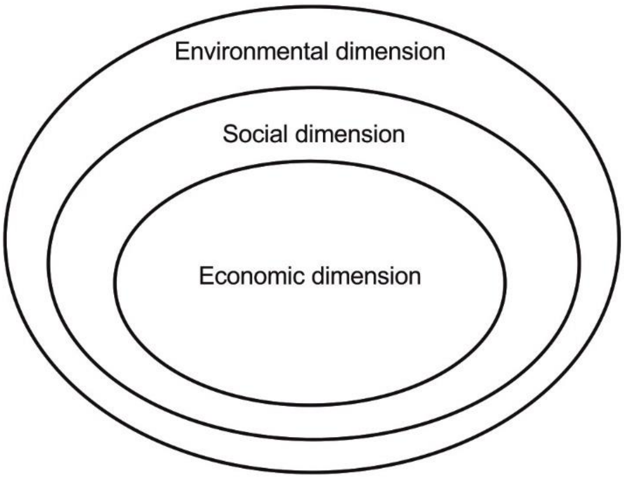

Figure 4. The hierarchical concept of the SD dimensions. Source: Adapted from Lozano (2008) and Passet (1979)

In this same line of work we can quote Georgescu-Roegen (1986) and his work 'The Entropy Law and the Economic Process.' He evocated a profound reform in the economic science and where he integrated thermodynamics and biology. In French scenario, it is remarkable the influence of Passet[25] (1979), with the '*L'économique et le vivant*'. Passet continuous to affirm this new conception of economic science in the same line than Georgescu. He thus retains the central idea of an economic activity conceived as a continuation of biological activity, and the new scientific references that are thermodynamics and evolutionary biology.

Passet (1979) stated three basic rules of how sustainability spheres are held:

- If economic activities are related only with men, it is in the field of human relations and not in the economic sphere that they will find their goal: social welfare;
- The reproduction of each of the sustainability spheres passes by the other two: the economic and the human cannot survive in time without nature that serves their support;
- The elements of the economic sphere belong to the biosphere and obey its laws, but all the elements of the biosphere are not part to the economic and do not comply with its regulations.

[25] René Passet contributed with the '*Groupe des dix*', in France, in 1966, integrating he system theory into the vision of society as an element of planetary ecosystem.

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Daly (1990), a former student and mentee of Georgescu-Roegen, proposed a distinctive framework that approaches sustainability through a hierarchy between the means and the ends of life. He rearranged sustainability into a triangular setup of the 3E's - Environment, Equity, and Economy (Figure 5). The 'environment dimension' or the 'ultimate means' is located at the bottom of the triangle, and that characterizes natural resources as a requirement for decent human life. The 'economy' is in the middle and is not independent; it serves as a vehicle to achieve 'ultimate ends.' At the top is located 'equity,' or the 'ultimate ends' which refers to the well-being of the human being.

As Daly, Costanza (1991) follows the perspective of non-degradation of the environment. He emphasizes that conventional economics conceive that technology can remove all resources constraints to persistent economic growth and the ecological economics believes it cannot eliminate those limitations. Current economic systems do not consider the sustainability of the natural life support system. Ecological Economics consider human-made and natural capital[27] as complementary.

[26] René Passet contributed with the '*Groupe des dix*', in France, in 1966, integrating he system theory into the vision of society as an element of planetary ecosystem.

[27] We can mention two types of natural capital: (1) the renewable or active natural capital, and the (2) nonrenewable one or inactive natural capital (*Ibid.*, 1992).

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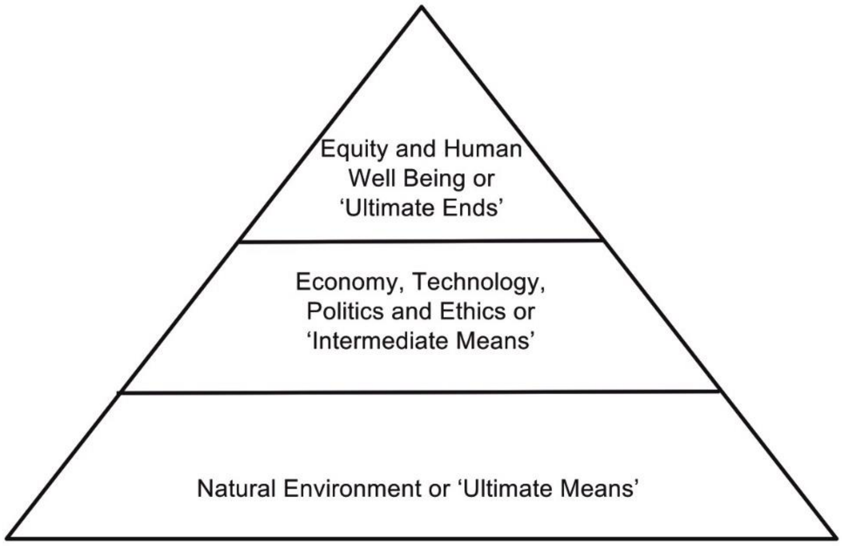

Figure 5. Daly's triangle of equity, economy, and environment. Source: Adapted from Daly (1990).

Hence, he proposes a definition of environmental sustainability:

> *"(..) is the relationship between dynamic economic systems and larger dynamic ecological systems but with slower changes in which: human life can continue indefinitely; individuals could be expanded; human cultures can develop; but in which the effects of human activity remain within certain limits in order to do not destroy the diversity, complexity, and function of the system which serves as a basis for ecological life"* (Costanza,1991, p.85).

Costanza and Daly, 1992 exposed the concepts and differences human-made capital and natural capital. Human-made capital can be differentiated in manufactured capital or human capital. Manufactured capital is related to buildings, factories, and tools. Human capital is the stock of education, culture, and skills. Natural capital is the stock that produces the flow of natural resources. For instance, *" stock or population of trees or fish provides a flow or annual yield of new trees or fish, a flow that can be sustainable year after year. The sustainable flow is natural income; the stock that yields the sustainable flow is a natural capital"* (Costanza and Daly, 1992, pg. 38).

Whatever the theoretical approach adopted, the condition of sustainability is that these flows should be maintained over time (Faucheux and O'Connor, 2002). In other words, we can consume the gain generated by the capital without reducing the capital itself (Gassama, 2016).

The relation between the human-made and natural capital defines if a system has a weak or a strong sustainability. The weak sustainability principle is to maintain intact the human-made and total of natural capital. On the other hand, the strong sustainability principle is to maintain intact the natural capital and human-made capital distinctly (Costanza and Daly, 1992).

On the weak sustainability, the natural capital reduction due to the production and the pollution must be compensated. The increase in the capital created by man might be a way to compensate and to keep available to future generations a capital stock equivalent to the current stock, and thereby, ensure their well-being. On the strong sustainability, to maintain the generations to come welfare at a level at least equal to the present generation, in other words, the natural capital cannot decrease over time. There is a focus here on the natural assets conservation (Hamaide et al., 2012; Atkinson et al., 1999).

Focusing on strong sustainability, we need to keep the natural capital intact. Daly (1990) presented six fundamental principles to SD:

- Maintaining the resource exploitation rate to a level equal to its renewal rate;
- Ensuring that the waste emissions rate will be maintained at a level equivalent to the assimilative capacity of the ecosystems in which the waste is emitted;
- Keeping natural capital and human capital intact at optimal levels;
- Ensuring that investments in the non-renewable resources use are followed by compensatory investments in renewable resources;
- Focusing on technologies that increase productivity;
- Guaranteeing that the total scale limit of production of economic outputs is within the carrying capacity of the environment, avoiding the overconsumption of capital.

4 SUSTAINABILITY IN THE URBAN PLANNING

All the SD background mentioned before open discussion to a deep transformation. This debate has covered issues concerned to population, biodiversity, agriculture, industry, energy consumption, pollution, global warming, equity to access to resources and urbanism (Jenks et al., 1996). Both Brundtland report and the Agenda 21 mentioned the major environmental problems of the rapid growth in the cities and its effects for the developed and developing countries. Global population has increased by 2 billion people over the past 25 years, from 5.3 billion in 1990 to 7.3 billion in 2015 (UN, 2015b).

Cities occupy a prominent place in society. Elkin et al. (1991, pg. 4) defended that *"urban centers are crucial to the functioning of the world economic order."* Cities concentrate a large part of the current productive activities and are the place where most paid employment opportunities are situated (UN, 2015b).

Achieving inter and intra-generational sustainability in society means to give much attention to the cities issues because that is where the most intense environmental damages are taking place. Cities are responsible for about 80% of GHG emissions (White, 1994; Martos et al., 2016). However, the transition to a SD society in the towns is not an easy task due to the high complexity of the cities.

Each city has its particularities, with unique urban experiences, inhabitants, industrial sector activities, buildings, infrastructure, mobility system, history, and culture. Moreover, manage all these particularities become complex when cities are growing. For building a sustainable city, all these issues should be considered, studied and improved (or protected - in the case of the history and culture).

The main challenge observed is, in a short time, to put in practice a big number of actions[28]. In 2016, 54.5 percent of the world's population were living in the cities (i.e., 512 cities with at least 1 million inhabitants globally). In 2030, this number will rise to 60 percent, and in 2050 will reach the 70 percent (UN, 2013). One in every three people will live in urban settlements (UN, 2016). The projected demographic changes must be highlighted in the new agendas definition to create opportunities and to deal with challenges.

The top priority is to adjust urban cities to an urban population of 8.5 billion by 2030 to achieve higher standards of living. At the same time, to minimize the negative impact of the human activity on the environment is necessary. Urbanization is vital for SD due to its ability to absorb almost all the future population growth and due to its importance for business, service delivery, and job creation. Hence, urban expansion needs to follow sustainable strategies and to target in the local population and biodiversity protection (UN, 2015b).

4.1 Progressist and culturalist models of urbanism of the XIX Century: from the industrial to the utopian cities

As we already stated at the beginning of this chapter, the main urban planning problems of the 19th Century had quantitative and qualitative roots. From the quantitative point of view, the Industrial

[28] We would like to emphasize that it is not that the time required for all these changes are short. The problem is in the investment given until right now. We can conclude that world society is late within its commitments with the SD.

Revolution boosted the population growth in the cities as London and Paris. From the qualitative perspective, the new cities started to allocate new urban functions and passed through many transformations. These transformations include the creation of new living spaces and lifestyles.

In Paris, it is, Georges-Eugène Haussmann[29], that was in charge to carry out a massive program of new parks, boulevards, and public works. Napoleon III asked Haussmann to integrate into his project hygienists' proposals, as the eradication of the unhygienic dwellings dating back several centuries, and a city modernization program. However, in the social context, the Paris of Haussmann was a city for the '*bourgeois*[30].*'* The working-class population was living outside the city, in the outlying districts.

The new proposals for urban development at the end of the 19th Century increased the emergence of the spatial projections models that created future city drawings. These models were a response to the material and social disorder of the industrial town. They represent the first projections to the future cities. François Choay presented these models at her work *'Urbanisme, utopies et réalités. Une Anthologie*'. Choay (1965) where she divided these patterns in progressist and culturalist (Choay, 1965).

A pré-urbanism (1810-1910) and an urbanism phase (1910-1960) were present in both models. The pré-urbanism period received this denomination because there is no evidence of the urbanism[31] practice until the end of the 19th century. Cities planned in the pré-urbanism[32] phase were utopias. Robert Owen, Charles Fourier[33] and Etienne Cabet contributed to the pré-urbanism progressist. They condemned the industrial society power of alienation and socialism promotion. The pré-urbanism culturalist model complained about the new urban situation. John Ruskin, William Morris contributed to weep over the image of the past (Choay, 1969).

Thereon, the urbanism progressist model was inspired by the future and by the vision of social progress. It was the first model to emerge and the most important. It is possible to find the modern

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[29] The main characteristic of the Haussmann's renovation urban plan, were the improvement of sanitation, circulation system design and opening a system of ventilation. He opened big axes of car circulation in Paris, to cut the city Nord to South and East to West, brining the city main points to direct communication (Choay, 1969).

[30] *Bourgeois* is the adjectival form of the French *bourgeoisie*, a designated group characterized by private wealth, an upper class social status, and its related culture.

[31] Urbanism in the sense of the science to organize places in the cities.

[32] It is important to highlight here that in the pré-urbanism models, a reflexive process of creation and discussion took place. Any objectivism of urban space was found. It relates its proposals to ideology (*Ibid.*, 1969). However, this reflexive moment was critical for the later urbanism models.

[33] Charles Fourier was a French philosopher and an influential early socialist thinker later associated with 'utopian socialism.' Fourier declared that concern and cooperation were the secrets of social success. He conceived communities called *Phalanstères*: organized buildings designed to integrate urban and rural features.

urban spaces origins of nowadays in the progressist model. Le Corbusier, the members of the International Congresses of Modern Architecture (CIAM), and Tony Garnier[34] are the main references of the progressist model.

The culturalist urbanism model, nostalgic, used references from the past and criticized the progressist model. The principal culturalist model figures are Camillo Sitte[35], Ebenezer Howard[36], and Raymond Unwin, who initiated reflections on the garden city (*Ibid.*, 1969).

4.2 The world wars as factor of changing the French cities

In France, Cornudet laws of 19 March 1919 and 12 July 1924 established the basis of the contemporary urbanism. The contemporary urbanism was born in the 20th Century with the main goal of the cities reconstruction after the First World War (1914-1918). The First World War destroyed or damaged about 660.000 residential buildings, 20.000 were industry buildings, and 200.000 farms (Vayssière, 2009).

Gaudin (1985) presents the Cornudet laws fundamental objectives:

- To establish the right to the soil attached to the land parcel, ensuring a proper water and energy supply, sewage networks, and paved roads to the land owners;
- To draw up the improvement, embellishment, and extension plans for the urban spaces;
- The gradual establishment of a land law defining the rules for use and construction for each land parcel.

In 1933, in the four CIAM[37] conference, the Swiss architect, Le Corbusier published the Athens Charter. The Athens Charter was the modern urbanism manifest of the 20th century and had a tremendous

[34] Tony Garnier was a French architect and city planner. In 1901, he started to elaborate solution to the perceived issues concerning urban design. His basic idea included the separation of spaces by function through zoning into several categories: industrial, civic, residential, health related, and entertainment. Garnier's drawings for an ideal industrial city called *Une cité Industrielle* were initially exhibited in 1918. *Une Cité Industrielle* was designed as a utopian form of living, for 35,000 inhabitants (Garnier, 1917).

[35] Camillo Site was an Austrian architect and city planner that was Inspired by medieval and baroque designs. Between his famous works, we can mention: 'City Planning According to Artistic Principles', 1889 and 'The Birth of Modern City Planning,' 1889.

[36] Ebenezer Howard was the founder of the garden city movement, and he is known for his publication 'Garden-Cities of Tomorrow ' from 1898, the description of a utopian city in which people live harmoniously together with nature (Howard, 1898).

[37] CIAM - In French: *Congrès Internationaux d'Architecture Moderne*. In English: International Congresses of Modern Architecture

impact on urban planning after the Second World War (1939-1945). The document determined the core functions of the City: "*The four keys to urban planning are the four functions of the City: dwelling, work, recreation (use of leisure time) and transportation*" (CIAM, 1933, pg.4). Moreover, it established the urban space needs in the city for each function. *"The city plan should determine the internal structure internal structure and interrelated positions in the city of each sector of the four key functions"* (CIAM, 1933, pg.4).

According to the Charter, the urban plan must ensure the proper functioning of the activities daily cycle between the workplace, dwelling, and recreation. Furthermore, it must guarantee that this cycle occurs with a maximum of time-saving. Dwellings are the urban planning center where all the other functions are attached. Cities must ensure the basic biological and physiological needs of their inhabitants. The dimensions of everything in the urban space should be close to the human scale (CIAM, 1933).

The reconstruction after the Second World War gave free rein to the new modern cities design. 1.900.000 residential buildings were destroyed or damaged (i.e., 18% of the real estate capital), 120.000 industries, and 250.000 farms in France. The War destroyed entire cities, as Le Havre, Caen and Saint Nazaré (Vayssière, 2009).

In the 70's many new cities designs were inspired by the Le Corbusier principles, with the recreation of separate areas, shopping malls, and green spaces. We can quote here the French cities created between the 1969 and 1973: Cergy-Pontoise, Evry, Saint-Quentin en Yvelines, Marne-la-Vallée, and Sénart. These cities were set up to absorb new population and to improve living conditions in the Parisian Region (Merlin, 1992. Deit, 1973).

These modern cities[38] were confronted to an unprecedented population explosion. From 1946 to 1968, the Parisian region population raised from 6.6 to 9.2 of millions of inhabitants (Deit, 1973). It was necessary to house, to work, to give leisure to millions of men and women, and to facilitate the market exchanges. During the 'thirty glorious years,' these suburban spaces also hosted the *bourgeoisie* and the new upper middle classes, which abandoned the heart of the cities.

The workers' populations were finally driven out a little further, toward the new large ensembles. Entire cities were expanded or created from scratch on new architectural and social rationality designs (Voldman, 1997). The idea was to provide housing (i.e., cooperative housing model prevailed) and

[38] Globally, we can mention here two projects that much expressed the modern city: Chandigarh of Le Corbusier, in India, and Brasilia, from Lúcio Costa AND Oscar Niemeyer, in Brazil.

working, with leisure and services options (Deit, 1973), what resulted in the urban spaces fragmentation, and a loss of overall coherence and in the life quality (Comite21, 2012).

It is correct to say that the modern movement glorious moment has collapsed on the disaster of the post-war suburbs[39], due to the Reconstruction urgency, with the horror of the concrete, towers, bars, and the large suburban habitat expansion. Furthermore, Vayssière (2009) brought attention to the post-war feelings that in the first place considered the victims desire to recover what they have lost. This pressure led to a fast reconstruction work based on the priority of victims' needs, which does not favor reflection and coordination. At the end of the 20th century, the city, was a symbol of improper living, pollution (i.e., due to the longer distances covered in the vehicle), noise, and violence.

In France, the 20th century was also marked by the appearance of the first urban regulation laws. The LOF (*Loi d'Orientation Foncière*) Law was created in 1967. The Law contributes to separate the urban planning law from the building construction laws, and determines the major urban planning documents used for local planning (*République Française*, 1968).

4.3 Urbanism of the 21st century and first environmental urban policies

The SRU Law and the *Grenelle Environment* featured a new approach developed to the urbanism of the 21st century in France. This new approach will seek to adapts the national policies to the new the urban centers' challenges.

The new SRU - *Solidarité et Renouvellement Urbain* Law[40] of 2000, promoted a general urban rehabilitation in France. At this moment, a destruction and rehabilitation of many buildings took place. The Law encouraged social mix buildings (i.e., the percentage of social housing) emergence and the city centers regeneration to attract the inhabitant presence during the day and night. The desertification of the city centers during the evening is a significant problem for many cities. It could bring insecurity for visitors or inhabitant according to Jacobs (1961)[41].

The SRU Law aimed to ensure (République Française, 2000, Article 1):

[39] Vayssière (2009) mentioned that the discrepancy between the formal research of architects and the conditions of public order after the great destruction contribute to a problematic architecture.

[40] The SRU Law is the culmination of the national debate launched in 1999 on the theme of "Living, Moving ... Living in the City" which highlighted the need to ensure greater coherence between urban planning policies and displacement policies with a view to SD (République Française, 2000).

[41] At her book 'Death and Life of Great American Cities' (1961) she mentioned that is important for a city to have buildings with its facade directed to the street. Those buildings will be the 'eyes of the street' for the visitors that ensures a sort of security.

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- The balance between urban renewal, controlled urban development and the development of rural areas, respecting the objectives of SD;
- The diversity of the social mix in urban and rural housing by providing construction capacity and sufficient rehabilitation for the satisfaction of present and future habitat needs, without discrimination;
- The urban functions for any economic, sports and cultural activities, general interest and public facilities;
- An economical and balanced use of the natural, urban, peri-urban and rural spaces, with an optimization of the displacement needs, traffic control, preservation of air, water, soil, ecosystems, green spaces, and the conservation of natural or urban landscapes;
- A noise pollution reduction, the safeguard of the remarkable urban complexes and the historical heritage protection, preventing foreseeable natural risks, technological risks, pollution and all kind of nuisances.

The SRU Law implementation was influenced by a particular context: the 'decentralization laws'[42] of 1980's and a new governance model. Users and residents were invited to prepare documents and operations to express their opinions, making visible their point of views with the Bouchardeau Act. Furthermore, the environmental concerns related to the protection of the natural spaces and the biodiversity, and the emergence of new laws and institutions (e.g., Natura 2000[43], ADEME[44] and ZNIEFF[45]) had significant influence.

The *Grenelle Environnement* was a conference that concentrated the government, local authorities, trade unions, business and voluntary sectors to determinate a concrete action plan for measures to tackle the environmental issue. The working groups meet from 6 July from 25 October of 2007 and set ambitious goals in many areas, as: biodiversity and natural resources; climate change; relations

[42] The policy of decentralization, or 1983 Laws (Gaston Defferre Laws), previewed more autonomy for municipalities and departments in France.

[43] Natura 2000 is a network of nature protection areas in the territory of the European Union. It is made up of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) designated respectively under the Habitats Directive and Birds Directive. The network includes both terrestrial and marine sites (Marine Protected Areas - MPAs) (EU, 2000).

[44] *The Agence de l'environnement et de la maîtrise de l'énergie* (ADEME) it is a public establishment with the mission of stimulate, animate, coordinate, facilitate or carry out operations for the protection of the environment and the energy control (ADEME, 1991).

[45] The ZNIEFF - *Zone naturelle d'intérêt écologique, faunistique et floristique* (In English: Natural zone of ecological interest, fauna and flora) it is a sort of natural environment recognized by France. The inventory of a ZNIEFF area is an inventory of natural resources and scientific program launched in 1982 by Minister of Environment Huguette Bouchardeau and confirmed by the Act of July 12, 1983 called the Bouchardeau act (République Française, 1983).

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between the environment and public health; production and consumption models; 'environmental governance' and 'ecological democracy' issues; the sustainable patterns promotion of development favorable to competitiveness and employment; and the waste management (République Française, 2008).

The Grenelle Law (i.e., Grenelle I) was adopted to implement these the commitments. The main goal is to reduce and divide by four the GHG gas emissions by 2050. Transport and building sectors received attention because both are together responsible for 40% of GHG emissions.

According to the Grenelle I, urban planning laws must consider new SD goals, as (République Française, 2010a):

- Fight against urban sprawl that results in declining agricultural and natural areas, energy wastage, greenhouse gas emissions and high infrastructure costs;
- Preserving biodiversity through the conservation, restoration, and creation of the ecological continuity;
- Implementation of renovation works to improve the energy performance of buildings;
- Globally considering design urbanism and create a link between density and level of service by public transport;
- Decrease in the car use and promotion of public transportation;
- The eco-construction promotion.

The Grenelle I set all the workgroup commitments. The implementation of these goals is the Grenelle II main role, launched in 2010. The main urban planning changes previewed in the Grenelle II from the Grenelle I are (République Française, 2010a):

- Creation of ZAPA (*Zone d'actions prioritaires pour l'air*) zones, where polluting vehicles may be prohibited;
  Less energy building promotion and decrease in the energy precariousness - establishment of the energy performance diagnostic for buildings (previewed in the current Thermal Regulation);

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- Environmental goals introduction in the SCOT[46], PLU[47] (created by the LRU Law) and municipal plans that must integrate the issues of greenhouse effect, energy consumption, renewable energy production, air, water and soil quality; and biodiversity restoration and protection;
- Establishment of an ecological coherence regional plan (SRCE)[48]: a new land use and protection of certain natural resources planning scheme, that also aims to conserve a correct ecological status of water;
- Creation of a climate, air, and regional energy plan (SRCAE)[49]: this plan should integrate into a single framework various planning documents that have a close link with energy and climate;
- Establishment of a climate, air, and energy national plan (PCET)[50]: is a sustainable development approach specifically focused on the fight against climate change.

In a European scale, the Charter of European Sustainable Cities and Towns Toward Sustainability or Aalborg Charter influenced the urbanism of the 21st century. The charter, signed in 1994, is an urban environment sustainability initiative approved by the participants at the first European Conference on Sustainable Cities and Towns in Aalborg, Denmark. It was conceived as an instrument for engaging in dialogue with citizens, associations, and professionals as a document facilitating exchanges and relations between elected representatives and inhabitants (EC, 1994).

Furthermore, globalization, democratization, the new era of information, communication technology, economic, social and cultural changes are strongly influencing or influenced the urbanism of the 21st century.

4.4 Sustainable urbanization: definitions and priorities

The elaboration of the strategic goals boosted countries to focus more on what we must to do to achieve the SD. All this context gave space to think the cities particularly and an implementation of sustainability as a broad concept which integrates social development, economic development aligned with an environmental management and urban governance.

[46] In France, the SCOT (*Schéma de cohérence territoriale*) is an urban planning document that determines, at the level of several municipalities, a regional project that aims to ensure consistency at all sectoriel policies, particularly, concerning housing, mobility, commercial development, environment and landscape (MLDH, 2014).

[47] In France, the PLU (*Plan Local d'Urbanisme*) is the main document for urban planning at the city or inter-city level.

[48] In French: *Schéma Régional de Cohérence Écologique.*

[49] In French: *Schéma Régional du Climat, de l'Air et de l'Énergie.*

[50] In French: *Plan climat-énergie territorial.*

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Many countries were engaged in building green cities or 'eco-cities' to make up environmental shortcomings of the urban space and as a starting point for the building a sustainable development. For these countries, eco-cities and sustainable cities are distinct concepts (UN, 2013; Comite21, 2012).

However, the Urban Ecology[51] (1996) organization launched the first studies about ecological cities in 1975 to rebuild cities in balance with nature. The organization determined ten ecological cities' principles:

- Creation of compact, safe, green, pleasant and vital mixed-use communities close to transportation facilities;
- A new transport approach that prioritizes walking, cycling, public transportation; and increase proximity;
- Urban environment revitalization;
- Social justice promotion;
- Support local agriculture, urban greening projects, and urban community gardening;
- Promoting recycling and resource conservation while reducing pollution and waste disposal;
- Work with business to support ecologically economic activity;
- Discourage consumption of material goods;
- Increase awareness of the local community.

When analyzing these principles, it is possible to affirm that even if eco-cities normally had focus in environmental approach, it also considers the necessity to answer local issues in the municipality and to answer to the users and inhabitants' expectations (Charlot-Valdieu and Outrequin, 2009). This study assumed that both concepts, eco-cities and sustainable cities, are overly similar with the same meaning.

The sustainable city enters here as a key to formulate the cities of tomorrow understanding. The new approach interrogates the humanity's current and future lifestyle. It also questioned how the transport, buildings, resource management, organizations, and urban spaces are going to adapt. Furthermore, it interrogates how cities will provide prosperity, security, and resilience.

The international conferences and events mentioned before affirmed this will. In 1978, United Nations HABITAT Program was created with the main goals of promoting the SD cities and working toward a better urban future through many programs. The program created the Sustainable Cities Programme

[51] Urban Ecology was founded by Richard Register and other authors in Berkeley, CA, in 1975, to develop studies in urban ecology.

(SCP) to ensure that the environmental sustainable local development fully realizes the crucial contributions that cities make to overall social and economic development.

The United Nations Centre for Human Settlements (UNCHS) spread the idea of sustainable cities and attempted to give a definition for it. *" the Sustainable city is where achievements in social, economic, and physical development are made to last"* (UN-HABITAT, 2002, pg.6).

For Godard (2009), the definition of a sustainable city is based on four axes including:

- Reduction in the resource consumption;
- Change of scale and spatial unity in the planning and management strategies;
- Increase in the integration between nature and the cities;
- The green manner of reasoning applied to populations and the transition to a permanent building over time.

For Charlot-Valdieu and Outrequin (2009), the sustainable city is a project implementation approach that aims to answer inside its scale the global (e.g., climate change, energy use, natural resources consumption) and local issues. It also seeks to enhance inhabitants and users' quality of life.

If we define the sustainable city as a product, the sustainable urbanization[52] is the process to reach the sustainable city. The UN-HABITAT (2002) defined the sustainable urbanization as:

> *"a dynamic, multi-dimensional process covering environmental as well as social, economic and political-institutional sustainability. It embraces relationships between all human settlements, from small urban centers to metropolises, and between towns and cities and their surrounding rural areas"* (UN-HABITAT, 2002, pg.4).

However, we consider that all these definitions are generic and do not present the specific action plan needed for this transition. In this sense, some questions can be raised: If the local government would establish some targets to sustainable power cities, what kind of requirements does it need to elaborate or to follow? What are the requirements for the transition toward a sustainable city? The UN-HABITAT (2013) presented a framework for achieving urban sustainability in four pillars: social development, economic development, environmental management and urban governance (Figure 6).

[52] "Urbanization is the process through which cities and towns develop and grow. It includes the movement of people from rural areas to urban areas as well as movements among towns and cities. It also encompasses the development of urban economies and urban social and political systems" (UN-HABITAT, 2002, pg.8).

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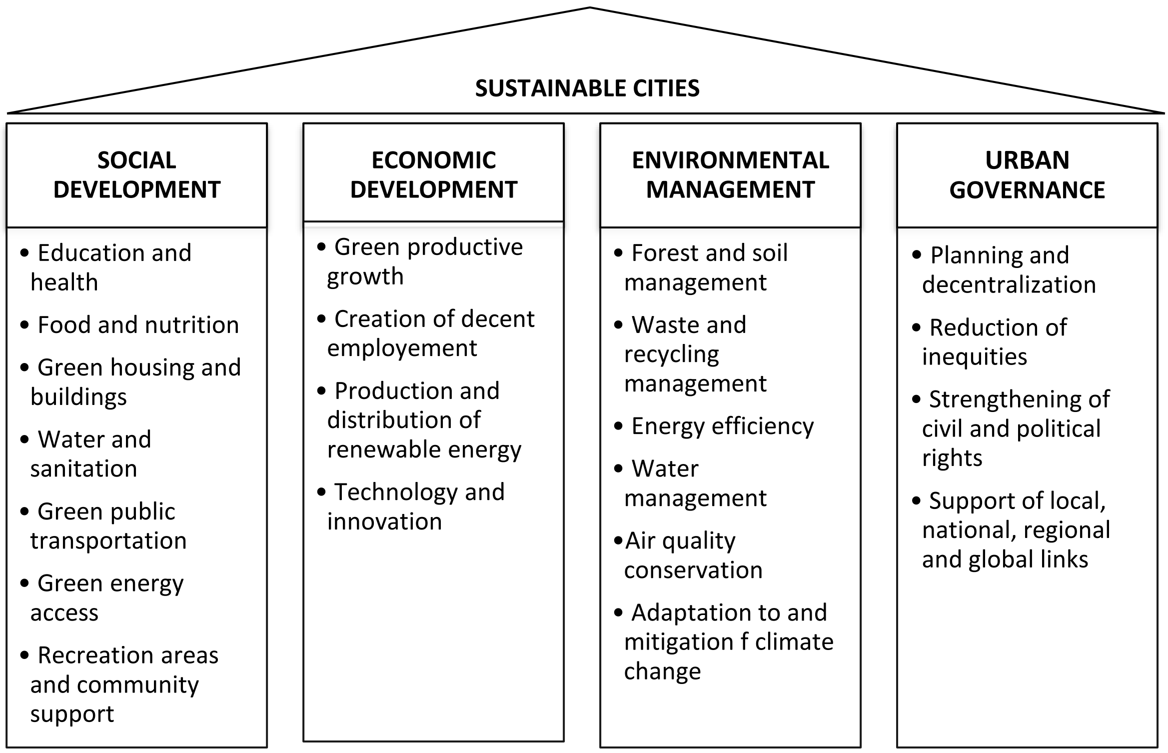

Figure 6. Pillars of sustainable urbanization. Source: UN-HABITAT (2013).

Furthermore, the promotion of sustainable cities and communities is the Goal 11 of the '2030 Agenda for SD' developed by the UN-HABITAT for the SD Goals. The Goal 11 encompasses a plan of ten actions (UN-HABITAT, 2016):

- Adequate housing: ensure access for everyone to adequate, safe and affordable housing and basic services and upgrade slums;
- Transport system: provide ways to safe, affordable, accessible and sustainable transport systems for everyone, improving road safety, notably by expanding public transport, with particular consideration of the needs of those in vulnerable situations, women, children, persons with disabilities and the elderly;
- Sustainable buildings: support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials;
- Public space: provide universal access to safe, inclusive and accessible, green and open spaces, especially, for women and children, older persons and individuals with disabilities;
- Sustainable urbanization: enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries;

- Urban-rural linkages: support positive economic, social and environmental links between urban, peri-urban and rural areas by reinforcing national and regional development planning;
- Risk reduction: substantially increase the amount of cities and human settlements adopting and implementing integrated policies and plans for inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels;
- Disaster preparedness: significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses about global gross domestic product caused by disasters, including water-related catastrophes, with a focus on protecting the poor and people in vulnerable situations[53];
- World Heritage: strengthen efforts to protect and safeguard the world's cultural and natural heritage;
- Cities environmental impact: reduce the adverse per capita environmental impact of cities, by paying attention to air quality and municipal and other waste management.

Inside the environmental implications in the city, attention should be given to waste disposal. The environmental management in the towns must go beyond end-of-pipe, avoiding waste disposal and embracing resources management concerns. Cities should use renewable and non-renewable resources as efficiently as possible and must develop an adequate municipal solid waste management. For this purpose, a recycling and reuse program should be discussed (UN-HABITAT, 2002; Martos et al., 2009)

Another priority is to ensure a reliable infrastructure and services; this includes water supply, waste management, communications, energy supply and transport; that should be available to all urban residents (UN-HABITAT, 2002). Inadequate public transport systems[54] increase the use of private cars resulting in a traffic jam, air pollution, an increase in accidents, and a reduction in the quality of life in the city that suffers from the adverse consequences of the current planning policy (Foo et Yen, 1999; Comité 21, 2012).

[53] "*Climate change effects deepen the vulnerabilities of cities in poor nations and threaten the resilience and adaptation capacities of cities in richer nations*" (UN-HABITAT, 2013, pg. 67).

[54] We use the word 'inadequate' here because even when there is an infrastructure, normally it facilitates and encourages the use of the individual car (Comité21, 2012).

In the economic context, the sustainable urbanization should promote local employment and economic development (UN-HABITAT, 2002). For this purpose, urban and rural producers need to answer back the demand for goods and services. Hence, rural and urban areas need proper interconnections, including transport and telecommunications networks, as well as essential services such as electricity and water (World Bank, 2000).

Inside the perspective of urban space reorganization, sustainable lifestyle can be built considering a proximity of employment, housing, and services. By reducing distances, it is possible to enhance usability, reduce energy consumption, and CO2 emissions (Comité21, 2012). The International Energy Agency - IEA (2012) evaluated that 20% of global primary energy consumption and 25% of CO2 emissions can be associated with the urban transport.

However, when it is not feasibly possible to approximate activities, eco-mobility options can be considerate. For the European Commission (2012), eco-mobility "*refers to the ability of any individual to travel, access opportunities and reach destinations in an environmentally-friendly, safe and healthy way.*" For example, the promotion of public transportation, bicycles, walking, environmentally friendly technologies (e.g.; electric vehicles, biofuel vehicles), and pricing and financing policies. All this must be considered in a multi-modal way (Martos et al., 2009; Grenier and Page, 2012).

This mobility definition that considers the natural environment conservation with the life quality promotion differs from the sustainable mobility definition that respects the ecological integrity but also ensures the material needs of life and guarantees equity between individuals (Boillat and Pini, 2005). Sustainable mobility contributes to the cities complexity investigation, and to enhance the links between land use and transport. The effective implementation of sustainable mobility depends on the stakeholders' engagement (Banister, 2008).

Still, inside the perspective of the urban space reorganization, cities must promote equity and social cohesion. Implementing a functional and social mix urbanization, prioritization in the issues related to the neighborhoods of social housing, and the inhabitants' involvement in the urban governance might contribute to improving social justice (GUYARD, 2006).

Green spaces inside the city have a substantial impact on people's well-being. They allow inhabitants to be in contact with the nature inside the urban environment. Extensive areas in the urban cities also act as urban lungs, absorbing contaminants and freeing oxygen (Martos et al., 2009). Urban green areas are also essential to the water cycle and biodiversity maintenance, and to reduce the 'Island heat effect' inside metropolises.

4.5 Challenges to the sustainable urbanization achievement

The fundamental challenges of sustainable urbanization is to obtain the critical contributions which urban settlements can make to economic, environmental and social sustainability at local, national and global levels (Figure 7).

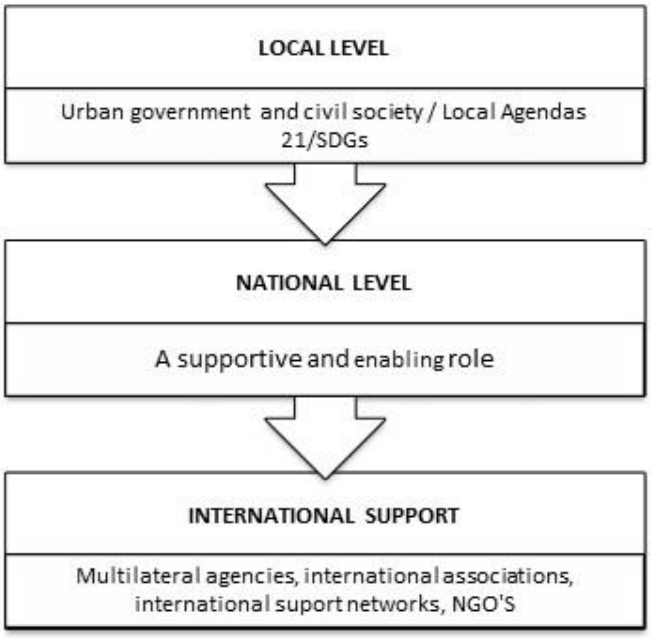

Figure 7. The fundamental challenges of sustainable urbanization. Source: Adapted from UN-HABITAT (2002).

Actions at the local level involve the local government and the civil society, and notably the implementation of the Local Agendas 21 as collaborative approaches to development and environmental planning. An effective local action for the sustainable urbanization needs a supportive national level policy. Furthermore, it requires a decentralization and the empowerment of the local authorities. The international support consists in the mobilization of the multilateral and bilateral development agencies, regional and international associations of local governments, professional associations, international support networks, and NGOs (UN-HABITAT, 2002).

The report 'World's Cities in 2016' defines the main differences between the city proper, urban agglomeration and metropolitan area. The city can be described according to an administrative boundary. The urban agglomeration considers the extent of the contiguous urban area, or built-up area, to delineate the city’s boundaries. The metropolitan area defines its borders depending on the level of economic and social interconnectedness of nearby areas (UN, 2016). Figure 8 describes the city proper in yellow, the urban agglomeration in blue, and the metropolitan area in red, for Toronto, Canada.

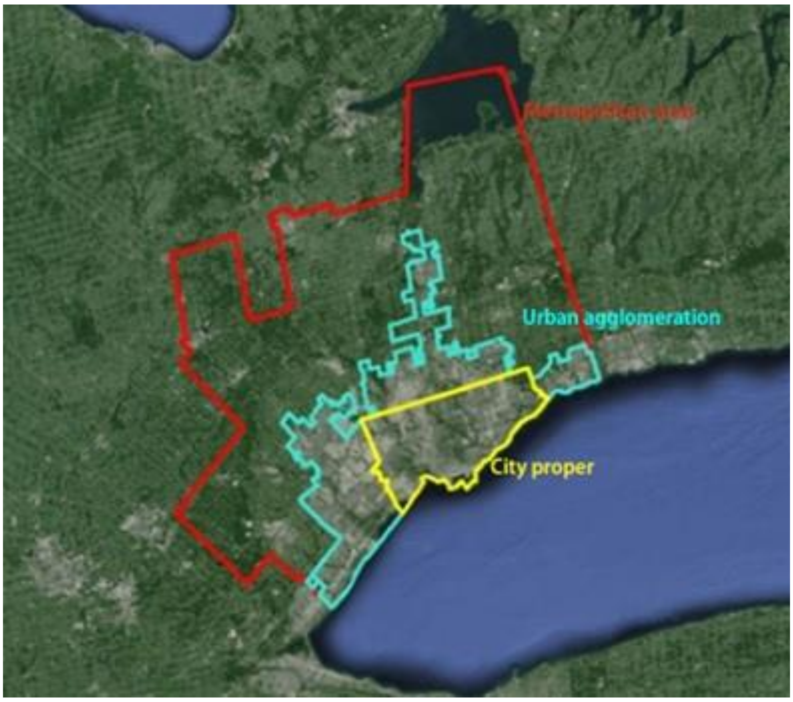

Figure 8. Representation of the city proper, urban agglomeration and metropolitan area in Toronto, Canada. Source: UN (2016).

The size of a city is most of the time a factor for public investment. In many countries, a significant part of the public investment (i.e., roads and transport, communications facilities, sewerage and drainage, water supply, and tertiary education) go to the cities with a critical size. This trend of investment in biggest cities, almost exclude small and medium-sized urban centers and it determines a break in their economic development. Most of the time this discourage private investment and turn the urban activities less productive and efficient (UN-HABITAT, 2002).

Identifying other challenges for the sustainable cities implementation is possible. The first one is related to the complexity of the urban systems. Analyzing and considering all the urban systems in a village is simple, however, in a city, in an urban agglomeration or in a metropolitan area, where there are a significant number of systems involved, and interrelated, it becomes more complex (Foo and Yen, 1999).

Many times the appropriate scale to study an urban system extrapolate the city limits and this turn the system study not easy due to the several incoming and outgoing flows placed in various scales. A form to solve the complexity, it is certainly to understand the system's internal loops, and especially to

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ensure that the cycles are closed to restore the balance and prevent the urban ecosystem from living the detriment of other ecosystems (Comité21, 2012).

Another challenge is correspondent to the diversity in the patterns of urbanization since there is a strong connection between urbanization and national levels of economic and human development (UN-HABITAT, 2002). Most of the world's fastest-growing cities are in Asia and Africa. In 2050 the urban population will reach a total of 6.25 billion, and 80 percent might be living in developing regions (UN, 2016). According to the UN's Sustainable Cities Programme, cities located in the developing countries have their transition to SD much more challenging. Many reasons can be exposed (UNCHS, 1994):

- The overwhelming scale and speed of urban growth;
- The inadequate existing urban infrastructure;
- Rapid and concentrated in the urban center's industrialization;
- Limited managerial, technical and institutional capacities;
- The urban and national economies with low levels of output and weak financial capabilities.

Furthermore, changes in the economic activity organization have distinct priorities for the north and south countries. In the developed countries, the priority is related to the regeneration and renewal necessities. On the contrary, in the developing countries, the priorities are related to the need to accommodate the rapid growth, provide the essential infrastructure, deal with the rapidly deteriorating physical environments, and improve the shelter opportunities (UN-HABITAT, 2002).

Developing countries should address many efforts to the poverty reduction because "*economic growth is unsatisfactory if it is accompanied by continuing or increased inequity and poverty, not least because low levels of education and health care provision or social disruptions have an adverse effect on economic development*" (*Ibid.*, 2002, pg.10).

Besides, a strong link between the poverty, the environment, and the health issues can be determined in urban areas. The poorest communities are the most impacted by inappropriate urban services, for instance, lack of sanitation, waste management, drainage, and adequate supplies of potable water (DFID, 2001). If the pollution and the waste generation from industry is a serious problem in many cities, it can be considered more severe in the developing economies where the rapid urban industrialization follows the fast urbanization, increasing air pollution, and water[55] and soil contamination (UN-HABITAT, 2002).

[55] The lack of proper treatment of sewerage is the principal source of pollution in lakes and coastal seas(UN-HABITAT, 2002).

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Moreover, many residents from the developing countries suffer from the health issues associated with inadequate access to public services. The potable water access is also a serious problem. Currently, about 1.1 billion of people still lack access to safe drinking water, and over 2.6 billion people do not have access to toilets and other adequate sanitation facilities (UN-Habitat, 2012).

While cities have a significant role to play in the economic development, they are also characterized by rapid social changes. These social changes might have adverse consequences. Inside the social dimension, the main challenges encompass injustice, inequality, and exclusion. Thin et al. (2002) identified four areas of social objectives that are SD elements: social justice, solidarity, participation (i.e., social inclusion and diversity), and security (i.e., resilience and adaptability).

The SD cannot be achieved without governance arrangements that might help to realize the economic potential of urban areas, achieve social justice and welfare, and decrease the environmentally damaging effects of urban growth (UN-HABITAT, 2002). The governance must promote the dialogue between the urban planning and the urban management stakeholders in common sense. One city more sustainable might be a result of the inhabitants' active participation that should deliberate and accept actions plan (Comité21, 2012).

Local governments have a key role here. They must be able to identify measures to improve urban development and to implement them. Local governments will need to prepare the political and institutional conditions that will facilitate measures application and ownership by stakeholders. Hence, it is possible to affirm that the projects for sustainable cities implementation are political projects as well, where the local government role is reinforced (*Ibid*., 2012).

4.6 An integrated and coordinated approach to urbanization

We presented in this section the main definitions, and priorities of sustainable urbanization. Besides that, we set out the main challenges regarding developed and developing countries. Followed this, we will present some cases to demonstrate further how projects were implemented and how the stakeholders participate in it.

As shown before, the holistic view basis of building sustainable cities is an integrated approach between social development, economic development, environmental management and governance components. This urbanization process implies the coordination of objectives and programs among various city stakeholders and the development of connections between and within socio-economic sectors and activities (UN-HABITAT, 2013).

The Copenhagen city won the European Green Capital in 2014 due to the significant city efforts to become the world's first CO2 neutral capital by 2025. To reach this goal, Copenhagen has implemented public-private partnerships at the core of its approach to eco-innovation and sustainable employment. The city has been working with companies, universities, and organizations in dedicated and participative forums. These forums aim to develop and implement green growth together through the 'Sharing Copenhagen Plan.' The success of the stakeholders’ engagement is due to the communication actions that engaged citizens to participate in the process. This experience globally inspired many other cities with storytelling and knowledge sharing (EC, 2014).

Copenhagen formulated solutions to enhance the life quality, traffic flow, health and the environment. The city promoted an urban farming engaging and enlightening citizens to address environmental and societal benefits related to urban nature. The city established guidelines to stimulate green mobility.

The key targets for 2025 include: increase the displacements by bicycle (a minimum of 50% of all displacements); 75% of all trips by foot, bike or public transport; and 20-30% of all light-weight vehicles use electricity, biogas, bioethanol or hydrogen. Furthermore, the city planned to reduce CO2 emissions by 1.2 million of tons through the building construction and renovation projects, reduction of heat consumption, and an electricity production on wind and biomass (*Ibid.*, 2014).

In a small scale, we can mention the Quartier Vauban - a neighborhood of 5000 people in the south of the town center in Freiburg, Germany. The Quartier Vauban was born from French military buildings and was inaugurated in 2001 as the first sustainable model district in the world. The district was founded by the partnership between public and private actors that integrated social, economic and environmental principles for future urban design.

Freiburg city hall Before to start the neighborhood construction, the Freiburg city hall launched a competition of ideas between the architecture offices with the main goal of developing a concept of urban design for the neighborhood. After acquiring the land, the Freiburg city hall town itself carried out a fragmentation and directed the sales in collaboration with its financial administrator, a public development company *Kommunalentwicklung LEG Baden Württenberg GmbH*. The Vauban's construction started in 1997 and was financed by the municipality that also is responsible for selling the parcel of land for an available price (GUYARD, 2006).

The 'Forum Vauban,' an association of citizens, guaranteed the public participation in the project conception and ensured the organization of life in the neighborhood. The association recruited some specialists[56]: a lawyer, a biologist, a town planner, an environmental technician, a physicist, a geographer, an economist and a banking expert. This multidisciplinary team has the role of following and advise the local inhabitants in their construction project in the neighborhood. Also, 'building groups' bringing together owners and promoters have been formed around mutual projects to reduce construction costs, and this helped to build the sense of community (*Ibid.*, 2006).

The urban planning was particular in the district. The land was divided into small plots favoring high urban density. Buildings are open to the city (i.e., the absence of walls) increase the effect 'eyes of the street' mentioned before. Social buildings are present with the same architecture and the same location of the other buildings promoting human population mix (*Ibid.*, 2006).

All the houses were built to a low-energy consumption standard, with 92 units designed to the *Passivhaus* ultra-low energy building standard, with 15 kWh/m2/yr, and ten plus-energy homes (Figure 9). 2500 m2 of photovoltaic panels and 500m2 solar panels were installed. Beyond that, the insulation and the efficient heat supply contributes for reducing 60% of the CO2 emissions (Eurbanlab, 2017a).

Inside the Vauban Model District, transport is made by foot or bicycle in a 'car-free' concept with emphasis on proximity. Tramway makes the connection to Freiburg city center. The tramway stops are readily accessible to all homes (*Ibid.*, 2017a).

Figure 9. Top view of the passive and plus energy houses. Source: Vauban (2017).

The experience of the Copenhagen Sharing Plan and the Quartier Vauban demonstrated how the public and private partners integration have a significant impact on building sustainability locally. As

[56] With the financial support of the foundation Deutsche Bundesstiftung Umwelt (GUYARD, 2006).

already mentioned by the SDG's, people should be in the center of SD. All these integrated and coordinated participation can be analyzed to inspire new projects but also to achieve continuous improvement in democratic governance.

In France, inside the *Plan d'actions Ville durable*, the [57]AEU2 is an urban environmental approach from ADEME (2013) for local authorities and urban planning stakeholders to help them consider the principles and purposes of SD in their projects. The methodology strengthens the consideration of the SD in projects and reinforces the participative construction of the SD projects through four stages: analysis of the territory project issues, the definition of the objectives and guidelines for the project, definition of the targets and orientations in the project, and definition of the accompanying measures for the project.

On a global scale, it is the role of the United Cities and Local Governments (UCLG) the representation of the interests of local governments on the world stage, regardless of the size of the communities they serve. The UCGL renews and deep partnership, and improves local governance across the world (i.e., including promotion of decentralization, local democracy, gender equality and access to basic service).

5 BUILDINGS AS AN ENVIRONMENTAL THREAT BUT ALSO AN OPPORTUNITY TO PROMOTE SD LOCALLY

In the same way as the public space (i.e., grand central plazas, parks, and squares), streets, transport system, and landscape, buildings are essential elements of the urban design. Buildings inside the cities can host the various activities or people from the diverse social category, can be individual or collective, can be new or historical heritage, and can have distinct colors, size, and materials. Furthermore, the building construction sector contributes strongly to the economy. Even with the decrease of 3,6%, in 2014, the French construction industry generated a profit of about 300 billion of Euros and gave employment to 6.6% of the population (ISEE, 2016).

The buildings heterogeneity brings singularity and identity for neighborhoods and cities and is a crucial part of the urban system. Nowadays buildings are not autonomous, and they depend on the city as much as the city depends on these interior spaces. Cities need building's structure to develop their economic activities but also to provide housing, education, health and other services for the population. Hence, they provide water, energy and raw materials to the building's construction and

[57] In French: Approche environnementale de l'urbanisme 2.

use. As an output, buildings are responsible for GHG emissions, waste production, and other environmental impacts.

Figure 10 represents this relation between the internal buildings systems and their external environment. As parameters do not change, in a normal situation, if the number of buildings in a city increase, the amount of water, energy and raw materials needed increase as well. Similarly, for the GHG emissions, waste production, and other environmental impacts, for instance, ozone depletion, water and soil pollution, deforestation (Rodriguez et al., 2011; Gangoles et al., 2007, Cherqui, 2005).

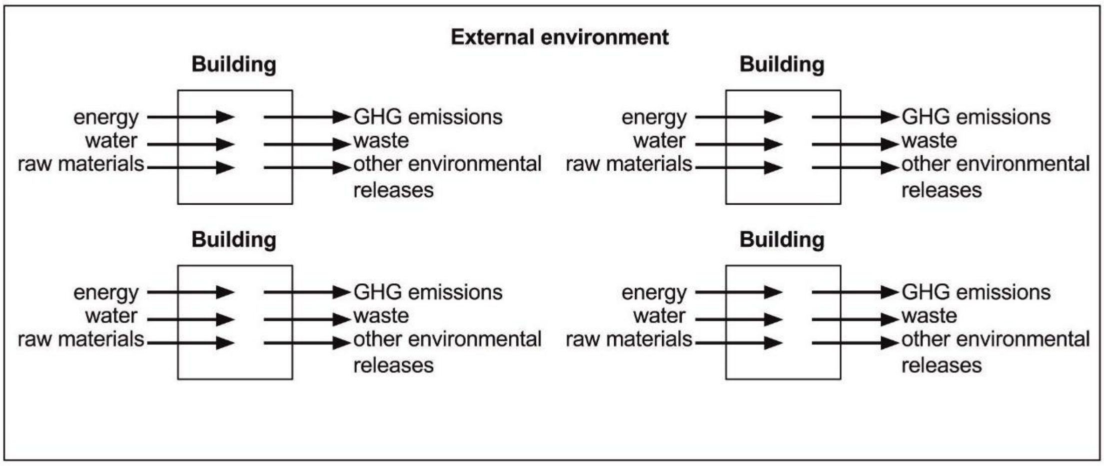

Figure 10. Input-output representation of the relation between buildings occupation and city.

A recent data about the building sector accuse a consumption of 40 percent of the world's energy and materials. The construction industry and its related industries are responsible for consuming 16 percent of the world's water used (Hoffman and Henn, 2008; Roodman et al., 1995; Dixit et al., 2010). Beyond that, in 2010 the sector was responsible for 6.4% of the global direct GHG emissions and 12% of the global indirect emissions (IPCC, 2014).

It is important to considerate that depending on the building, the amount of input and output could double in the sense that every construction works uniquely. The input-output for a building's use is not constant; it also depends on the number of users or occupants that have a direct effect on it. The growth in the worldwide population has been stimulating the urbanization phenomenon and additionally increasing the demand for new and retrofit buildings.

At the end of the 90s, boosted by the growing on environmental regulations and societal pressures, the construction sector started to recognize the environmental aspects related to its activities to find solutions to reduce the adverse effects on the environment and society (Happio, Viitaniemi, 2008).Green buildings can act in the reduction of the environmental threat of the construction sector due to the decrease in energy, water, and raw materials needs. After that, it contributes to the minimization of the GHG emissions, waste disposal and other environmental impacts in the external environment and for the occupant's comfort, health, and well-being (Figure 11).

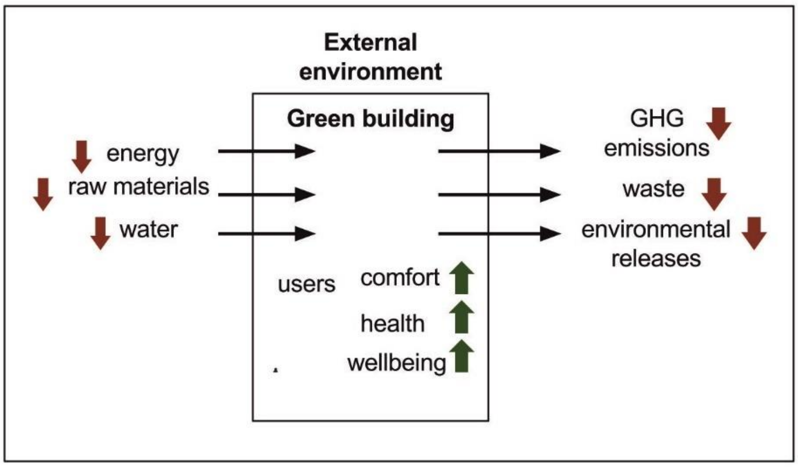

Figure 11. Main environmental contributions of green buildings during the occupation phase.

Furthermore, as buildings are the biggest energy consuming sector globally, they are an important part of the strategies and opportunities to 2050 when the world population is projected to reach 9.7 billion. If society continues with the same energy consumption trend in the building sector, it is expected that the energy demanded by the sector rises 50% in 2050. To achieve the goal of limiting world's temperature rise to 2°C, as required by the Paris Agreement, it is recommended an estimated of 77% reduction in total CO2 emissions in the buildings sector (IEA, 2013; UN, 2016; UNFCCC, 2015).

Green buildings can act significantly to fight climate change through mitigation and adaptation actions. Mitigation strategies are actions that can assist to prevent climate change. On the other hand, adaptation strategies capacitate people or community to adjust to the impacts of the climate change locally. Adaptation and mitigation are strongly linked and together can bring new opportunities (Nyong et al., 2007).

According to the Mitigation of Climate Change report from the AR5 of IPCC (2014), the main mitigation actions for the building sector are constituted by technological options, design practices, and behavioral changes. Adaptation measures to future climate conditions and extreme weather events include building's passive design, optimization of natural resources and resilient strategies to increase risk prevention (IPCC, 2014).

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With this new population and urbanization provision for the next years, green buildings might be an essential element for the implementation of sustainability concepts in the construction industry. However, the whole sector needs to progress. Companies should recognize their responsibilities and need to implement the sustainability values at their overall goals. When identifying their CSR internal policies, companies will be able to give priority to their approach for a green building construction process.

The implementation of sustainability concerns in the construction sector is about achieving a win-win outcome for all the stakeholders. For users, the improvement in the air quality and comfort can act in favor of health and well-being and can contribute to the rise of productivity at work. For construction companies, the implementation of sustainable construction contributes to the improved environment and the advanced society, and, simultaneously to the enhancement of competitive advantage in the market and profit (Shen et al., 2010; Atsusaka and LeVan, 2003).

Rating systems, as the LEED, HQE, BREEAM, and CASBEE, could contribute in this process. Nonetheless, when the construction actors are not engaged in the implementation of the CSR and SD strategies, the adoption of this rating systems can be interpreted as contradictory. In this sense, rating systems could be used as a tool to improve their image in the market. The establishment of SD and CSR goals and the commitment of all stakeholders are crucial for the establishment of sustainable buildings, cities, and society.

5.1 How can we implement the sustainability in the construction sector?

'Sustainable construction' was originally used to describe the responsibility of the building industry to meet 'sustainability' goals (Hill, 1994). When construction companies want to meet sustainable goals, they establish corporate social responsibility (CSR) policies for the enterprise and a project feasibility study for the building project (Shen et al., 2010).

The main reasons for the construction companies to focus on sustainability strategies are governments policies when they are efficient and environmental considerations. Both factors have been boosted construction establishments to manage their performance based on this new societal demand guided by the sustainable development goals (Teo and Losemore, 2003; Ofori et al., 2000). Furthermore, competition is also another factor that has been stimulating construction companies to improve their corporate image and to benefit from a competitive advantage (Zhao et al., 2012).

Inside this context, the CSR concept implicates a corporate sustainability expression with the business operations to promote continuous development. The CSR became an attractive concern to the companies in the several business sectors from the mid-1990s onwards (O'Connor and Spangenberg, 2008; Lehtonen, 2004).

The identification of the key stakeholders helps in the organization of the attributes of CSR. Each stakeholder in a construction process is involved in the distinctive levels during the several phases of a construction project management.

The stakeholders can be grouped into nine categories: (1) employees, (2) customers, (3) shareholders, (4) government, (5) suppliers and partners, (6) resources and environment agencies, (7) local community, (8) NGOs, and (9) competitors (*Ibid.*, 2012). Conventionally, contractors might answer to the societal expectations of the ISO 26000 (AFNOR, 2010), or Social Accountability 8000, ECS 2000 Standard, and Global Reporting Initiative.

The Global Reporting Initiative (GRI), an international, independent organization, founded in 1997, developed a generic framework for organizations to understand and communicate their sustainability practice.

Even with all the new tools that assist companies to meet their societal responsibilities within SD goals, a change of behavior is necessary and commitment is required to planning and implementing CSR. Only with the real commitment, the companies could be able to enjoy the benefits of implementing CSR that includes improvement of brand image and the financial performance enhancement (Zhao et al., 2012).

It is possible to affirm that for the construction companies, the complexity of distinct construction projects and the various sites might act as a challenge for the implementation of sustainability. Project management has a significant role here.

A typical building construction project is constituted by four stages: design and costing, lot preparation or preliminary works, construction and occupation. The first stage is composed of initial design, preliminary design, development and detailed design. Inside the preliminary design, it is possible to find the first feasibility studies for construction projects (Figure 12).

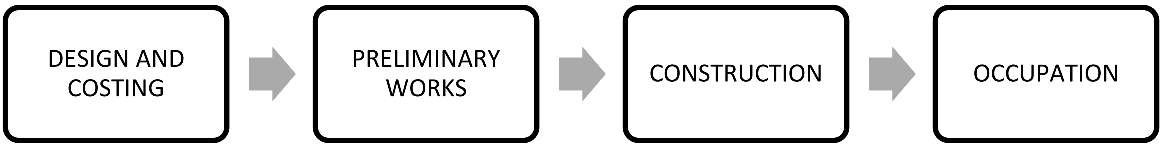

Figure 12. Building construction project stages.

Inside a public field, which is the goal of our study, the preliminary stages of the project design and concept are regulated by law. In France, the project management of a public building[58] (i.e. cultural centers, universities, social center, public pool, hospitals and others) it is determined by the Public Procurement Code from 2006[59] (*Code des marchés publics*) that defines that (République Française, 2006, Articles 1, 2, 74):

- *Marché public de fournitures*: are contracts with suppliers whose purpose is the purchase, lease ownership, rental or hire purchase of products or equipment;
- *Marché public de services*: are contracts concluded with service providers whose purpose is the provision of services;
- Marchés de maîtrise d'oeuvre: the main objective is to carry out one or more elements of a public building construction or an urban planning project.

In France, five stages compose the public building project management (i.e., for construction or renovation): project set up, project specification, design conception, construction works, project delivery, and occupation (CEREMA, 2014). Figure 13 presents these five stages and the activities related to each one.

As we can notice in Figure 13, the feasibility studies are a part of the project specification, and it is an essential study for the project program elaboration and approval.

[58] In French, this is denominated *Maîtrise d'Ouvrage Publique*.

[59] The Public Procurement Code from 2006 is actually passing through many modifications previewed by the Law n° 2015-899 of 23 July 2015.

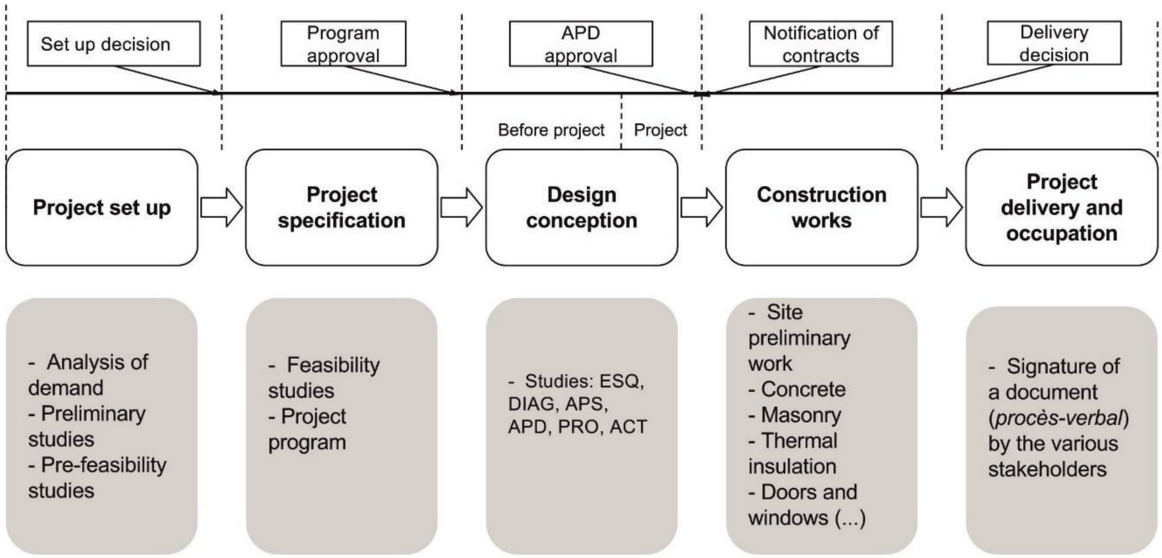

Figure 13. The five stage of a public building management construction. Source: Adapted from CEREMA (2014).

The feasibility studies help to ensure the project solution adequacy chosen with the identified constraints and objectives of the client. It is necessary to investigate the technical, urban, functional, environmental, economic, financial, legal, administrative, risk, social and temporal feasibility (*Ibid*., 2014; Corrie, 1991). The effectiveness of these studies might influence the success of a project and the clients' confidence when deciding where the project goals are feasible or not (Shen et al., 2010).

A project feasibility study that has as the main purpose to embrace the principles of SD should encompass *Ibid*., 2010):

- Economic performance attributes: for the assessment of the economic performance of construction projects. Those are used to reflect market availability, project financing and economic interest of implementing a building project. For example, market forecast, location advantage, technology advantage, demand, and supply analysis, budget estimate, and others;
- Social performance attributes: are used for evaluating the social performance of construction projects. For instance, it is possible to mention the influence on the local social development, provision capacity of public services, employment, and others;
- Environmental performance attributes: are necessary for assessing the environmental performance of construction projects. For example Waste assessment, noise assessment, air impacts, energy consumption performance and others;

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It was concluded, from a study performed by Shen et al. (2010)[60] encompassing 87 feasibility studies report that feasibility studies are usually giving more priority to economic attributes. TSocial and environmental performance receives less attention.

The importance of incorporating all the SD attributes in the project feasibility studies are not persuasively clear to project stakeholders. The active participation of the project stakeholders (i.e., clients, government, architects, engineering consultants, contractors, and suppliers) in the feasibility study might increase the incorporation of SD principles.

Sangree (2012) suggested some components for the elaboration of the market feasibility study and financial analysis for green buildings projects:

- Area, demographic and neighborhood assessment;
- Market analysis;
- Site review;
- Recommended development usage and pricing analysis;
- Financial analysis;
- Valuation analysis;
- Comparison of value created by projected costs.

5.2 Clarifying the sustainable buildings concept and ecological, economic and social aspects

As we already determined why it is crucial to change the trends of resources consumption and emissions for the construction sector, now we will be focusing on how we can do this. Before to start to present the drivers and barriers of sustainable buildings (SB) it is coherent to come up with definitions. There are several definitions of SB, and among many benefits, the environmental impacts reduction and human health promotion are highlighted by many authors.

For the U.S. EPA (2016) the term SB is used to describe structures and processes that are environment-friendly, resource-efficient, provide comfort and safety and protects human health, throughout a building's life-cycle. For this organization, sustainable construction, green buildings, sustainable buildings and high-performance buildings have the same definition "... *is the practice of creating*

60 Shen, L., Tam, V. W.Y., Tam, L. & Ji, Y. (2010). Project feasibility study: the key to successful implementation of sustainable and socially responsible construction management practice. Journal of Cleaner Production, 18 (3), 254-259.

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structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle from siting to design, construction, operation, maintenance, renovation, and deconstruction". For Kibert (2008, pg. 9), SBs are *"healthy facilities designed and built in a resource-efficient manner, using ecologically based principles."*

Johnston and Gibson affirmed that:

> *"Green building is ultimately about the relationship between a house and its occupants to the world around them. It is a process of design and construction that fosters the conservation of energy and other natural resources and promotes a healthy environment"* (Johnston and Gibson, 2008, pg. 6).

The World Architecture Community defined the green building as:

> *"A structure that is designed built, renovated, operated or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health, improving employee productivity, using energy, water, and other resources more efficiently, and reducing the overall impact on the environment*" (World Architecture Community, 2011).

Usually, the SB is a concept that incorporates several solution and best practice, as the use construction materials that have low environmental impact, renewable energy, waste recycling, high energy-efficient systems, water conservation, pollution prevention and waste reduction, high durability and decrease in the use of automobiles (USGBC, 2017; Wilson, 2006; Singh et al., 2010). A sustainable construction needs to coordinate all these systems in other to develop and manage a healthy built environment based on environmental, economic and social benefits promotion (Shen et al., 2010).

Furthermore, SBs aim to promote occupants physical and mental well-being by maintaining high levels of indoor air quality and comfort. User's comfort can be reached through the use of natural ventilation, integration of the natural environment with the building, low-toxicity finishes and furnishings, daylight and adjustable windows and fans that enable personal control over ambient conditions. User's comfort also can increase the productivity of work (Bittencourt et al., 2012; Yudelson, 2009; U.S. EPA, 2016; Heerwagen, 2000b; Warren and Peter, 2008; Singh et al., 2010; Robichaud and Anantatmula, 2010).

Other benefits can be mentioned, as (Yudelson, 2009; Heerwagen, 2000b; Kats et al., 2008; Singh et al., 2010):

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- Reduction of water and energy use and maintenance costs;
- Carbon footprint reduction;
- Natural resources consumption decrease;
- Waste reduction;
- Increase of the value from higher net operating income and in the public relations for commercial buildings;
- Productivity improvements for occupants;
- More competitive real estate holdings for private sector owners over the long run;
- Improvement in the health benefits, as less risk of occupants exposure to irritating or toxic chemicals in building materials, furniture, and furnishings;
- Reduction of infrastructure costs and transportation;
- Marketing benefits, and tax advantages and incentives.

The main principles of SB were determined by Abidin and Pasquire (2005):

- Ensuring a healthy, safe and productive built environment for people and a connection with nature;
- Considering the benefits and costs of society and the environment;
- Meeting the needs of the present without compromising the potential of future generations;
- Implementing technology for building energy efficiency and effectiveness improvement;
- Reducing environmental impacts.

Over the year, researchers developed several methods to evaluate the building performance as a manner to create standards to drive project developer and building's owners to implement SB. Several green buildings rating (GBR) systems emerged and presented their 'goal-pillars' that divers from each other.

Many examples can be mentioned, such as the Leadership in Energy and Environmental Design (LEED) from the US Green Building Council; the *Haute Qualité Environnementale* (HQE), from France; the Building Research Establishment Environmental Assessment Method (BREEAM); Green Star, from Australia; the Comprehensive Assessment System for Buildings Environmental Efficiency (CASBEE), from Japan; and the Building and Environmental Performance Assessment Criteria (BEPAC), from Canada. The Green Building Council strongly disseminated the term 'green building' (GB) (Robichaud and Anantatmula, 2010).

Figure 14 presents a green building comprehensive framework that encompasses some environmental, economic, and social aspects determined by some authors (U.S. EPA, 2016; Kibert, 2008; Wilson, 2006; Yudelson, 2009; Heerwagen, 2000a; Warren and Peter, 2008; Robichaud and Anantatmula, 2010; Bittencourt et al., 2012; Singh et al., 2010).

Even if the SB encompasses many environmental concerns, the energy consumption is usually a subject of SB's research due to the high-energy consumption and GHG emissions of the construction sector. Strategies to reduce energy consumption involves energy reduction by active and passive techniques, renewable resources implementation, and user’s behavior. These strategies are defined conforming to the building type, location and initial investment available, and have a focus on heating and cooling systems (GhaffarianHoseini et al., 2013). Many national and international policies drive the construction sector to build and retrofit buildings in the Zero Net Energy, Positive Energy, Low Energy and Passive House concepts that will be better discussed afterward.

Water is also an important resource that society depends on that must be conserved. Sustainable buildings need to stimulate water use in a self-sustainable manner by reducing, recycle and reuse strategies (Singh et al., 2010). The execution of green roofs improve thermal comfort but also can contribute to the rainwater management (Mentens et al., 2006). In many cases, green roofs are also used as a place for 'urban agriculture' production in a concept of self-sustainable cities. The indicate is to preview intensive green roofs in the design project for the building structure calculation.

The recycled and bio-sourced material can be integrated into sustainable materials in the construction project to reduce raw materials dependency and energy consumption. Sustainable materials can be defined as materials that are *"sustainable during their whole lifecycle"* and that *"are non-hazardous for human health"* (Elisa, 2011, pg.885).

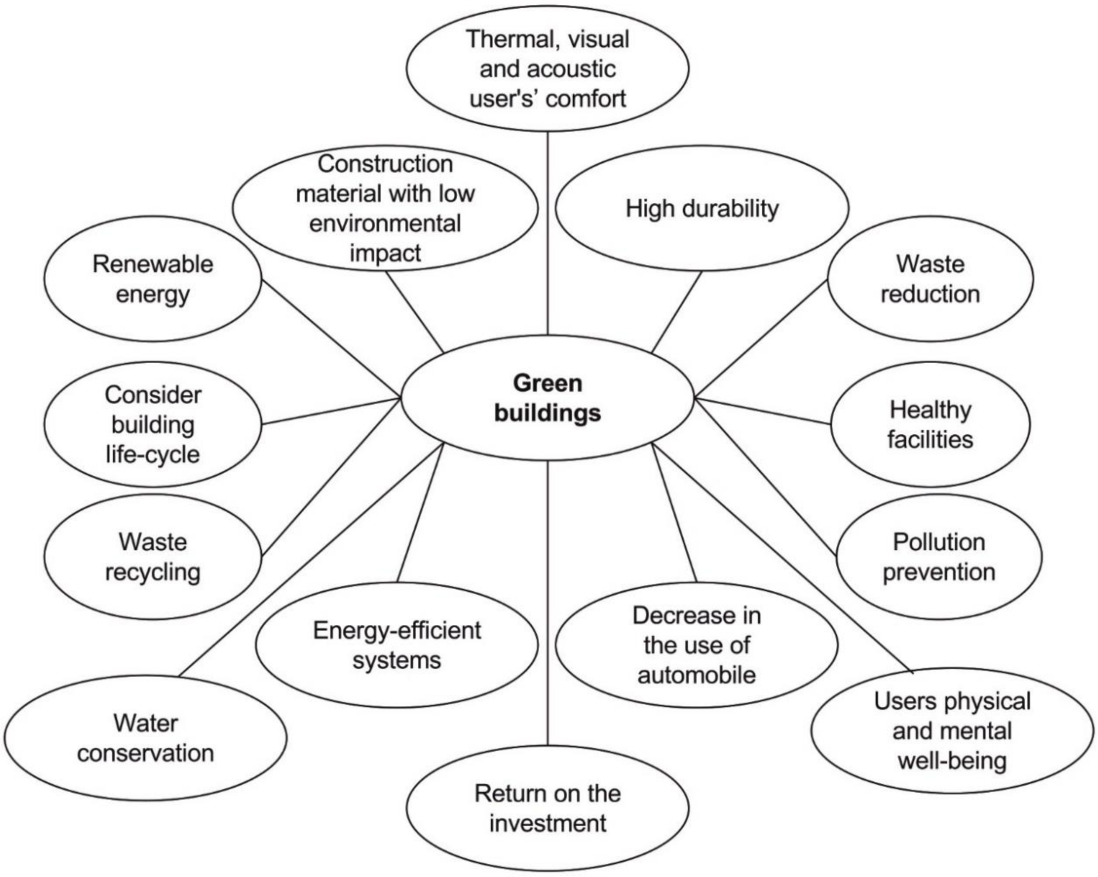

Figure 14. Green building comprehensive framework. Source: U.S. EPA (2016), Kibert (2008), Wilson (2006), Yudelson (2009), Heerwagen (2000a), Warren and Peter (2008), Robichaud and Anantatmula, (2010), Bittencourt et al. (2012), Singh et al. (2010).

An assessment of green building's materials selection is composed of mechanical properties, thermal and acoustic performance, durability, safety, costs analysis between others parameters. The reduction of mistakes on the construction site through a quality control is also an efficient way to reduce waste and resource consumption.

GHG emissions is also an important issue of building life cycle that can be related to the energy consumption with lighting, heating and cooling systems. However, also with the life cycle of each material and product used to construct or renovate the building. Furthermore, the relationship

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between building and the city might be taken into account since transportation has a significant impact on the GHG emissions.

As much as in the occupancy stage, the construction site is also a stage of the building construction where many environmental impacts can be avoided. It is also a moment for implementation of sustainable strategies, like energy, water use, and pollution reduction. A sustainable management system should be implemented to study the risks of biodiversity damages, water pollution, and soil contamination, to ensure that not just the building will be sustainable but also the whole construction process.

The sustainable management system should predict an effective waste management system to decrease the construction and demolition disposal. Common waste management practices can be determined in the design, in the planning, and the construction phase. For instance, the design project optimization, prefabricated technologies use, workers training programs, waste separation in appropriate containers, site cleanness and order (Gangoles et al., 2014; Jaillon et al., 2009).

Construction companies use their GSR strategies to provide social sustainability to all stakeholders. Inside the building context, it is essential to ensure a healthy and a safe environment to all construction staff, operators and users (Wong et Fan, 2013).

During the operational phase, a thermal, visual, and acoustic comfort added to a high interior environment air quality can guarantee a salubrious environment. Building accessibility to people with disabilities is a social aspect that needs to be considered. Inside the construction site, health and well-being of workers are an important social aspect related to the satisfaction of work the conditions that cannot be neglected.

Social sustainability in construction should overpass the physical limits of the building to reach the local community (Bernardi, 2013). In this sense, the building should contribute to the security and health promotion of the community (Zuo et al., 2012). The participation of the all the stakeholders (i.e., including users and local community) in the planning and design phases of the construction projects is also an important social aspect approached by Valdes-Vasquez and Klotz (2013).

Social sustainability also can be perceived in the contractor's selection process, as product and service suppliers (Sarkis et al., 2012). Furthermore, the contract of construction site workers should give priority to engage the local community and to stimulate the local economy. Egality in the recruitment of employees and the team developer is an important issue for social justice promoting.

Bernardi approaches the conservation of the local heritage and culture. The author affirmed that the SB principles in the literature are limited to safety and healthy environment creation. He stated that an SB "*should increase social equity, cultural and heritage issues, traditions, human health, and social infrastructure, as well as safe and healthy environments*" (Bernardi 2013, pg.76).

Education is an important social aspect that should be taken into account in the building's life-cycle. Inside the construction site, the sustainable site management implementation and new technologies might find necessary a training of the workforce. For the building's user's perspective, training and a monitoring and reporting actions are mandatory.

It is recommended to provide training, local environmental issues awareness, and an understanding of national and local regulations (Ruano and Cruzado, 2011). A critical task for the sustainable construction is to educate users behavior for contribution to energy and water reduction (GhaffarianHoseini et al., 2013).

The economic context can be perceived in the project design, construction site, during the occupational building phase and through the value creation for the local community and sector. The GB project design conception can integrate spaces adaptability and flexibility for the building area reduction and, consequently, costs reduction (Parr and Zaretsky, 2010). Besides that, the project design conception is crucial to ensure accessibility for the building maintenance.

Energy reduction can be reached in the occupational phase through behavior changes and retrofitting initiatives. Between the several benefits of retrofitting initiatives, we can highlight the energy reduction and cost savings. Retrofit investment at the end of the payback period can be defined as a potential value added to the property (Popescu et al., 2012).

Inside the construction site, the productivity is related to the costs reduction. Construction management strategies implementation ensures certain quality inside the construction site, a proper flux of materials and products, and a waste and time reduction. Thus, the reduction of costs inside the construction site can be related to the time optimization and waste reduction. Figure 15 presents a broader GB concept with the three environmental, social and economic aspects.

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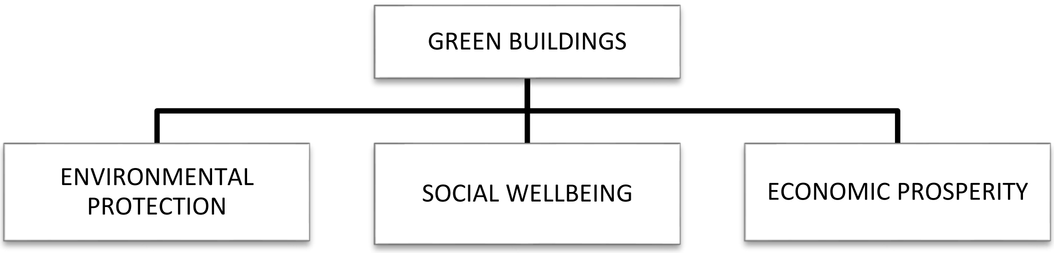

Figure 15. The diagram of the three aspects of GB. Source: Abidin (2005).

5.3 Increasing energy performance in the buildings by active and passive techniques

As indicated previously, the contruction sector is the biggest energy consuming sector worldwide. Ordinarily, more than 80% of the total energy consumption occurs during the operation and use phase of the buildings’ lifevcycle, and around 20% during the construction phase (Singh et al., 2009). Thus, it is evident the need to apply the efficient energy strategies in the new buildings design concept, but also in the retrofit of the old building.

As stated by the *Grenelle Environment,* old buildings need to meet the Thermal Regulation goals to reduce their high-energy consumption and GHG emissions. The Energetic Transition Law of the 17 August 2015[61] determines this principle:

> *"France has set itself the target of renovating 500,000 homes a year, starting from 2017, of which at least half is occupied by low-income households, with the goal to reduce 15% of energy precariousness[62] by 2020"* (République Française, 2015, Article 3, Personal translation).

According to the IAU (2009), in the Île-de-France region, 72% of the existing buildings were built before 1975 (i.e., date of the first Thermal Regulation in France). The primary energy use of the buildings that were constructed in France before 1975 is about 457 kWh/m2 per year. This consumption is significant when compared with the buildings’ consumption built between 2000 and 2007, that correspond to 158 kWh/m2 per year. The old buildings’ renovation can reduce energy consumption and the GHG emissions while improving energy efficiency. Other effects can be perceived in the indoor air quality and the user’s health quality and work productivity (Jensen and Maslesa, 2015).

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[61] In French: Loi de transition énergétique pour la croissance verte.

[62] According to the Grenelle II, energy precariousness is a situation where "is experiencing difficulties in obtaining the supply of energy necessary to meet his basic needs due to the inadequacy of its resources or its habitat condition" (République Française, 2010a).

Energy efficient measures can be grouped into three categories: building envelopes, internal conditions, and building services. Building envelopes are composed of thermal insulation, thermal mass, windows/glazing, and reflective/green roofs. Internal conditions are all the indoor design conditions and internal heat loads. Finally, building services systems encompass HVAC, vertical transportation, as lifts and escalators, and electrical services (Li et al., 2013).

The renovation process of a building is composed by monitoring, diagnosing and retrofitting stages. In the follow-up stage, the data collection assists in the building energy performance assessment (e.g.; physical, utilization, meteorological and geographical information). In the diagnosing stage, a diagnostic of the building energy performance is made through asset rating or operational rating.

Energy audit has a major role here to identify the real opportunities to save energy. The retrofitting phase aims to improve the building's energy performance and at the same time, maintain satisfactory service levels and adequate indoor thermal comfort. The main goal is the achievement of the zero energy buildings - ZEBs or net zero energy buildings - Net ZEBs[63] (Hong et al., 2015; Brás et al., 2015).

Renovating process of educational institutions was much explored in the literature since energy efficiency is connected to comfort, air quality, and costs. Many studies presented retrofit possibilities for educational building. Brás et al. (2015) worked in an integrated approach for school bindings rehabilitation in a Portuguese city. They found that implementing rehabilitation measures; it is possible to reduce 40% of cost-effectively annual energy.

Santamouris et al. (1994) launched an energy audit in 238 school buildings in Hella, Greece. They discovered that the annual average total energy consumption for these buildings is 93 kWh/m2 and the heating system consumes about 72%. The energy audit showed a potential of 20% of the reduction in the global energy use.

Still, in Greece, Dimoudi and Kostarela (2009) assessed the energy performance of school buildings in the C climate zone in Greece (i.e., lowest air temperature during winter period) to analyze the energy conservation potential. The authors concluded that combined various energy saved measures could result in energy savings of approximately 29%. Desideri and Proietti (2002) presented an energy assessment of the school buildings in a province in central Italy. They concluded that thermal energy savings could reach 38% and electric energy consumptions could be reduced by over 46%. Alajmi (2012) performed an energy audit of an educational building located in a hot summer climate. He

[63] There is an essential difference between ZEB and Net ZEB. ZEB is used to characterizes an autonomous building, while Net ZEB refers to buildings that are connected to the grid, there is a balance between energy taken and supplied back to the energy grids over a year (Sartori et al., 2012).

found that the change of habits of users can save 6.5% of the building's annual energy consumption while retrofit techniques can save 49.3%.

The retrofitting stage consists in the implementation of the energy saving techniques, as the passive and active design skills (Hong et al., 2015). We can take for example a house heated by a heat pump. If it is desired to improve the house energy performance, we can use passive techniques, or in other words, improve the energy efficiency by improving insulation and its thermal capacitance. We can utilize active techniques through the study and implementation of a new technology (e.g., Boiler).

Thus, passive design techniques are techniques that consider climate conditions of the site and can be divided in building envelope and internal conditions; or thermal insulation, thermal mass, windows/glazing/shading/day lighting and reflective/green roof (*Ibid.*, 2015).

a) Thermal insulation

It depends on the insulation material, the thickness of the insulation material, and the air gaps in building's walls (*Ibid*, 2015). Many cold countries, as Germany and Switzerland, are investing in the buildings retrofitting by improving the buildings thermal insulation as a solution to reduce energy consumption.

b) Thermal mass or thermal capacity

Thermal mass is a feature of a building's mass that make possible to store thermal energy, providing inertia in opposition to temperature fluctuations (Weir and Muneer, 1998). High thermal capacity is an important characteristic of the vernacular architecture[64], where the climate conditions, localization, and culture are important determinant factors.

In this context, architecture solutions can be adapted to the cold climates, dry warm climates, warm wet climates, windy climates and complex climates to enhance inhabitants thermal comfort.

Similarly, a vernacular architecture developed for hot dry climate needs to take advantage of the temperature variation during the day-night cycle delaying the heat entry so that it reaches the interior building environment at night. Materials with high thermal inertia are used, as adobe bricks and tick

[64] It can be defined as an 'architecture of the place' since it uses local materials and it is adapted to the climate conditions. For Rodriguez (2015, pg.15) *"This vernacular architecture is an optimization over the long term of strong constraints such as available resources and climatic and geographic characteristics (....). In other words, it is a simple and pragmatic architectural answer to the equation of place, available materials and climate."*

stones (Coch, 1998). Figure 16 and Figure 17 present some examples of vernacular buildings in African countries.

Figure 16. Vernacular architecture made in adobe in Mali, Bandiagara Dogon city. Source: African Vernacular Architecture Data Base (2017).

Figure 17. South Africa vernacular home. Source: African Vernacular Architecture Data Base (2017).

c) Windows/glazing/shading/day lighting

It is essential to consider the acoustic, thermal and visual performance of the windows/glazing systems in the building conceptual design stage.

The use of glazing façades by architects has increased over the years, and it can contribute positively or negatively to the daylight quality. This depends on the location of the windows, glass area, type and characteristics of glazing, building activities and climate orientation. Inadequate building design and

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glass type can conduct to poor daylight interior spaces. 'Super windows' with low-emissivity[65] (e.g., double and triple glazing) might be a correct solution to provide daylighting without interfering with the user's comfort (Hong et al., 2015; Aboulnaga, 2006; Wilson et al., 2002).

d) Reflective/green roof

The reflective and green roof can be applied to avoid building energy excessive. Reflective roofing materials or 'cool roof systems' reflect solar radiation better than conventional roofing (Hong et al., 2015; Golden et al., 2007).

Jo et al., (2010) analyzed the reflective roofs benefits through a literature review. The main advantages found were air conditioning energy savings, environmental and financial benefits. The authors affirmed that reflective roofs implementations could decrease energy 5% of electricity demand yearly with a payback period of 8 or 9 years. As much as reflective roofs, green buildings have a significant impact in the building energy performance improvement.

Crookes et al. (2010) performed an assessment to quantify the performance of a LEED certified university building at the University of Western Ontario, in Canada. The study concluded that green roofs assist in decreasing daily temperature fluctuation, contributing to the reduction of the urban heat island.

Also, green roofs contribute to the precipitation storage and the attenuation of the storm water runoff. Many studies can be mentioned. Santamouris et al. (2007) assessed energy and environmental performance of a green roof system installed in a nursery school building in Athens, Greece. They concluded that a green roof could reduce the electricity consumption used in the summer for air-conditioning by 6–19% for the entire building, and by 12–87% for the top floor alone.

Lin et al., (2013), explored the impact of climatic conditions on the thermal efficiency of an extensive green roof. They concluded that during the day, green roofs could reduce the increase of outdoor temperature around 42% and the augmentation of the indoor temperature by 8%. During the night, it can contribute to keeping 7% of the temperature in the outdoor environment. Figure 18 presents the Green roof at the Nanyang Technical University in Singapore. Green roof inside universities is necessary for the living lab context inside a sustainable campus.

[65] It refers to a surface aspect that emits low levels of radiant thermal energy.

Figure 18. Green roof at the Nanyang Technical University in Singapore. Source: Inhabitat (2015).

Passive techniques are implemented to modify the building energy need for heating, cooling, domestic hot water, ventilation, lighting, and appliances. The active techniques will influence the technical building systems. On the other hand, active design techniques toward a net zero energy building will be working in the search a more efficient HVAC system and artificial lighting (e.g., energy saving lamp, occupancy sensors in interior spaces) and in the occupancy control (Hong et al., 2015).

The occupancy control has as main goal the energy management to reach a smart system. Building energy managements systems (BEMS) can be installed inside the buildings to monitor the energy consumption of the equipment installed (e.g., electricity, HVAC system, lighting, security, shutters, counters). The technologies employment with low energy consumption is also active strategic techniques to reduce the energy consumption.

Consumers can be informed about the equipment energy consumption by the energy label, for instance: ENERGY STAR, in the USA, and the energy label for the CE countries, established by the European Directive 92/75/EEC of 22 September 1992 (EEC, 1992). Hong et al. (2015) emphasize that in occupancy control, even user's pattern, behavior and learning preferences studied.

Colmenar-Santos et al. (2013) affirmed that the active design techniques optimization could contribute to 30% of energy savings in the office buildings. Even with this numbers, when talking about the energy efficiency, it is also recommended the adoption of renewable energy systems in buildings, for instance: photovoltaic system (PV), building-integrated photovoltaic (BIPV), ground source heat pump systems (GSHP), wind turbines, solar thermal and heat pump. PV is the most implemented renewable energy technologies in buildings. PV panels are typically installed on the roof and sometimes in the façades of the building's envelope, composing a BIPV system. The electricity produced is used to power the building demand and the grid-connected PV/ BIPV systems. The excess will then be fed directly to the local power grid (Li et al., 2013).

Figure 19 represents a zero-net energy building sketch with passive and active techniques incorporated to try to reach a better energy global performance. If we focus just on techniques and we forget to add the human factor, it will not be possible to arrive at a zero-net energy goal.

Hence, we can affirm that energy efficiency[66] is the sum of effectiveness energy passive (i.e., reduction of energy needs) and active (i.e., management of technical equipment). However, to evaluate the global energy performance[67], it is essential to add the user's behavior (FIEEC, 2011).

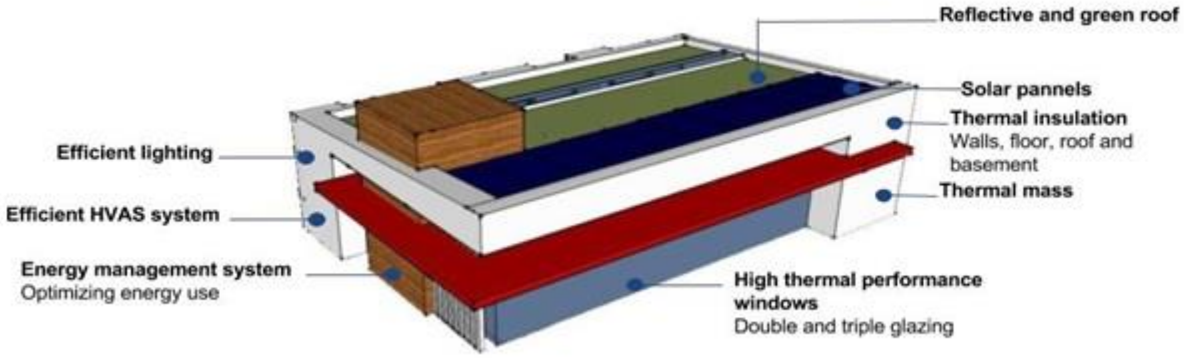

Figure 19. Zero energy building with passive and active techniques.

5.4 Main energy efficiency targets for 2020: the emergence of ZEB, BBC, Passive Houses and BEPOS concepts

Many energy efficiency policies appeared due to the increasing amount of energy consumption by the buildings and the cities. In 2012, the Energy Efficiency Directive established a set of measures to help the EU countries to reach its 20% energy efficiency target by 2020 (EC, 2012). On 30 November 2016,

[66] According to UNEP and EPA (1997) ad Wang (2012), energy efficiency is defined as *"using less energy without compromising the performance of the building".*

[67] Energy performance is defined *"as the quality o buildings toward energy consumption"* (GhaffarianHoseini et al., 2013, pg.6)

the Commission launched an update to the Energy Efficiency Directive, including a new 30% energy efficiency target for 2030 (EC, 2017).

A new challenge was established by the European Commission and Parliament in May 2010. They started to adopt the recast of the Directive on Energy Performance of Building. The new directive stated that all members states must ensure that:

> *"By 31 December 2020, all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings"* (Directive on Energy Performance of Building, 2010, Article 9).

According to the Article 2, a nearly zero energy buildings (ZEB) is defined as:

> *"a building that has a very high energy performance" and "the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". For Sartori et al. (2012, pg.220), ZEB "are energy efficient buildings able to generate electricity, or other energy carriers, from renewable sources to compensate for its energy demand" (Directive on Energy Performance of Building, 2010, Article 2).*

An answer to the energy consumption in the building sector. An answer to the climate change. ZEB cannot be understood as an option for a remote future. ZEB is perceived as a pragmatical solution for the reduction of energy use and CO2 emissions for the urban cities. However, there is a lack of ZEB common definition. Countries are developing new policies and goals without a clear conceptual definition of ZEB, sometimes implementing expensive PV oversized project without administering energy saving resolutions (Marszal et al., 2011; Satori et al., 2012).

Marszal et al. (2011) stated that some authors imagine the ZEB as a building that needs a total of zero energy from the conventional grid. Building electricity is supplied by renewable sources that can be on-site or off-site. Table 2 presents an overview of possible renewable supply options described by Torcellini and Crawley (2006). 'ZEB off-grid' or also called 'self-sufficient buildings' or 'autonomous,' are not connected to any utility grid (even the renewable energy sources). These buildings need to have a proper storage system for periods with peak loads.

The OECD and IEA launched in 2008 the report 'Energy efficiency requirements in building codes, energy efficiency policies for new buildings' to orient countries in term of energy efficiency requirements. Many prototypes of new ZEB and Net ZEB have been built to improve investigations about how to reach and how to keep stable the zero consumption.

Table 2. Overview of possible renewable supply options. Source: Torcellini and Crawley (2006).

OPTIONS	ZEB-SUPPLY OPTION-SIDE OPTIONS	EXAMPLES
ENERGY REDUCTION	1. Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, and others
ON-SITE SUPPLY OPTIONS	2. Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located in the building
	3. Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building
OFF-SITE SUPPLY OPTIONS	4. Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off-site, or waste streams from on-site processes that can be used on-site to generate electricity and heat
	5. Purchase off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered

Figure 20 exhibits Net ZEB that was built on the island of Namhae, in South Korea. The house has an efficient envelope and is powered by photovoltaic panels located on the rooftop and by the solar thermal system. The ultra-envelope minimizes energy loss and is made by reinforced concrete building wrapped in 20 cm of Styrofoam insulation, which is then sprayed with Polyurea, a resilient and waterproof material. Thermal comfort is appropriate to the climate conditions. No air-conditioning is necessary for the summer season. The orientation and window placement help in providing natural daylighting and ventilation (Meinhold, 2013).

Furthermore, beyond the building codes, apart from the ZEB, many other buildings types have as main goal energy efficiency improvement. Those are the: low energy buildings, passive houses, and the plus-energy buildings.

Figure 21 presents an overall framework of buildings types have as main common goal energy efficiency improvement.

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Figure 20. Net zero energy house in South Korea. Source: Meinhold (2013).

The denomination low energy buildings are used to indicate buildings that have better energy performance than conventional buildings or than the energy efficiency requirements in the local construction regulation (IEA and OECD, 2008). These buildings require less energy consumption than standard dwellings for heating in the winter and for cooling in the summer (MEDDE and ADEME, 2011).

In France, the label BBC Effinergie (*Bâtiment Basse Consommation* or BBC 2005)[68] has its roots in the *Grenelle Environnement through* the RT 2012 and Effinergie manages it. The RT 2012 requisites a maximum of primary energy of 50kWhep/m2 per year for new housing, to modulate according to climatic zone and altitude. For commercial buildings, the reference consumption must be calculated case by case, and the maximum of primary energy consumption must be 50% of the regular reference consumption.

The label BBC 2005 certifies that the buildings have a lower consumption than the buildings that are not certified and provide to building's owners tax and financial benefits. The label BBC 2009 or BBC renovation (*BBC Rénovation*) is focused on the renovation of the building. It aims to decrease the energy consumption to 80kWhep/m2 per year (MEDDE and ADEME, 2011; Effinergie, 2010).

The main differences between the BBC and the ZEB are related to the grid dependency. The ZEB do not require any energy from the regular grid. It demands a high initial investment since most of the ZEB implementations requires not just passive but also active techniques and a renewable energy source. Both ZEB and BBC need significant initial investments. Regarding the environmental benefits, a high-energy reduction and CO_2 emissions are obtained with the ZEB.

[68] Created by the Decree of 8 May 2007.

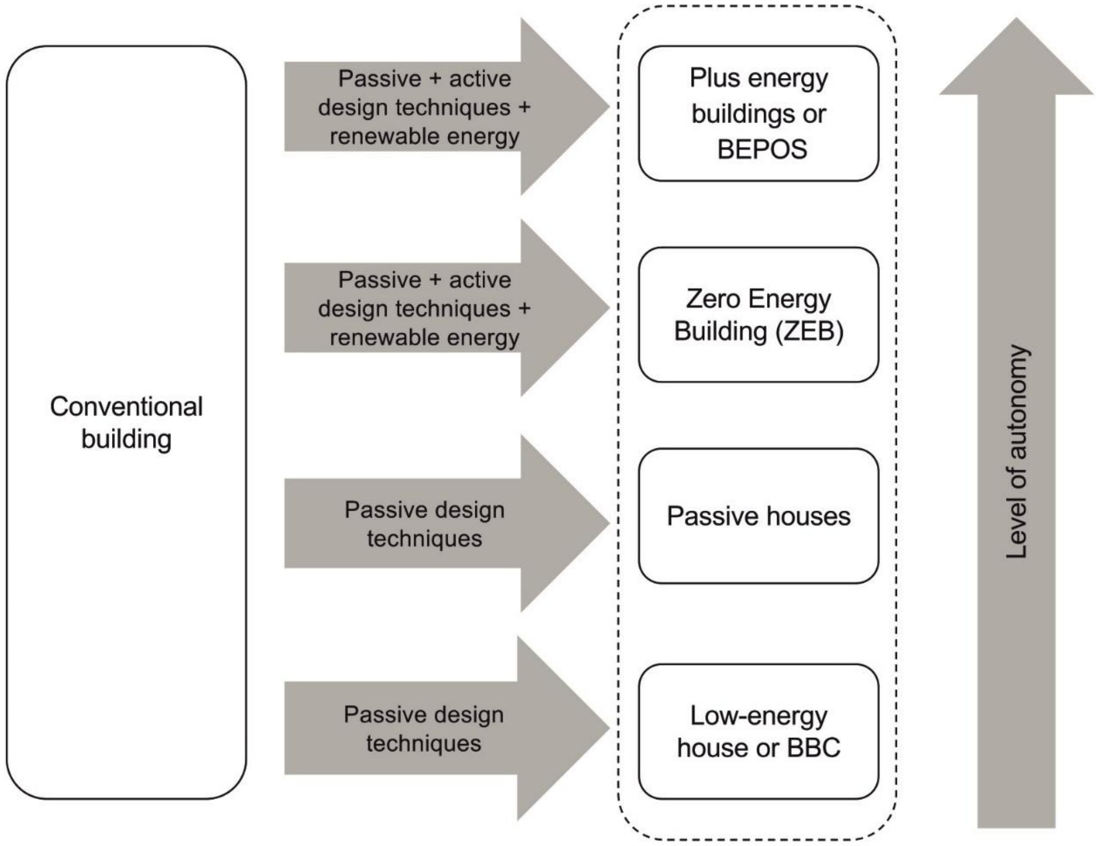

Figure 21. The overall framework of buildings types has as main common goal energy efficiency improvement

In the same perspective of the buildings energy efficient variety, it is possible to mention the passive houses, prevalent in European countries as Germany and Switzerland. One of the passive houses pioneers was the Swedish Professor Bo Adamson. He gave the name of 'passive houses' to the buildings that he developed in China, and that did not require heating. He met Professor Wolfgang Feist when he returned to Europe, and together they developed the concept and requirements of Passive House. After many calculations, combined with the knowledge of local conditions and with existing projects of energy efficient buildings in Europe, they created the Passive House's standard (Müller and Berker, 2013).

Figure 22 presents the five most important principles of the Passive Houses: (1) Thermal insulation, (2) Passive House windows, (3) Ventilation with heat recovery, (4) Air tightness and (5) Thermal-bridge-free design.

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(1) Thermal insulation: the buildings' exterior envelope need to be particularly insulated. The maximum of heat transfer coefficient (U-value) is 0.15 W (m^2K);

(2) Passive House windows: these types of windows are usually much isolated and filled with Low-E glazing filled with argon or krypton to prevent heat transfer. The maximum of U-value is 0.80 W/(m^2K) or less;

(3) Ventilation recovery: this feature is the key to reaching an efficient air quality control system. Inside Passive Houses, at least 75% of the heat from the exhaust air is transmitted to the fresh air again by a heat exchanger;

(4) Air tightness of the building: uncontrolled escape through gaps must be less than 0.6 of the total house volume per hour during a pressure test at 50 Pascal;

(5) The absence of thermal bridges: all edges, corners, connections, and penetrations must be planned and corrected with a comprehensive care so that thermal bridges can be prevented. Thermal bridges which cannot be avoided must be attenuated as much as possible (Passive House Institute, 2017);

According to the Passive House standard, there are two main prerequisites to receive the label 'passive house'. The building annual energy for heating demand should not go beyond 15 kW h/ (m y). Moreover, the building annual primary energy consumption should not exceed 60 kW h/ 2 (m y) (*Ibid*, 2017).

To better explain this standardized concept, we will use as an example the Rotlintstraße building refurbishment case, in Frankfurt, Germany. Seven dwellings and 61 apartments, with a total of 3800 m², were renovated in an operation that started in 2008 and was finished in 2011.The thermal insulation was improved in the whole buildings and especially in the basement ceiling and exterior walls. Passive House windows, mechanical ventilation with heat recovery in each flat, and thermal solar system for domestic hot water were installed (Großklos, 2014).

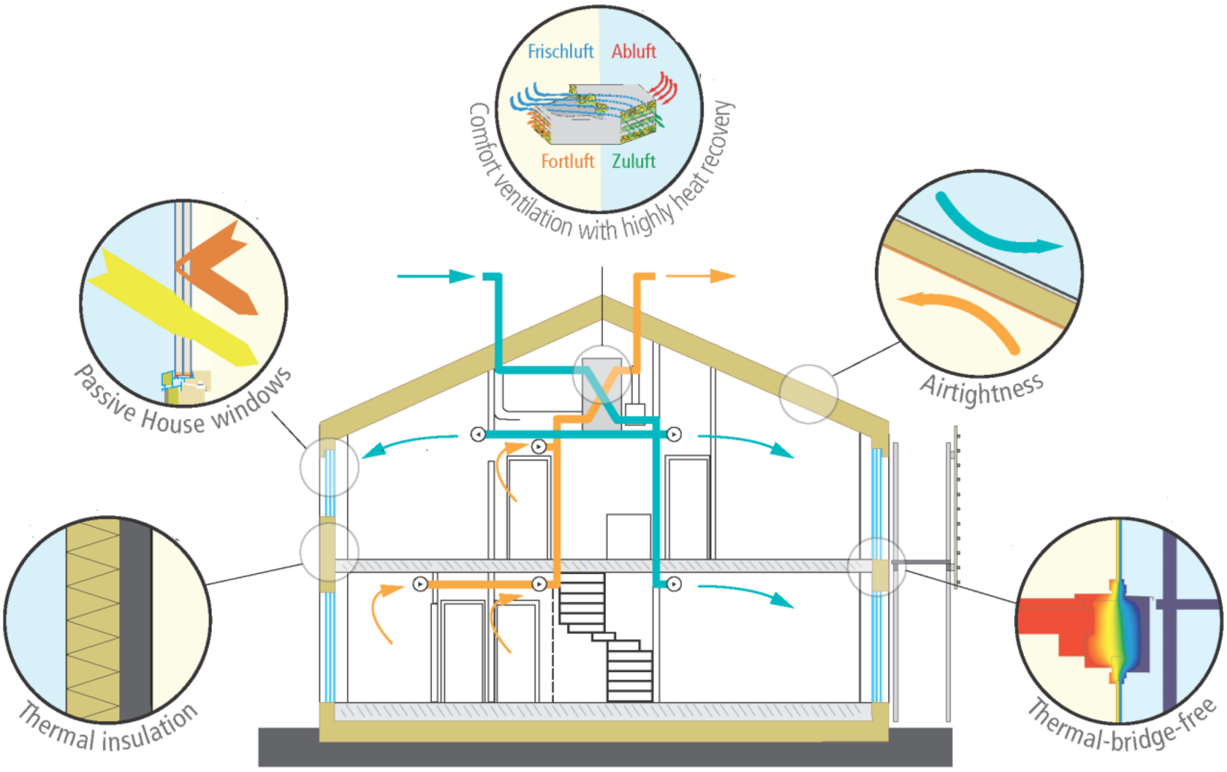

Figure 22. The five basic principles of the Passive House Standard. Source: Passive House Institute (2017).

Figure 23 presents the implementation of the Passive House windows in the façades and the sealing for airtightness on the existing outer plaster. Figure 24 shows the thermal analysis performed to ensure that all the thermal bridges were eliminated. The image on the left showed building façade with still some hollow spaces that were not insulated and on the right-side the façade with quality assurance. All these strategic measures decreased 70% of the final energy consumption and 72% of the CO2 emissions.

The Passive House Institute defines passive House as *"a building standard that is truly energy efficient, comfortable and affordable at the same time"*. The main benefits are (Passivhaus Institut, 2017):

- 75 - 90% of energy savings from cooling and heating system;
- Efficient sun use, internal heat sources and heat recovery rendering the traditional heating systems useless throughout even the coldest of winters;
- Adapted also for warm climates as make use of passive cooling techniques such as strategic shading to maintain comfortably cool;

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- High comfort level;
- High efficient heat recovery allows air re-used;
- Energy costs reduction.

Figure 23. Passive House windows in the façades. Source: Großklos (2014).

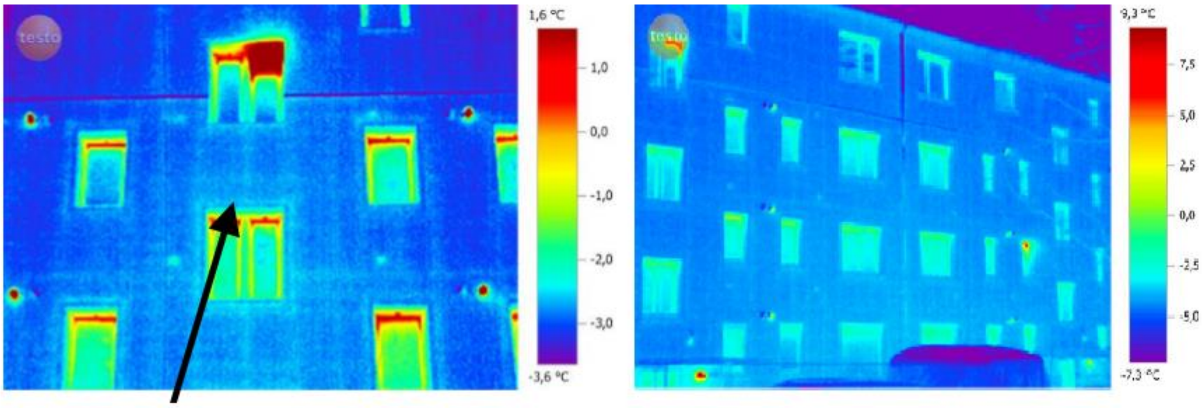

Figure 24. Quality assurance of the façade. Source: Großklos (2014).

Many factors collaborate with the Passive House concept success and dissemination: a strong belief in the scientific basis of the five principles mentioned, the certification adhesion, demonstration through prototype examples as for instance the first Passive House building in Darmstadt (Germany), built in 1991, extensive training activities and a strong marketing of the concept, standard, definition and technologies (Müller and Berker, 2013).

Some authors, Mlakar and Strancar, 2011; Rohdin et al., 2014, determined an overheating of passive houses during the hot summer months in Slovenia and Sweden, respectively. However, with the simple strategies implementation as shading during the day and ventilation through opened windows at night. It is possible to avoid overheating and keep high thermal comfort (Mlakar and Strancar, 2011).

Audenaert et al. (2008) held an economic analysis of passive houses and low-energy houses or BBC, compared with standard houses. They found that initial costs of a BBC house and passive houses are 4% and 16%, respectively, higher in comparison with the standard house. Isolation and ventilation are the main elements of this surplus cost.

Even with the long-term benefits of energy consumption decrease of a Passive House, they concluded that a BBC is the safest choice for a minimum impact on the family budget. Passive Houses has an adverse impact on the budget in the first 20 years. After 20 years, the budget impact of the passive houses is positive, even with 15% of an annual rise in the energy costs. They concluded that the expenses impact of the Passive Houses depends on the increase of energy costs and because of this in many situations, a BBC house is more recommended.

In France, passive houses are denominated *Bâtiment à Energie Passive* (BEPAS). The BEPAS standard determines a maximum of 15 kWh/m². year of energy for the heating system, and a maximum of the total energy consummation of 120 kWh/m². year. Every item required for a BBC certification is needed for a BEPAS certification with extra exigency level.

Concerning energy efficiency, it is possible to affirm that a BBC building has less exigency than a BEPAS and that the main goal of a BEPAS is to become ZEB or BEPOS - *Bâtiment à Energie Positive* (La Maison Passive, 2017). The Plus Energy Buildings or BEPOS "are buildings that deliver more energy to the supply systems than they use. Over a year, these buildings produce more energy than they consume" (IEA and OECD, 2008, pg.72).

In France, the *Plan Bâtiment Durable,* launched in 2009 works with six national strategies (MEEM and MLH, 2017):

- 40% of the GHG emissions reduction;
- Increase in the renewable energies proportion to one-third of the power generation;
- Reduce to a half the energy consumption by 2050;
- To construct new buildings to high energy and environmental performance;
- Massif energy renovation;
- Moreover, better control of the consumption-related behaviors and specific use of the electricity (MEEM and MLH, 2017).

The increase in the building's energy efficiency by the *Plan Bâtiment Durable* is proposed in three stages:

- Implementation of the BBC certification according to the RT 2012;
- Increase of the BEPAS buildings construction inside the perspective of the RT2020 that is still in the process of construction;
- Construction of the BEPOS buildings according to the RT 2020 (Ibid., 2017).

The Green Office®, in Meudon, France, built by Bouygues Immobilier has a surface area of 23,300 m2 and it is the first significant positive energy tertiary building in France. It is equipped with a boiler with biomass cogeneration and 4000 m2 of photovoltaic panels. The building received many certifications as the BBC, BREAM, and an HQE certification with a 'very much' label in the nine categories. The building's consummation is 62 kWh/m2/year, and the production is 64 kWh/m2/year (Bouygues immobilier, 2017).

The French Institute of Low Energy Buildings (In French: *L'Observatoire de Bâtiment Basse Consommation*), coordinated by ADEME and Effinergie, presented a benchmark of low energy building. According to this institute, there were 441 positive energy buildings in France implemented from 2013 to 2016 (Observatoire BBC, 2017).

5.5 Existing barriers and drivers for implementing the sustainability in the construction sector

It is possible to mention many challenges and drives for applying the sustainability in the construction sector. Understand the obstacles is an important way to promote the sustainable market.

For GB adoption, the main drivers identified are the environmental, the economic, and health and community benefits. Environmental benefits include enhancing the air and water quality while reducing energy and water consumption and waste disposal. Economic benefits are related to the reduction in the maintenance, energy and water costs, and increase of building value. Health and community benefits are reached through the growth in the occupant comfort and health (Al-Yami and Price, 2006).

The high costs in adopting and investing in the GB represent the main barrier. Roughly, green buildings can cost [69] 1% - 4% more to build than a conventional one, but the green one can provide a wide range of financial (i.e., once installed, GB can help the users to save 8-9% in operating costs), health and social benefits. Normally, these costs are higher when green design is incorporated in the middle of the project, when there is a lack of time to research materials and technologies options, and no experience with green buildings between the construction workers or the team design plan (Kats et al., 2008; Cassidy et al., 2003; Chan et al., 2009).

The high initial costs of the GB implementation and the energy efficiency improvement can be reduced. Government incentive is recognized to have a significant impact on the both markets evolution (Ofori, 2006; Sutherland, 1991; Varone and Aebischer, 2001). Moreover, the government fiscal incentives, about GB implementation and GB products purchase, when they exist, are not enough, impacting directly in the attractiveness of GB (Chan et al., 2009).

As we can notice by many authors observations, the role of the government in promoting sustainable construction and building energy efficiency is essential, and in some cases, efficient (Varone and Aebischer, 2001; Chan et al., 2009; Gan et al., 2015; Atsusaka and LeVan, 2003; Qian and Chan, 2010). The government strategies can contrast for each country due to the concerns and policy instruments for the building industry (Chan et al., 2009). According to Gan et al. (2015), it is the role of the government to provide support; to develop codes, standards, legislation, regulation; and in contributing to subsidies funding, and others monetary incentive instruments. Eyre (1997) brought attention to the importance to combine economic and regulatory instruments.

In many cases, even with the lack of government support, construction companies adhere to labeling programs as LEED, Energy Star and HQE (Chan et al., 2009). Building rating system is important drivers because of the information and guidance on GB subject provided to construction stakeholders, but also due to the increase of the image and market competitiveness that they provide.

The government tax incentives to drive energy efficiency in the renovation of the building encouraged the rise in the implementation of ZEBs, Passive House and Energy Plus in France. Among then it is possible to mention the CITE - *crédit d'impôt pour la transition énergétique*[70], the '*L'éco-prêt à taux*

[69] We are mentioning here the costs of a green building and not a BEPOS, BEPAS, BBC, or ZEB. For these variety of energy efficient building, the initial costs can be higher.

[70] The '*crédit d'impôt pour la transition énergétique*' - CITE, allows the homeowners and tenants, to deduct from the income tax 30% of the expenses incurred, for certain improvement of the energy performance renovation works (ADEME et al., 2015).

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zéro'[71], value-added tax (VAT) reduction, and the *'Habiter Mieux'* program, that gives an assistance and coaching to renovate buildings (ADEME et al. 2015). These financial supports are dedicated to the insulation refurbishment and technologies implementation, notably the renewable energies. Many countries experienced difficulties in the renewables employment due to the lack of public awareness, technology, proper and required equipment; and poor planning approach (Quaemi and Heravi, 2012).

Gan et al. (2015) identified the critical factors that impede owners to adopt sustainable construction strategies, as the economic feasibility, awareness, regulation and legislation framework, involvement of project stakeholders, risk of determined technology or material, and project management model. Issa et al. (2010) concluded that practitioners are uncertain about green buildings because they consume more time to design and construct than a conventional building. Häkkinen and Belloni (2011) added as obstacles the lack of previous experience and the lack of manufacturer and supplier support and information.

Furthermore, from the practitioners' point of view, the requirements and the standards can be challenging and playback cannot be guaranteed or might be particularly long. On the other hand, the high initial costs of GB measures as an investment that adds value to the building over the years. GB investments will benefit many stakeholders, for instance, the buyers and consumers, likewise the project developers, contractors, and architects. The GB market development might contribute to the new job opportunities and competitiveness (Issa et al., 2010; Prakash, 2002; Chan et al., 2009).

A change of attitude and behavior can be understood as a challenge but also a drive. GB implementation and dissemination will be not possible without a change of behavior of stakeholders. Consciousness should be the start point for this change of behavior (Plessis, 2007; Pitt atl., 2009). In many cases, the construction site workers demonstrate a reluctant behavior in integrating waste control and cleaning habits. In the same way, users inside the buildings have a reluctant attitude in turning on lights to use daylighting, or to reduce the heating or cooling systems in the midseason.

Cooperation between the project stakeholders can also be a challenge or a driver. A GB's project might be thought, discussed, developed with the various project actors participation. The project planner should consult and involve the future users and the client in the project design development. The lack of cooperation between project stakeholders is a crucial challenge to succeed with the GB implementation (Hwang and Ng, 2013).

[71] Is a zero-interest loan to finance a coherent package of energy performance improvement (*Ibid*., 2015).

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Concerning the developing countries, other obstacles for the GB implementation can be highlighted. As mentioned previously, with the accelerated urbanization process, developing countries need to put many efforts to provide the basic infrastructure for the population. In this sense, to produce adequate housing and infrastructure in a social and ecologically responsible way is a real challenge (Plessis, 2007). In general, these countries still face the sustainable construction as a 'nice-to-have' inclusion to standard practice, and due to this, they do not integrate the sustainable construction in the business practices and the decision-making process (CIB and UNEP, 2002).

Moreover, developing countries are more affected by the problems caused by climate change because of the lack of technologies, and investments in the fight against climate change (Stern, 2006). The absence of policies to encourage the employment of low carbon technologies and the economic instruments to improve the progress of implementing new technologies provoke some resistance to GB (Chen et al., 2015).

6 CONCLUSION

We concluded that the Industrial Revolution and the First and Second War had a major contribution to the development of theories and movements. All these theories and movements had positive and negative points that lead society to the elaboration of the sustainable development concept. The Stockholm Declaration and the Brundtland Report helped to the dissemination of the SD idea, but also the strategies regarding the population and human resources, food security, species and ecosystems, energy, industry and urban planning.

The Rio Declaration emphasized the connection between environmental protection and SD, and in the establishment of a common goal. The Agenda 21 published the main challenges that humanity was facing regarding social inequality and environmental degradation. The Agenda had a substantial impact in mobilizing nations and industrial sectors toward SD. Nowadays, the main challenges of the society are defined by the Sustainable Development Goals.

Inside the literature, it is possible to find many criticism and contradictions according to the Brundtland Report definition of SD. This search for a thorough understanding of the SD, boosted research to develop new concepts, models, and representations. This models and representation have as main goal the determination of aspects and principles of SD.

Inside the urban perspective, we can conclude that progressist and culturalist urbanism models were critical to the history of the urbanism and as a source of inspiration to many projects development.

Regarding sustainable city needs, we can finish concluding that both models brought a significant contribution toward an SD city.

Progressists aspects of the Charles Fourier, Robert Owen, and Le Corbusier had a major impact on the studies of the cities. We can mention here the ambitions for improving human living conditions, the engagement in the scientific studies to improve human well-being, and the emphasis in the collective housing. The culturalists aspects highlighted the importance for the cities to exchange with its immediate environment.

The works of the Camillo Site and the Ebenezer Howard deserves recognition. Camillo Sitte analyzed the whole city globally and gave priority equally to all the aspects (i.e., cultural have the same importance than material), searching for the identity and diversity in the spaces, creation of spaces to stimulate the meetings between people. Ebenezer Howard created the 'garden city', and contributed to an idea of auto-sufficient cities.

The world wars scenario gave place to an emergency plan for the cities reconstruction and development of the urban planning regulations, as the Cornudet Laws. In parallel, the Modern Movement emerged and published it functionalists' ideas in the Athens Charter. However, the urgency of the reconstruction, the glorious moment of the modern movement collapsed on the disaster of the post-war suburbs.

Brundtland Report and the Agenda 21, brought attention to the environmental (e.g., pollution, waste disposal, energy and water consumption, and others) and social problems (e.g., physical and social division, poverty and others) due to the fast growth in the cities post world war and an uncontrolled urban sprawl. The difference between this new need for a new urban concept and the utopian ideas of the 19th century is the temporal factor.

Global reports, like the IPCC that emphasize the climate change effects, and the United Nations world population prediction boosted the formulation of new solutions and action plans to achieve inter and intra-generational sustainability. The top priority is to adapt the 8.5 billion of the global population to the cities by 2030. Urban augmentation needs to pursue sustainable strategies to protect the local inhabitants, conserve natural resources and to promote social justice.

We concluded that sustainable cities concept appeared as a new vision of a prosperous, secure, and resilient city of tomorrow. Sustainable cities are an approach to foster social and economic development through an environmental management and urban governance.

However, we identified some sustainable urbanization challenges, such as the coordination between distinct actions in several scales; the economic and social differences between city, urban agglomerations and metropolitan areas; and the complexity of urban systems. Urban challenges are bigger in developing countries due to the lack of the adequate infrastructure and the weak financial capacities. The urban priorities discrepancy between the developed and the developing countries must be highlighted in global policies and agendas.

After our literature review, we can conclude that planning the urban environment inside the SD principles requires a new kind governance with a democratic participation and collective efforts of local government, municipality, inhabitants; and partnership between public and private sector. Together all these stakeholders should formulate actions plans and policies to put forward the transition toward a sustainable city.

In France, many laws and regulations emerged to act for sustainable urbanization, for example, the *Grenelle Environment* and the LRU. On the other hand, relevant urban planning regulations, such as SDRIF, SRADT, PADD, SCOT, PLU were reformulated to embrace the design and sustainable management of urbanization as a new way to organize the territory.

Buildings were determined as having substantial impacts on the cities and were also identified as an opportunity to promote SD locally. Green buildings and sustainable buildings can reduce the energy, water, and raw materials needs, and the GHG emissions, waste disposal, and environmental releases. At the same type can provide comfort, healthy, safe built environment for the occupants.

Green building is a concept that incorporates a broad spectrum of the solution and best practices, and it is feasible for all kind of climates and countries. Rating systems are LEED, HQE, BREEAM boosted society to build green. However, national and international policies target in the reduction of energy consumption through active, passive, and renewable energy adoption. Many concepts emerged over the years to reach the ideal of a zero energy concept, especially in existing buildings. For instance, the ZEB, BBC, Passive Houses and the Energy Positive Buildings; where energy consumption, comfort and pay-back period plays an important role.

The main drivers identified for the GB implementation are the environmental, economic, health and community benefits, the building rate systems, and the government financial support. The biggest challenges are related to the high initial costs, the project stakeholders' involvement, the awareness, the risk of determined technology or material, time, lack of manufacturer and supplier support and information. A change of attitude and behavior, and the cooperation between project stakeholders, can be understood as a challenge but also a drive. Extra barriers are identified for developing countries.

Chapter II. The case of the sustainable campus

1 INTRODUCTION

It is crucial to take a deep dive into the past to understand the mutations experienced by the universities regarding their architecture, governance, and relations with the cities. All this context will conduct us to understand the development of university public politics in France and how this contributed to the sustainable campus development.

In a first moment, we will present the Reconstruction period, after the Second World War, when universities agglomerations started to emerge outside the cities with a strong influence of the practicality of modern architecture. We will present the massif growth in the number of the university students in the 1960's, the democratization process of the university admission and the industrialization process of the universities buildings. Furthermore, we will explain about the second 'boom' period of the universities' structures and how it differs from the previous one through the modernization programs.

Once the historical context is explained, we will determinate the relation between the university campus and the city using three specific cases: (1) inside the old cities centers universities, (2) in the peripheral universities, (3) and inside the universities that are not located in urban peripheral, and neither in city centers. Thereon, the universities architectures (i.e., modernist, brutalist and contemporary) will be studied conforming to the period to understand which issues interfered in the present architecture.

We will introduce the role of the higher education system inside a sustainable perspective using a timeline of events and conferences related to this thematic. The green campus and the utopia of the sustainable campus will be presented. The social role of the universities will be discussed.

Finally, we will present in each way the universities participate promoting the sustainability on a local scale, and the critical role of the GSR, RSU and Agenda 21 for the society.

2 HISTORICAL MANIFESTATION OF FRENCH UNIVERSITY CAMPUSES

The French urban planning evolution, the architecture, and the universities' history path were influenced by relevant facts in the society. At the moment that the Second World War was finished a whole new world called for a reconstruction period.

In France, after the Second World War, the government aimed to repair the disastrous consequences in the urban and architectural scales. Brest, Caen, Calais, Dunkerque, Évreux, Le Havre, Lorient, Saint-Lô, Saint-Malo, Rouen, Royan, Saint-Nazaire, Maubeuge are an example of the cities that were almost entirely destroyed.

The Ministry of the Reconstruction and the Urban Planning[72] conducted the reconstruction works regulated by the Reconstruction and the Development Plans and financed by the Marshall Plan[73]and others sources. Urban development plans took advantage of the destruction to create new ways to facilitate circulation, new roads, new pedestrian lanes, new green spaces and new public and private buildings.

Some prominent public organizations have been set up after War. The Ministry of the Reconstruction and the Urban Planning[74] was formed in 1944 by the provisional government of the French Republic General Charles de Gaulle with the purpose of controlling and organization of the reconstruction activities.

All this upheaval gave birth to the new universities from the second half of the 20th century. By all the new urban development, universities were confronted to a new space scale. In a first moment, the reference model of the Anglo-Saxon's campus, developed in North America, took place in Europe that had a high expectancy to create renowned international universities (Compain-Gajac, 2014)[75].

The new University of Caen, destroyed in 1944, was the first French university built in the form of an Anglo-Saxon campus designed in a large green area. The goal was to separate the buildings from one to another to make the buildings largely ventilated and opened to sunlight (Gourbin, 2011).

During the first thirty years after the Second World War, the universities progressively developed and grown in the area, fostering agglomerations outside the cities-centers. These new “campuses” were installed in large spaces, giving to the architects and urban planners freedom to had new ideas and experiences (Compain-Gajac, 2014). Nonetheless, time was critical for the reconstruction period. On the one hand, architects and urban planners had the occasion to develop innovative projects, on the

[72] French: Ministère de la Reconstruction et de l'Urbanisme.

[73] The Marshall Plan (officially the European Recovery Program, ERP) was an American initiative to aid Western Europe, in which the United States gave over $12 billion in economic support to help rebuild Western European economies after the end of World War II.

[74] French: *Ministère de la Reconstruction et de l'Urbanisme*.

[75] However, in French, the implementation of this model was a disastrous with a visible lack of life students concerns.

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contrary deadlines were short reflecting the anxious society that is expecting to witness better-reconstructed cities.

The architecture of the universities after War was influenced by the Modern architecture that emerged and became dominant at this period. It was based on the new construction, the use of glass, steel and reinforced concrete (Tietz, 1999). The modern manifest intended to turn constructions in more performing structures, effective to build, less expensive to build and faster to set up, as this architecture style do not have many decorations (Monnier, 1996). This was what this reconstruction moment needed.

2.1 The first 'boom' period of the universities construction: the utopia of the university city

There was an increase in the number of students, training and research contents inside the French universities in the 1950s. At the beginning of the 1900s, the student's estimations were 30 000, and before the Second World War, 80 000. In the 1950s there were approximately 130 000 students in France. From the 1960s and 1970s, the number of students went from 240 700 to 694 800 (Charle and Verger, 2012, p.145).

Between the 1960s and 1970s, the massive arrival of a university-age generation associated with the higher education democratization[76] contributed to the emergence of a quantitative policy for the university construction (Delanes, 1999).

This period is also denominated as the first 'boom' period of universities construction in France. Many universities buildings were constructed and student's life undergone by transformations. New Universities campus were installed outside the cities. The lack of the teaching and research facilities was so significant that there was no physical space inside the towns to accommodate all the square meters needed. Furthermore, the land's price outside city centers was lower when comparing to the city centers. Other factors directly influenced the architecture and the urban planning of this type of campus, as:

- Democratization of the University;
- Increase in the number of students - consequence of the demographic evolution of the after-war and the rise in the educational rate;

[76] This democratization is translated through the social opening for less-favored groups and inequality reduction. In 1975, women reached half of university students (Charles and Verger, 2012).

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- New propositions of education and training programs;
- The increase in the research program importance inside universities.

All these elements obliged the society to brainstorm about the role of the University, and, consequently, about the universities buildings resulting in construction, renovation and modernizing process (Compain-Gajac, 2014).

The displacement of the university's campus to outside the main city centers[77] had some consequences. City centers witnessed the dissipation of a significant part of the population, compromising some activities and services. On the contrary, the new universities venues, implemented in low-infrastructure zones that were not prepared to welcome an academic campus, without cultural, commercial and entertainment activities, and with the lack of material and logistic in the transport system (*Ibid*., 2014).

The main explanation for this situation was the politic and administrative centralization in France, reflexes of the 'République Gaullienne', in place since 1958[78]. The traditional administration has undergone changes influenced by the new government. The new government expected a more managerial administration, with tactic and controlling, and more attached to the flexibility of the solutions. Concerns about the living environment were neglected.

Furthermore, another factor made the integration between the new university campuses and the city urban planning difficult and almost impossible to reach: the absence of coordinated actions between the National Education, the local government services, and the municipalities to integrate 'city' and 'university'. Besides that, the National Education Ministry, which was the responsible for the coordination of the project, preferred to demand famous architects to develop beautiful and useful projects systematically, leaving aside the integration with the urban planning.

However, at the same moment that the urban planning inside the universities was neglected, there was an insufficient integration between these actors when taking decisions. The university projects'decision-making was an exclusive role of the architects and the General Council of French Buildings.

[77] It was previewed by the 'Parisian General Organization Plan' (In French: '*Plan d'Organization Générale de la Région Parisienne*' - PADOG) new universities implementation inside new cities 50km from Paris.

[78] Charles de Gaulle was the leader of Free France (1940–44) and the head of the Provisional Government of the French Republic (1944–46). In 1958, he founded the Fifth Republic and was elected as the 18th President of France, a position he held until his resignation in 1969.

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Even with the problematic communication between the university project stakeholders and the susceptive failures on creating a real connection between the city and the university, the current government worked in a massif construction of university buildings until 1968. The University of Nanterre, Villetaneuse, Vincennes, and Creteil were constructed.

The role of the industrialization had a vital importance to construct huge buildings considerably fast. Buildings were all delivered before the end of 1968's summer vacations. Building's construction prelimary studies and design were accelerated, and construction sites were developed in record time. A repetitive architecture took place to speed up the conception design project (Delanes, 1999; Compain-Gajac, 2014).

The universities' structure of this period lacked in urban logistics. Students' life quality and university accessibility were not prioritized. In the place of using the denomination 'campus', Delanes (1999) considered that the most appropriate is to designate the agglomeration of the French university buildings of this period as "*grands ensembles de l'enseignemen*t" (English: immense teaching complexes), defined by Delanes (1999).

The idea of the 'American campus' was distinct from this one, basically due to the special attention given to the students' life. The 'American campus' aimed to build a student's living space and not just a place to disseminate knowledge; it is an urban utopia; a laic, an urban and a democratic ideal in the architecture merged with the city (Leheis, 2011).

In parallel with this important program with industrialized construction methods outside the towns, city centers gave place to some significant architectures. For example, in Paris, the *Faculté de Droit d'Assad*, designed by Charles le Maresquier, the *Cité Internationale Universitaire*[79] (CIUP), developed by Claude Parent; and the University Library of Nanterre and the Jussieu Campus, designed both by the architect Édouard Albert.

The Jussieu Campus[80] is a higher education campus located in the 5th arrondissement of Paris, which is the main campus of the Pierre and Marie Curie University (Paris VI). Édoaurd Albert 's project is a massif architecture, 400 000 m² distributed by a quadrilateral slab of 275 meters by 333 meters

[79] CIUP was established for the after-World War I by André Honnorat, rector at the Sorbonne, in cooperation with Émile Deutsch de la Meurthe in order to create a meeting place for students, researchers and intellectuals from around the world in a spirit of peace, unity and friendly cooperation.

[80] In French: Jussieu Campus.

delimited by the Quai Saint-Bernard, rue Cuvier, rue Jussieu and rue des Fossés-Saint-Bernard as presented in Figure 25 and Figure 26.

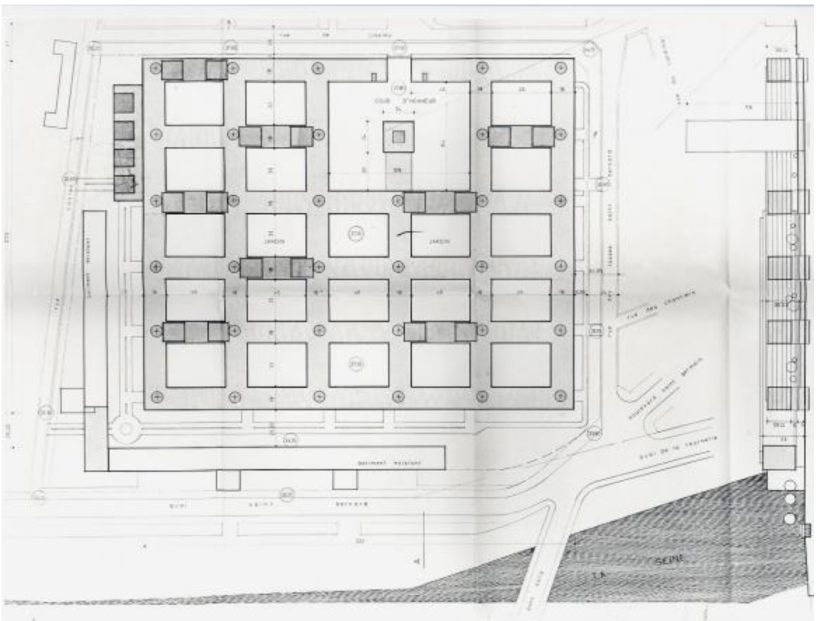

Figure 25. Plan of the Jussieu Campus. Source: Hottin (2007).

Figure 26. Top view of Jussieu Campus in Paris. Source: Davril (2011).

The building was designed as a modular structure with three basic elements: the small blocks for the teaching activities; the large blocks for the research activities; and the rotundas, at the intersections, containing means of access (stairs, lifts, freight elevators). The Tour Zamansky, or Tour Jussieu, with

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24 floors and a height of 90 meters, is used for administrative purposes and is in the center of the campus.

The Jussieu campus project could not be concluded, and nine towers were never built due to several reasons. The lack of integration between buildings, and the presence of small corridors that do not consider the place of the man in his working environment are the main project critiques. For many people, the campus is viewed as an "inhuman" place (Hottin, 2007). Moreover, the 'campus' does not provide students' meeting points, and it does not consist of a cozy and inhospitable - the wind that rushes under the buildings in the *pilotis* area.

The University democratization and its structures problems aligned with the economic, political and cultural issues resulted in a series of events consisting in strikes and manifestations in May of 1968[81]. In France, these manifestations started in the Nanterre Faculty, where the new campus, built in 1964 on the outskirts of Paris as a Sorbonne extension, could not manage the students increase that jumped from 1450 to 11000, from 1964 to 1967.

This period had a significant impact worldwide and in the French society. The Grenelle Agreements[82] were negotiated during the crisis of May of 1968 and resulted in the work quality improvement and raise the real wages. Afterward, in December of 1968, the law Faure[83] was signed. This administrative reform gave more autonomy to the universities that started to manage their organization and especially their finances. However, when the new universities were set up, many units were dissociated between two universities.

2.2 The second 'boom' period of the universities construction: the modernization programs

New utopian ideologies took place after the May 1968 in North America and West Europe. Inside this context, universities tried to introduce an open campus concept with distance education programs and night educational programs. It is a diversification period with new institutional educational

[81] The university crises of May of 1968 had a global scale and has in common a social and political crisis where university students were the spark to embrace all the society that was unhappy with the repressive government. Not just France but also Germany, United States ('Free speech movement' inside the most liberal universities: Berkeley, Stanford, Columbia and Harvard), Italy, Africa and South American Countries (Columbia, Peru, Chile and Brazil suffered with the brutally reaction of the government) participated actively in this moment of the history (Charle et Verger, 2012).

[82] In French: Accords de Grenelle.

83 In French: Loi Faure. Law n°68-978 of 12th November 1968 about the higher education.

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development, heterogeneity in the university students age, feminization, and internationalization of students (Charle and Verger, 2012).

This open ambiance aligned with the academic diversification ensured an increase in the number of new students. Despite this, due to the economic difficulties generated by the oil shock[84], the government decided to settle the university campus growth breaking the new university buildings construction. The economic crises contributed to the emergence of new solutions and theories for the economic slowdown. Little by little, a new utilitarian view was being diffused. At the beginning of the XXI century, the term "*économie fondée sur le savoir*"[85] is widespread (*Ibid*., 2012).

From 1960 and 1980, the number of university students grew from 240 700 to 1 076 700 (Charle and Verger, 2007, p.203). During this period, public authorities profited on this opportunity starting, gradually, to correct the serious errors made in the architecture and urban planning during the last years.

In 1981, the Socialist Party under President François Mitterrand announced an urgent demand for the university buildings. A new real estate policy is fixed to answer this request, and it was organized in three axes:

- Modernization of the existing university buildings to improve optimization;
- Resumption of major university building investments abandoned by previous administrative management and direct engagement of the municipalities in this action;
- Catching up the disturbances caused by the industrialized, peripheral, and repetitive academic urban planning (Compain-Gajac, 2014).

The Law on Rights and Liberties for Communes, Departments, and Regions (*lois Defferre*)[86], was the decentralization law from 1982, proposed to redefine the relationship between local politicians and the state administrative apparatus. This motivated a change in the way that the government was habitually dealing with the university construction buildings. Regions, departments, and communities,

84 The 1980s-oil shock was a serious surplus of crude oil caused by falling demand following the 1970s-energy crisis.

85 The 'economy based on knowledge' is characterized by an increase in the demand for skilled workers (OCDE, 1996).

86 In French: *Loi n° 82-213 du 2 mars 1982 relative aux droits et libertés des communes, des départements et des régions*.

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with the articulation of DATAR,[87] started to be more engaged to find a better university building insertion inside their urban sites.

The Interdepartmental Mission for the Public Buildings Quality[88] was created in October of 1977. The emergence of this mission contributed to engaging the various ministries on making efforts to develop preliminary building studies, to explore the natural site features, to collect historical, physical and climate data in every project. A methodology for buildings construction execution was put into practice. The actors enrolled in the design phase, and the construction site were defined to ensure that all the actions be monitored (*Ibid*., 2014).

These long-term modernization programs were created to react to the increase in the number of students. The implementation of these programs resulted in the quality construction improvement of the universities buildings. Beyond that, planning and process construction were applied to the new university buildings.

During the 1990s two important manifestations were set up: *Université* 2000 (U2000)[89], in 1990, and *Université du Troisième Millénair*e[90] (U3M), in 1999. These actions changed the relations between state, communities, and universities, and allowed the communities to consider the academic development and as an important issue that deserves to be an element of the urban development.

During the period of 1990-2000, the funding designated to the U2000 allowed eight new universities construction. Between then Cergy-Pontoise, Évry (Val d'Essonne), Versailles-Saint-Quentin-en-Yvelines, Créteil (Marne-la-Vallée);196 departments of UIT (University Institutes of Technology) and 24 full UIT, 7 European centers that will become later PRES[91]. Universities were constructed and renovated (in particular the university libraries of Paris 8, at Saint-Denis, and Cergy-Pontoise) reinserted inside the cities and more attention paid to student life (DATAR, 1998; Renoult, 2000).

[87] DATAR or "*Délégation interministérielle à l'aménagement du territoire et à l'attractivité régionale*" (English: Interministerial Delegation of Land Planning and Regional Attractiveness) was a French administration working for the regional planning and attractiveness with actions oriented to the sustainable development of the territories.

[88] In French: Mission interministérielle de la qualité des constructions publiques.

[89] This plan was adopted by the Council of Ministers on 23 May 1990. With initial funding of 32 billion of French francs over five years (1991-1995), it would increase the number of premises, while the number of students was increasing (DATAR, 1998).

[90] In English: University of the Third Millennium.

[91] In French: Pôle de Recherche et d'Enseignement Supérieur. In English: Research and Higher Education Centers.

The plan U2000 filled a significant delay on the university equipment. The extension of the public transport, especially the RER, worked as a major element in the new universities development (Hottin, 2009).

The U3M was a plan that consisted in the extension of the U2000 to keep the actions established before. The main goal was to define a long-term strategy (2000-2015) for higher education and research based on financial support and annual government-local contracts. At the national level, a committee is set up in each region, headed by the mayor, the university dean, and a mission officer. (Renoult, 2000).

A global strategy for the Ile-de-France was elaborated by the university deans of the University of Créteil, Paris, and Versailles. The improvement in the admission rate to the *baccalauréat*[92] and the higher education and the university's sites restructuration were the major goals of this strategy. Additionally, municipalities affirmed their willingness to get involved particularly in the student housing and libraries (*Ibid*., 2000).

The Program Law for Research of 18 April 2006 created the PRES. It contributed to the improvement of the higher education governance through the reorganization of the relations between institutions and networking increase.

2.3 Operation Campus and the case of Lyon University

The U2000 and the U3M allowed universities to interact with the several components of the territory, and in 2008 the Plan Campus[93] was launched with the main goal of the creation of twelve university centers of excellence of international level, thanks to exceptional endowments. The projects usually gathered several universities grouped in a PRES[94].

Buildings' project applications had to follow specifications and to promote public-private partnership (PPP) concerning investment and property management. Four criteria were used to judge the projects:: development of a campus life, pedagogical and scientific ambition, the urgency of the real estate situation, and the project coherence 'vis-à-vis' the territory concerned. The Ministry of National

[92] The *baccalauréat* is an academic qualification which French students take at the end of high school.

[93] The Plan Campus or Operation Campus it is a project of François Fillon government announced in January 2008 by the Minister of Higher Education and Research, Valérie Pécresse.

[94] French law in effect from 2007 to 2013. The 2013 Law on Higher Education and Research (In French: *loi relative à l'enseignement supérieur et à la recherche*) discontinued the PRES; these have been largely replaced by the new Community of Universities and Institutions (In French: Communauté d'universités et d'établissements).

Education, Higher Education, and Research - MESR[95] gave preference to large-scale projects by the Grenelle Environnement spirit.

Twelve projects were selected: PRES of Bordeaux, the project "Grenoble, the University of innovation", "Lyon city of campus", Montpellier project, Strasbourg University, PRES of Toulouse, PRES of Aix-Marseille University, Project "Campus Condorcet Paris-Aubervilliers", campus Saclay, Lille University, Loraine University and Central Paris (see in Figure 27).

Figure 27. Map with the "Operation Campus" selected projects. Source: MESR (2008).

The Plan Campus "*was the emergence of the excellence campus that will be the showcase for France and will reinforce the attractiveness and influence of French universities*"[96] (MESR, 2008). However, some points in the plan were criticized. The funding opportunities were concentrated on a few campuses, and not based on recurrent funding.

The 'Lyon city of campus' project, approved by the Plan Campus, pointed out due to its innovative features and the contribution to the urban evolution of the city. The project received about 575 M€ (MESR, 2009, pg.16) and it was a major restructuring and modernization project of the property assets of the Lyon University. The idea was to renovate the existing buildings and to construct new ones to provide to the students living spaces with quality and a proper environment for the knowledge exchange.

[95] *Ministère de l'Education nationale, de l'Enseignement supérieur et de la Recherche.*

[96] Author's translation from "Il s'agit de faire émerger des campus d'excellence qui seront la vitrine de la France et renforceront l'attractivité et le rayonnement de l'université française".

The project has two main targets: the consolidation of the excellence in training and research and the improvement in the student's life quality. Two campuses were selected: Charles Mérieux (composed by three universities sites Quais Berthelot, Gerland and Lyon Sud) and LyonTech (la Doua). The Campus modernization also the objective to rise the academic attractiveness, international visibility and the opening to the city.

The 'Lyon city of the campus', inspired by the Grenelle Law, has ambitious goals regarding the energy consumption for new university construction and the renovation projects. The project aims to reduce 20 to 25% of energy consumption in the Quais Berthelot site and 20 to 30% in the Gerland, both inside the Charles Mérieux project, but also 40% of the energy used by the heating system in La Doua site (University of Lyon, 2017).

The La Doua is located in the north of Villeurbanne (Neighboring city of Lyon). It is evident, in the project, the desire for creating cozy spaces and reinforcing university's permeability to the city through the creation of green axis[97]. La Doua has the strong ambition of becoming both a global benchmark for clean technologies and an "eco-campus demonstrator" (Florin, 2014).

The renovation of 22 scientific buildings (in total 140 000 m2) focuses on improving energy performance, as mentioned before, improving fire security safety and upgrading accessibility to people with disabilities[98]. The scientific districts' renovation, certified by HQE Rénovation, is part of the eco-campus initiative and contributes to improving the living and working conditions of users (Figure 28).

Furthermore, some important constructions were planned, as the building of the Innovation Platform Axel'One, the University Residence, the A and D Tower and the Chemical-Bio Building (University of Lyon, 2016).

The second project covers an axis linking the Rhone Quays to the Lyon south through the Gerland district. Renamed Charles Mérieux campus, it includes a significant part of rehabilitation and restoration[99], considering the environmental standards, for the buildings of Lyon 2, Lyon 3 and ENS. New buildings were also planned, like the Languages and the Culture House, new laboratories in

[97] This green axis was created to connect the university buildings and also to introduce exterior living areas with urban furnishings and adequate public artificial lighting, and bike paths.

[98] According to UN (2003), this group is composed by wheelchair users, the sightless and partially sighted, people with limited walking abilities and the hearing impaired.

[99] Rehabilitation and restoration are both terms very common for describing universities buildings. Rehabilitation emphasizes the retention and repair of historic materials, but more accent is provided for replacement because it is assumed the property is more deteriorated prior to work. On the other hand, restoration targets on the retention of materials from the most significant time in a property's history, while permitting the removal of materials from other periods.

Gerland, and the extension of the Faculty of Medicine and the new building of the CROUS restaurant in Lyon South (Figure 29).

In the Charles Mérieux campus, the renovation project also aimed to reduce the energy consumption and to increase the respect for the accessibility and security norms. The project enhanced the campus life, the well-being inside the buildings and in the exterior spaces, the pedestrian and bike lanes, and the vegetation.

Figure 28. Renovation construction project of University buildings inside La Doua that will be delivered in 2020. Source: University of Lyon (2017).

Figure 29. Architectural extension projects of the Faculty of Medicine in Lyon South. Source: University of Lyon (2017).

Urban and social dimensions played a major role in the 'Lyon city of campus' project. While new student’s residences, cultural and sportive buildings were installed, communication with the city, including green corridor, road network extension and bike lanes were implemented.

The 'Lyon city of the campus' is still in progress, and the estimation is to complete the project by 2020. A part of the delay is due to the changes in the financial resources arrangements as a result of the non-expected evolution in the rules imposed by the Ministry of Higher Education[100]. Only the Lyon South project was signed in the form of PPP (public-private partnership). The other operations are being carried out in MOP[101] (public contracting authority).

The University Development Plan (SDU[102]) was launched in 2007 by the Lyon region, and voted in 2010, and it was a reference regarding the university urban development. The SDU presented strategic action to the deployment of the higher education and research inside the major cities. It was organized in three important axes: increase attractiveness and legibility of Lyon, optimization of the urban organization of the university development, and adapting Lyon to become a welcoming university metropolis (Compain-Gajac, 2014).

3 DETERMINATION OF THE RELATION BETWEEN UNIVERSITY AND THE CITY

After the presentation of the historical context of the universities in France, we would like to hold the attention for the university definition before to start exploring the relationship between the university and the city.

Introducing the university in a general way is a delicate task due to its complexity and the multiplicity of its traits. In an institutional context, inside the term 'university' we can embrace all the participating institution in the field of higher education and research. However, this definition is too large and is likely to encompass various entities worldwide (Bouckaert, 2016).

The etymology of the word "university" derivates from the Latin "*universitas*" and refers to some persons associated with one body, society, company, community, corporation, and others (Lewis and

[100] The Report Peylet, presented to the Geneviève Fioraso, on the 29th of October of 2012 called into question the public-private partnership contract obligation. The members of the Peylet mission required to the minister a period of appropriation and a claimed that some institutions has difficulty to understand financing mechanisms in the long term (Peylet, 2012).

[101] In French: *maîtrise d'ouvrage public.*

[102] In French: Schéma de Développement Universitaire.

Short, 1966). According to Bouckaert (2016, pg. 49)[103], universities are "entities that are active both in the field of higher education and research, with a general and multidisciplinary profile, with an essentially collective vocation, in other words, a public or private non-profit status".

Magdaniel (2013) outlined five main roles played by universities in the cities: a crucial function for city's economic growth, engines to attract, shape and retain knowledge workers, nodes in a collaborative network, universities as real estate developers and agents of urban changes, and universities as cities within the city.

3.1 Universities location as a determining factor for connecting to the city

The connection between the university campus and the city depends on their location. In a simplified way, we can resume the universities in France in three types regarding their physical perspective: (1) old city center universities, (2) universities build in the 1970s located in the peripheries, (3) and the universities located in the middle term. Each variety of the university campus interacted in a particular way with the city.

- Old city centers universities: Universities located inside the city centers endowed with an elitist character of traditional universities, lacking in parking lots[104] and car access, implemented in a local neighborhood, served by local public transportation. For example University of Lyon II site "Berge du Rhône" and University of Lille site "Vauban" (CERTU, 2008);
- Peripheral universities build in 1960s-1970s: Universities built in the urban peripheries, close to the highways, to answer to the grow in the number of students due to the education democratization, with an isolated characteristics and no urban dynamism, served with vast parking areas and with a public transportation to connect the university to the city center. For example University of Lille I site 'Cité Scientifique' at Villeneuve d'Ascq and Lyon II site 'Porte des Alpes' (Hottin, 2009 and CERTU, 2008);
- Universities located neither in the city centers and neither in the urban peripheries: These universities are situated close to the entrance of the towns, are provided with several public

[103] Personal translation from: "*…les entités actives tant dans le domaine de l'enseignement supérieur que de la recherche, de profil généraliste et pluridisciplinaire, à vocation essentiellement collective, autrement dit de statut public ou privé à but non-lucratif* ".

[104] Their constructions dated before the automotive era (CERTU, 2008).

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transportation options and with a vast parking area. For instance, the University of Bourgogne in Dijon-Montmuzard (CERTU, 2008).

In general, city-center campus have more vertical connectivity while outside city center campuses have more horizontal connectivity. City center campuses have less car dependency as outside city center campuses have (Balsas, 2003).

On an integrated perspective, Den Heijer (2008) studied Dutch universities and divided than in three distinct relations with the cities: separated from the city, gated inside the city and integrated inside the city. In this classification, Den Heijer (2008) found that even inside the cities, depending on the integration perspective, universities can relate with the towns distinctly.

3.2 The importance of large spatial scale and mobility

Indeed, the modern university campuses have a unique position to establish a clear relationship with the city as the result of two conditions. The first condition is the large spatial scale required to accommodate university's activities. Universities are institutions that need physical space inside the cities and at the same time participate as a fragment of the city, state, and country in a normal complementary relation.

The second condition is the mobility infrastructures. Depending on their location,n universities need to drive mobility options for students to improve university accessibility and to provide options for the students. Additionally, factors related to the urban planning insertion and the student's life quality must be considered.

This 'surface-mobility' typology represented a lack in the relation between the development of universities and urban development. This form of urban planning reached its limits. However, after the 1980s, this typology was reviewed and municipalities to start to integrate the development of universities as an element of cities urban planning (Compain Gajac, 2014) and universities have once again the right of 'the city in the city'[105] (CERTU, 2008).

Balsas (2003) defined university campus as a unique place and self-contained neighborhoods where classrooms, apartments, offices, students centers, child care facilities, swimming pool, gymnasiums,

[105] As stated by Burdése (2008 cited from CERTU, 2008), "the universities are noticed as a major economic, social and policy issues of the local development..." (English translation of *"les universités sont perçues comme un enjeu majeur économique, social, politique du développement local*...").

sports arenas are built closely, furthermore, they have their squares, streets, green open spaces, where students can meet and get together. The university campus, as stated by Balsas (2003), generates substantial flow displacements. Nevertheless, is a meaningful mobility generator and is weakly identified in the urban transport policies. Over the years, local authorities are investing to improve the public transportation offered to improve universities campuses mobility (CERTU, 2008).

Investment in public transportation is not enough. Studies proved that universities must work with municipalities to adequate their infrastructure to serve users better. This is what happened with the University of Lyon II site "Berge du Rhône". The University held a survey to access the mobility choices, made by the University students, staff and teacher. They found that 58% of students go every day to the University by public transportation, 26% by walk, 3% by bicycle, and just 13% used to go by car; and 15% of the staff and teachers go by walking, 39% using public transportation and 46% use the car to arrive at the University.

Hence, after analyzing this study results, some actions of urban space restructuring were taken. The existing parking lot was reduced in size (Figure 30). In the place occupied by the parking lot, a green public space (Figure 31) was created to stimulate people walking (*Ibid*., 2008).

Figure 30. "Berge du Rhône" before the urban intervention. Source: CERTU (2008).

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Figure 31. New green and public space proposed in "Berge du Rhône". Source: CERTU (2008).

4 WHICH ARCHITECTURE FOR THE UNIVERSITIES? FROM MODERNISM, BRUTALISM, CONTEMPORARY TO ENERGY EFFICIENCY BUILDINGS

A university campus is defined as a building complex that includes higher education buildings, university residence and administrative services (Hottin, 2009) surrounded by green spaces, pedestrian and bicycled lanes and supplied by proper mobility structure. Buildings are the core of a university campus, are the interior spaces were teaching, learning and researching activities are carried out. University buildings can have diverse architectures, shapes, sizes depending on the local, activities served, historical values, and climate conditions.

In France, it is possible to compare the differences in the buildings' architecture[106] of universities from the last thirty years[107]. Campuses designed during the first boom, in the 1960s-1970s, had an architecture with the lack of user's quality of life. The universities buildings architecture of the 1990s, transmitted certain architectural quality and a search for the identity that allowed to identify distinct

[106] Architecture is the 'building as a final product', is also 'the results of all the drafts and preliminary projects', is 'the process of creating, reformulating, inspiring, innovating, and dreaming'. If architecture is the art of create new spaces and buildings, the architect is the artist.

[107] Before the first boom, the architecture style of the elitists universities was basically the "Beaux-arts". Universities were cities monuments and a way for increased visibility and prestige (Compain-Gajac, 2014).

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buildings inside the campus (*Ibid*., 2009). In the XXI century, the architecture of the building passed through the ecological and energy transitions.

4.1 The rise of modern and brutalist architecture during the after-War universities buildings

The modern architecture influenced universities architectures after the Second War. The modern architecture or modernist architecture emerged from 1945 to 1975. It is a term applied to a group of architecture styles, rise around 1930 and led by some architects - Le Corbusier and Robert Mallet-Stevens, in France, and Walter Gropius and Ludwig Mies van der Rohe, in Germany. The group was no longer satisfied by the neoclassicism and the *beaux-arts* architecture styles. They wanted an architecture composed of simple forms and the eradication of any decoration. Students at Bauhaus[108] school of design, taught by Walter Gropius learned that 'form follows function'. Modernists believe that ornament should match the structure and the purpose of a building[109].

Le Corbusier[110] was a recognized architect of modern architecture in France. He promoted the idea of a simple and functional architecture. He published the book "Toward an Architecture" in 1923, where he presented the 'Five Points of Architecture' that are listed below:

- *Pilotis*: Buildings are raised up on reinforced concrete pylons, which allows for free circulation of people on the ground level, and eliminates dark and damp parts of the house;
- Roof terrace: A flat roofs replace sloping roofs; the roofs can be used as a garden, for promenades, sports or a swimming pool.
- Free plan: Load-bearing walls are replaced by a steel or reinforced concrete columns so that the interior can be freely designed, and interior walls can put anywhere, or left out entirely.
- Ribbon window: Since the walls do not support the house, the windows can run the entire length of the house so that all rooms can get similar light.
- Free Facade: Since columns in the interior support the building, the façade can be much lighter and more open, or made entirely of glass.

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[108] Bauhaus, was a German art school operational from 1919 to 1933 that combined crafts and the fine arts, and was famous for the approach to design that it publicized and taught.

[109] This movement will be later on criticized by the Postmodern architecture that accuses Modernists of overvalue form and design architectures with no identity (i.e, around the world all the modernism buildings were similar). Post modernists architects will propose a re-evaluation of the history and culture role.

[110] Charles-Édouard Jeanneret, a Swiss-French architect, one of the pioneers of what is now called modern architecture.

The Villa Savoye was built in 1928-1931, in the Paris suburb of Poissy, and can be considered as an important project of this period (Figure 32). The project can be described as a white box building wrapped with a ribbon of glass windows around on the facade, with living space that opened upon an interior garden and countryside around, raised up by a row of white pylons in the center of a large lawn. Another remarkable project was the *Cité Radieuse*, an *Unité d'Habitation* in Marseille, built in 1947-52 - a building with a concrete frame raised up above the street on pylons.

Universities building constructions from the first boom found in the Modern Architecture the ideal combination to build promptly substantial buildings, made with prefabricated structures, with a low price to answer the demand of this period.

The University Center of Vincennes (1968-1980) was designed with strong elements of the modern architecture, as the *pilotis*, the free facade, the free plant and the presence of some windows (see Figure 33 and Figure 34).

Figure 32. Villa Savoye Project. Source: Villa Savoye Foundation (2017).

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Figure 33. University Center of Vincennes' entrance. Source: Boissier (1980).

Figure 34. University Center of Vincennes' pilotis area and free plant. Source: Boissier (1980).

Furthermore, brutalism architecture was also particularly influential. Brutalism buildings[111] are usually formed with repeated modular elements forming masses representing specific functional zones, distinctly articulated and grouped into an unified element.

Concrete is used for its raw feature, contrasting with the highly-ornamented buildings constructed in the elite Beaux-Arts style[112]. The same lack of cultural and historical identity observed in the modern

[111] Not just in France, but also in United States, Canada and UK, university campuses architecture had a strong brutalism influence.

[112] Beaux-Arts architecture is constituted by sculptural decoration along conservative modern lines, employing French and Italian Baroque and Rococo formulas combined with an impressionistic finish and realism.

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architecture it is also detected in brutalism architecture. Critics called the architecture as "piles of concrete."

The Benjamin Center of the Technology at the University of Compiègne[113] (Figure 35); and the IUT du Campus de Villetaneuse of the University Paris XIII Nord (Figure 36) are examples of brutalism architecture in France, both projects characterized by geometric and repetitive forms, and the raw concrete aspect.

Figure 35. Benjamin Center of the Technology University of Compiègne, Picardie. Source: Images de Picardie (2013).

Figure 36. Campus de Villetaneuse. Source: Seine-Saint-Denis (2017).

[113] The center was designed by the architect Adrien Fainsilber, founded in 1972, in Picardie Region.

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4.2 University contemporary architecture connected with the place

The universities buildings architecture of the 1990s were linked to the idea of a contemporary architecture diversified. It was a search period for an identity where any style predominated. Contemporary architects are working in a dozen several styles, from postmodernism to high-tech architecture.

Under the influence of the U2000 Plan, many universities were created, as the University of Cergy-Pontoise, the University of Versailles-Saint-Quentin-en-Yvelines, the University of Marne-la-Valée and the Université d'Evry-Val d'Essonne. These universities campuses tried to integrate the urban landscape in their project to build not just a university building but also a contemporary patrimony.

The University of Cergy-Pontoise was founded in 1991 inside Île-de-France region, with centers in Cergy, Pontoise, and Neuville-sur-Oise. The 'Chênes Site' at the University of Cergy-Pontoise, was designed by the architect Michel Rémon. It is composed of a large building in the shape of a white ship that runs along the Boulevard de l'Oise to set up its prow on the Boulevard du Port. The building's façades are open to the pedestrian lane and the city (Figure 37).

In the first and second floor, the research spaces are organized as peaceful internal street tie up to the library and open toward the west on the quiet landscape of the Oise loop (Figure 38). The building's architecture is connected with the place that it belongs and has a strong identity. What was just a utopia in the 1960's became a reality in the 1990's?

The new universities architecture are designed as a mesh of tridimensional connections between the teachers, students and researchers to diffuse, produce and share knowledge inside and outside of the building (Compain Gajac, 2014). Architects need to answer to the 'university institution' requirements, they must incorporate into their projects a transdisciplinary profile and ensure the right harmony between these activities inside the building, ensuring productivity and comfort[114], but also cannot negligee the relation with the city and other buildings.

[114] Thermal, acoustical comfort but also visual comfort. Users comfort has an incontestable relation with satisfaction and productivity.

Figure 37. Façade of the University of Cergy-Pontoise 'Chênes Site'.
Source: Cergy Pontoise Agglomération (2012).

Figure 38. Peaceful internal streets to connect the research offices. Source: Rémon (2012).

4.3 Launching an architecture trend for the universities of tomorrow

Planning and constructing new buildings is not the real challenge for France. Indeed, the environmental impacts of French university buildings are related to the existing and inadequate buildings from the 1960's and 1970's that have high energy consumption.

Energy issues are imperative when planning and constructing new buildings or when renovating the existing ones. However, universities buildings architectures should integrate more than energy issues at their projects.

The connection between the architecture and the place is vernacular and imperative for the university campus. A campus is an ecological location with a geographical, cultural, and landscape context for its materials use. This means that what works best in one place may not be well suited for another site. In any case, sharing experiences and experiments by developing common expectations about sustainable materials practice is possible and recommended (Thomashow, 2014).

Independent of the architectural style, the current university campus has as the main goal to prepare the current universities buildings for a new environmental approach (i.e., through construction and renovation works) improving the climate resilience for tomorrow.

University buildings should bring natural lighting, have a connection with the natural environment, work in energy and potable water consumption reduction, but also promote energy efficiency strategies.

Architects must design university buildings considering the flexibility of spaces (i.e. depending on the user's needs interior spaces can hold several activities), to reduce the building's surface, and consequently, needs by natural resources. Users winter and summer thermal comfort should be integrated as an essential project's axes priority to avoid low user's productivity in their work. Moreover, visual and acoustical comforts are also relevant.

This approach has been integrated especially in the design (i.e., in France universities will search for an HQE certification) of the university libraries due to these buildings significance for the whole campus as libraries are the university's showcase. Significant projects in the area can be cited, as the university's library of Havre.

Even with the rigidity of the building, performed in a cube form, the University Library of Le Havre, was designed to break the rigidity of the old libraries, with its interior curves inside the building (i.e., with a strong influence of Niemeyer's and Alto's work[115]) as shown Figure 39.

The architect, René Dottelonde, optioned to designed façades largely glazed, to provide a correct natural lighting, associated with the vertical and horizontal sunshades to guarantee optimal protection against the sun. Besides that, the terracotta façade, it is inspired by both the material chosen by the vibration of vertical lines that structure, and the traditional architecture of the region where the

[115] In reference to Oscar Niemeyer - Brazilian modernist architect, famous for his use of abstract forms and curves - and Alvar Aalto - Finnish architect, modernist during the 1930s to a more organic modernist style from the 1940s onwards.

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window frames, pilasters, the rhythm of the game red and white bricks. The building was the first building in the Normandy Region to receive the certification HQE (Le Havre patrimonial, 2010).

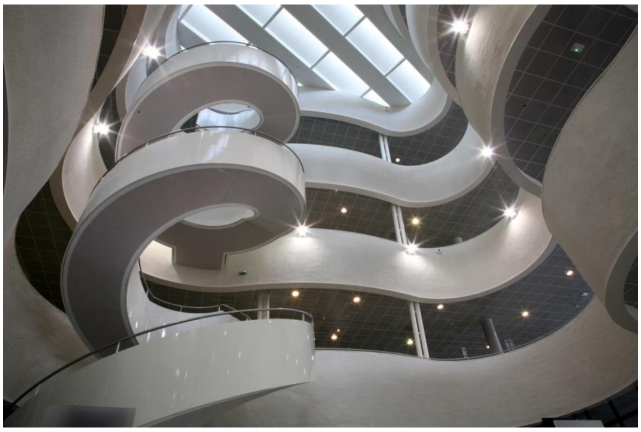

Figure 39. University library of Havre interior design. Source: Le Havre patrimonial (2010).

Beyond that, new technologies increase library's spaces of conviviality and collective to change the information learned and searched inside the calm spaces of libraries. Inside classrooms, new spaces should integrate a similar and decentralized atmosphere where knowledge will be distributed everywhere. "*Classrooms of yesterday are dead, even if today we see just this type of classrooms and even if the spectacle society try to impose them still*" [116] (Michel Serres, cited at Campus Responsables, 2013, pg.50).

In a general way, there is a less necessity for large conference rooms and more demands for numerous smaller spaces, even in corridors, allowing individual and group work. Interior spaces must be open and flexible to promote the knowledge exchange (MESR, 2015).

5 HIGHER EDUCATION ON THE WAY TO A HOLISTIC APPROACH TO THE IDEA OF SUSTAINABILITY

Universities located in the cities, participating as an active institution that exchanges material, energy, waste with the territories. Nonetheless, universities are also a piece of the city as an urban agglomeration that consumes energy, water and produces waste. Study the university campus inside

[116] Original quote in French is *"La salle d'autrefois est morte, même si encore, on ne voit qu'elle, même si on ne sait construire qu'elle, même si la societé du spectable cherche à l'imposer encore"*.

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a sustainable development perspective it means that we cannot neglect economic, social and environmental dimensions, but also cultural and institutional pillars

5.1 Global declarations and reports for sustainability in higher education

National and international statements and reports (Table 3) had a major role and assisted universities to create their policies and implementation plans. The way how universities interact with sustainability issues differ from country to country, campus to campus, policy to policy and declaration to declaration (Wright, 2002).

Table 3. Chronology of declarations and reports related to sustainability in higher education. Source: Wright (2002) and Sauvé et al. (2007).

YEAR	CITY - ORGANIZATION	DECLARATIONS AND REPORTS
1972	Stockholm - UN	*The Stockholm Declaration on the Human Environment*
1975	Belgrade - UNESCO-UNEP	*Belgrade Charter: A Global Framework for Environmental*
1977	Tbilisi - UNESCO-UNEP	*Tbilisi Declaration*
1982	New York - UN	*World Charter for Nature*
1987	Moscow - UNESCO-UNEP	*International Strategy for Action in the Field of Environmental Education and Training in the 1990s*
1990	Talloires - ULSF	*The Talloires Declaration*
1991	Halifax - ULSF	*The Halifax Declaration*
1992	Rio de Janeiro - UN	*Report of the United Nations Conference on Environment and Development - Agenda 21* - Chapter 36: Promoting Education, Public Awareness, and Training
1993	Kyoto - UN	Ninth International Association of Universities Round Table: *The Kyoto Declaration*
1993	Swansea - Association of Commonwealth Universities	Association of Commonwealth Universities' 15th Quinquennial Conference: *Swansea Declaration*
1994	Cairo - UN	*United Nations Programme of Action of the International Conference on Population and Development*
1994	CRE	*CRE Copernicus*[117] *Charter*
1994	Yale University - Campus Earth Summit'	*Blue Print for a Green Campus*
1997	Thessaloniki - UNESCO	*International Conference on Environment and Society - Education and Public Awareness for Sustainability: Declaration of Thessaloniki*

[117] COPERNICUS - CO-operation Programme in Europe for Research on Nature and Industry through Coordinated University Studies.

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1998	UNESCO	*The Adaptation of Content to the Challenges of the Twenty-first Century*
1999	UNESCO	*Education and Population Dynamics: Mobilizing Minds for a Sustainable Future*
2002	Johannesburg - UN	*The Johannesburg Declaration on the Sustainable Development*
2005	UN Decade of Education for Sustainable Development 2005-2014	Report by the Director-General on the United Nations Decade of Education for Sustainable Development: *International Implementation Scheme and UNESCO's Contribution to the Implementation of the Decade*
2005	Vilnius United Nations Economic Commission for Europe - UNECE	*Vilnius Framework for the Implementation of the UNECE Strategy for Education for Sustainable Development*

The discussion around sustainability in the higher education dates from the 1970s. Inside this international context, we would like to highlight here the contribution of the 'Stockholm Declaration' for the sustainable higher education idea emergence that recommended a global implementation of the international program in the environmental education.

> *"It is recommended that the Secretary-General, the organizations of the UN system, especially UNESCO, and the other international agencies concerned, should, after consultation and agreement, take the necessary steps to establish an international program in environmental education, inter-disciplinary in approach, in-school and out-of-school, encompassing all levels of education and directed toward the general public, in particular, the ordinary citizen...with a view to educating him as to the simple steps he might take, within his means, to manage and control his environment"* (Recommendation 96 of the Stockholm Declaration, 1972).

This recommendation linked the environmental protection with an environmental education to provide to citizen's knowledge to understand and later formulate solutions to manage and control their environment.

In response to the Recommendation 96, the UNESCO[118] and the UNEP launched the UNESCO-UNEP International Environmental Education Program (IEEP). From 1975 to 1995 the IEEP promoted the environment education for the sustainable development by linking institutions and specialists in a network, and processing and disseminating information.

[118] The United Nations Educational, Scientific and Cultural Organization (UNESCO) is an agency of the United Nations that was born in 1945 with the main goal to contribute to peace and security by promoting international collaboration through educational, scientific, and cultural reforms in order to increase universal respect for justice, the rule of law, and human rights.

The evolution for environmental sustainability concerns regarding the higher education took place in 1990 when 350 university administrators from 40 countries signed the 'Talloires Declaration'. The 'Talloires Declaration' was an action plan to incorporate the sustainability and the environmental literacy in research, teaching, operations, and outreach at colleges and universities (ULSF, 1990).

In 1994, the 'Campus Earth Summit', held at the Yale University, set several recommendations regarding the green campus. The 'Blueprint for a Green Campus', presented suggestions for the higher education institutions worldwide to work toward an environmentally sustainable future, as (Heinz Family Foundation, 1995):

- Integration of the environmental learning into the relevant disciplines;
- Improvement of the undergraduate environmental studies courses offering;
- Providing to the students some opportunities to study the campus and the local environmental issues;
- Campus environmental audit;
- Campus waste reduction;
- Increase the campus' energy efficiency;
- Settlement of the environmentally responsible purchasing policies;
- Prioritization of the environmental sustainability in the campus land-use, transportation, and building planning;
- Establishment of a student environmental center, and support students who seek environmentally responsible careers.

Shortly, the main themes presented in the declarations and policies of this period were: sustainable physical operations, sustainable academic research, environmental literacy, ethical and moral responsibility, cooperation amongst universities and countries, the development of interdisciplinary curriculum, partnership with the government, non-governmental organizations (NGOs), and industry and public outreach (Wright, 2002, pg. 214).

5.2 The French context of sustainability in the higher education

In the French context, the 'Conférence des Présidents d'Université' (CPU) with the 'Conférence des Grandes Écoles' (CGE), formalized the higher education engagements with the sustainable development. Both signed in 2010 the '*Plan Vert*' or Green Plan, previewed in the article 55 of the 3rd August of 2009 of the Grenelle Law 1.

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The Plan is destined to the higher education institutions and aims to help them to develop their sustainable development approach in a logic continuous improvement. Beyond that, the challenges of the National Strategy for the Sustainable Development 2010-2013[119] are (Ministère de l'Environnement, 2017):

- Sustainable consumption and production;
- Knowledge society;
  Governance;
- Climate change and energy;
- Sustainable transport and mobility;
- Natural resources conservation and sustainable biodiversity management;
- Public health, prevention and risk management;
- Demography, immigration, social inclusion;
- International challenges to the sustainable development, and the global poverty.

In 2015 the CPU and CGE launched the 'Label SD/RS' that enables the national and international valorization of the higher education. Furthermore, the label gives value to the institutions' researchers about the sustainable development and the social responsibility approach, and to the ability to develop skills within a committed collective.

All those environment educational manifestations around the globe and in France built a new definition for education. Education has become a strategy for promoting sustainable development (Sauvé et al., 2007). It became *"a means to bring about changes in behavior and lifestyles, to disseminate knowledge and develop skills, and to prepare the public to support changes toward sustainability emanating from other sectors of society"* (UNESCO, 1997, p. 1).

In this sense, universities have the critical mission, defined by the article 55 of the Grenelle I Law, of being acutely aware of the sustainable development (SD) issues. Over the years, universities recognize their decisive role in shaping the thinking and training of decision-makers. They are aware that these leaders' decisions engage the future of humanity on ecological, economic and social terms (CPU, 2012).

To meet the challenges of a sustainable society, regarding architecture and urban planning, universities should be engaged in the knowledge dissemination and the training of architects and urban planners.

[119] In French: *Stratégie Nationale Développement Durable* 2010-2013. This plan aims to develop a low natural resources and low-carbon economy. it articulates around nine strategic challenges, consistent with international and European commitments.

Universities must offer a training and research program associated with the relevant topics as SD and GSR (Global Social Responsibility).

Afterward, regarding GSR, universities need to adequate their spaces to the research and training activities but also structures to promote the students' quality of life, and all the new design and renovations project must integrate the sustainability requirements.

All the official documents which are results of all these international events (e.g. conferences, seminars), brought out their conclusion, proposals, and recommendations, in general, with shallow proposals requiring a critical analysis from the part of the actor to take action. This might be an explanation because higher education institutions worldwide approach sustainability in distinct ways.

6 UNIVERSITIES TOWARD A SUSTAINABLE CAMPUS

Much has been written about the sustainable campus. Inside our literature review, we found common themes when searching about sustainable campus energy efficiency, carbon footprint, transportation planning, greenhouse gas (GHG) emissions and environmental performance. Furthermore, when searching for the way to the sustainability inside the universities, the concept of green campus appeared as well.

6.1 Energy efficiency inside the campus: technology implementation but also a behavior changes

Energy efficiency is a recurrent theme since universities buildings have a large surface and require energy to perform several activities inside their buildings (e.g., teaching, laboratory, research) as stated by Thomashow (2014, pg.6), *"energy refers to the ability to do work."* Energy efficiency strategies can be integrated into the design concept or renovation of higher education buildings. However, as highlighted by Agdas et al. (2015), energy policy on the university campus, require managing the energy efficiency of the buildings effectively over time. Some universities buildings (e.g., University of Reading, University of Leicester, University of Sheffield, between others) adopted the implemented BMS[120] to control energy efficiency and to improve user's awareness of energy usage.

[120] BMS or Building Management System is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.

Employing efficient technologies, as replacing incandescent light fixtures with fluorescent fixtures might improve sustainability by providing the same level of lumens[121]. However, changing the behavior of facility users to reduce energy consumption improves sustainability by lessening the demand of amount of energy (Faghihi et al., 2014).

The behavior of facility users might guarantee energy reduction by replacing the artificial light for the natural daylight when it is visually comfortable, or turning out the lights when the room is empty, or reducing room temperature in 1 or 2 degrees during the day.

Macarulla et al. (2015) developed the ENCOURAGE[122] project that aimed to increase energy efficiency, interaction with external users, monitoring and controlling, correct users comfort levels, economic optimizations and raise awareness. University campus users of the Terrassa School of Industrial and Aeronautical Engineering, Spain, awareness was carried out using a Twitter account to publish correct habits and the variation of buildings consumption.

Whittle and Jones (2013) investigated the current energy consumption practices and perceptions of students and staff at the University of Sheffield, UK. They found that awareness of energy consumption between students was limited by virtue of the lack of information from the University. The insufficiency in transmitting information to the users generates a lack of responsibility and, consequently, in the perceived control over the building's energy consumption.

Thomashow (2014) also approached the need for information transparency for the users. He mentioned that energy policies in university campus should be transparent so that all energy users will be aware of the flow from the source to destination.

Some authors investigated the energy efficiency in the Leadership in Energy and Environmental Design (LEED) building university campus[123]. Agdas et al. (2015) analyzed the viability of blanket sustainability policies, for instance, Building Rating Systems, in achieving energy efficiency in American campus buildings. Impacts of the LEED certification on the energy performance of the university campus buildings were accessed. Bittencourt et al. (2012) held a life cycle analysis (LCA) of a LEED building at the University of Western Ontario, in Canada, to investigate the environmental effects produced by the energy use.

[121] The lumens is a measure of the total quantity of visible light emitted by a source.

[122] More about the project in the: https://artemis-ia.eu/project/35-encourage.html

[123] Building constructions certifications inside Universities have been rising national and international visibility of universities campuses.

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Economic benefits to saving energy were also highlighted. Faghihi et al. (2014) investigated feedback in the design of energy improvement programs that achieve efficiency and conservation by developing a system dynamics model. Both can contribute to saving significant amounts of energy and money. However, conservation demands maintenance to perpetuate energy savings practices.

6.2 Campus Greenhouse gas emissions

About GHG emissions, we found studies that focused in universities carbon footprint. Townsend and Barret (2015) performed an Environmentally Extended Input-Output Analysis to derive the carbon footprint of the University of Leeds to generate some results of the environmental dimension of the triple bottom line to evaluate the efforts campus greening efforts of the university.

Li et al. (2015) analyzed students carbon footprint in the University of Shanghai, identified student behavior changes that were more effective at reducing carbon emissions, and provided sustainable university improvement scenarios and predictions.

Furthermore, Balsas (2003) explored the mobility subject in a manner to reduce GHG emissions by planning and promoting campus bicycling and walking, using a case of study composed by eight American Universities[124]. Vásquez et al. (2015) evaluated the GHG emissions of the Curico Campus, in Chile, and concluded that the principal contribution to the GHG emissions is staff commuting[125], student commuting and electricity consumption.

Even many authors as Balsas (2003) pointed the GHG emissions as the significant environmental impact of the university users commuting, many other impacts related to can be found. Tolley (1997) pointed as another environmental impact disturbance on the teaching activities the deficit in green spaces inside the campus, the visual pollution caused by the parking installations, and the health effects.

[124] In his study the author explores the various combinations of transportation and stated that "walking and bicycling are complementary modes of transportation to get and around campus" (Balsas, 2003, pg.38).

[125] Commuting is periodically recurring travel between one's place of residence and place of work, or study, and in doing so exceed the boundary of their residential community.

6.3 Campus greening as a critical stage for the sustainable campus

Among these studies, Townsend and Barret (2015) and Li et al. (2015) mentioned the concept of green campus as an energy and resource efficient campus[126]. Muller-Christ et al., 2014 highlight that for many universities, campus greening is the first step toward sustainability. In this sense, universities have been developing their strategic sustainability plans inside the campus. The intention is to communicate to all the stakeholders the main university's actions toward a future, but also to conserve and to reinforce the campus attractiveness[127].

Thomashow (2014) suggested nine elements to elaborate a strategic sustainability plan inside the campus: energy, materials, food, governance, investment, wellness, curriculum, interpretation, and aesthetics. A study conducted by Velazquez et al. (2006), found that energy efficiency, water efficiency, waste management and transportation and commuting are considered priority on the elaboration of the sustainability initiatives on campus.

For instance, The University of Copenhagen created the 'Green Campus 2020', and the University of Yale the 'Yale Sustainability Strategic Plan.'

The University of Copenhagen created the 'Green Campus 2020' plan to communicate all the stakeholders about the strategies to achieve sustainability targets for 2020. These targets involve: the reduction of the CO2 emissions from energy consumption and transport, reduction in the energy consumption, new construction without health and environmental contaminants, reduction of the University's total pollution and chemical environmental impact, reduction of the waste produced, reduction in the water consumption, changes in the organization and in the behavior, and campus as a living lab (University of Copenhagen, 2013).

The 'Yale Sustainability Strategic Plan' is divided into three stages. The first stage was held from 2010 to 2013. The results from the first stage include a reduction in the 16% of the campus GHG emission, 24% of in the municipal solid waste. Furthermore, it resulted in 95% of dining hall food waste composted, increase in 28% of the recycling rate, and 100% of achievement of the certifications LEED gold for the new campus constructions and major renovations. Remarkable progress was also noticed

[126] The concept of environment protection education from 1972 (i.e., Stockholm Declaration) evolved to the green school and then green campus.

[127] Even if France is the third preferred destination of international students and researchers, campus attractiveness is an important point for all the universities nowadays (Campus Responsables, 2013).

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in the second stage (2013-2016): water management plan, sustainable stormwater management plan, and green purchasing guidelines.

The third stage of the Plan was launched the last year (2015-2016). It has as main goals the reduction of the fleet emissions by 80 MTCO2e per year, of the storm water, of the potable water use by 5%, of the single occupancy vehicle use to and from campus by 5%, of the cleaning chemicals by 30%, and the expansion of the green certification programs (Salovey, 2013).

In a French context, higher education institutions are also developing their responsibilities agenda and are, as the universities quoted previously, informing in a local, national and international scale their goals, achievements, and barriers through reports at their website to make visible their engagement with the SD.

The '*École Nationale Supérieure des Mines de Douai' l*aunched in 2015 their 'Action Plan Sustainable Development Report' to communicate relevant achieved points in 2015. Furthermore, the plan aims to publish targets points for 2016, regarding teaching and research activities, innovation, communication, energy, health and prevention, campus management, transport, and biodiversity protection. The establishment created its own agenda 21 to guide SD actions.

Progressively universities have been incorporating sustainability strategies in the infrastructure and campus operations, but also in teaching and research activities. Environmental actions are valuable to implement green campus that is the first step to implementing the SD strategies inside university campus for creating a sustainable campus. According to Velazquez et al. (2006), the sustainable campus:

> *"Involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles"* (Velazquez et al., 2006, p.812).

7 RESPONSIBILITIES AND SOCIETAL TRANSITION OF THE UNIVERSITY REGARDING DISTINCT SOCIETY PILLARS

As mentioned in Chapter 1, changes regarding the environmental policy agenda marked the last decade. Environmental concerns evolved from the simple unidirectional protection principles toward a broad sustainable development concept. The tools, to reach these goals, also progressed, following the policy agenda changes. Consequently, the traditional methods of command-and-control gave place to expansive policy-oriented choices (Joas and Grönholm, 2004).

However, changes in the policy agenda and the tools are not enough to promote the SD. It is essential to analyze society's system from several perspectives and also distinct scales. Fundamentally, the SD is a macroeconomic concept regarding a social project evolution. Companies and entities are actors of a global project however their evaluations are made on a microeconomic scale (Bouckaert, 2016).

Global society must, while it establishes SD strategies, to promote sustainability initiatives through the society's pillars. For this purpose, it is necessary to transfer the SD notions to a smaller spatial scale, as cities and regions and economic entities (Atkinson et al., 1999). As the idea disseminated by Rene Dubos[128] "think globally, act locally" (Original in French: "*penser global, agir local*") it is, therefore, a matter of integrating the global and local context into strategic thinking.

Many models for transferring the sustainability to a local scale were developed. The Agenda 21 - for the local government, and the Corporate Social Responsibility (CSR) or Global Social Responsibility (GSR) - for the companies; achieved more notoriety over the years (*Ibid*., 2016).

7.1 Local Agenda 21 for the local authorities

The Agenda 21 is an action plan of the UNEP that was declared during the Earth Summit, held in Rio de Janeiro, Brazil, in 1992. The goal was to foster a climate cooperation and solidarity between all countries to reach a more equitable and efficient world economy. It is a call for a "*global partnership for sustainable development*" (UNEP, 1992, Chapter 1.1).

In other to change globally, it is imperative the participation and the cooperation of the local government considering that many problems and solutions have their roots in the local activities and choices taken by local governments that can affect the national context

Therefore, the dialogue promotion with various local stakeholders is the role of the local authorities. Citizens, local organizations, companies, and public entities must collaborate with the decision-making (*Ibid*., Chapter 28.3). Without the stakeholders’ participation, there is no possibility to build a sustainable community.

[128] René Dubos is credited for having made famous Jacques Ellul's environmental maxim, "Think globally, act locally" during the Earth Summit of 1972.

The 'Local Agenda 21' (LA21) is a voluntary and a participative sustainability policy tool. It intent aims to assist and to follow the local government in planning their local action strategies in the long term to answer the requirements of the Agenda 21 daily in the local activities.

In French, the Law for the 'Management and Sustainable Development of the Territory,' from 25th June of 1999, stated that the LA21 would be the main existing tool to implement the SD locally. Five elements are required to successfully apply the SD (Ministry of Environment, 2012):

- Continuous improvement strategy,
- Stakeholders participation,
- Transversality of approaches,
- Piloting organization,
- Moreover, shared evaluation.

Even with its significant and undeniable pedagogical value, the French experience with the LA21 has been criticized, when compared with others European countries' LA21, denouncing some limits for the Agenda 21.

Emelianoff (2005) mentioned that, in France, the LA21 process is not significantly participatory due to a lack of public awareness and a weak tradition of participatory democracy. Lazzeri et Moustier (2008) highlighted that, in a general way, the various actors do not have a shared vision about the actions toward a goal of sustainability at the local level, especially due to the Agenda 21's general nature.

7.2 Corporate Social Responsibility

Inside the companies' context, World Bank, OECD and the UN promote the CSR as a call for action for enterprises responsibilities. Carroll, 1999 determined these responsibilities as economic, legal, ethical and philanthropic.

CSR has become an increasingly important concept both within the European Union and globally. It is about the contribution of the business environment to the SD and proactive solutions to environmental and societal challenges (Vasilescu et al., 2010).

Many similar definitions for the CSR can be found. The European Commission has defined CSR as *"the responsibility of enterprises for their impact on society"* (EC, 2017). Business for Social Responsibility (BSR, 2017) determinates CSR as "*the business operations meet or exceed social expectations of industrial and commercial institutions in the ethical, legal, commercial and public area."*

According to the World Business Council for Sustainable Development (WBCSD, 2000), the CSR "is a corporate commitment to contribute to sustainable economic development, employees and their families, local communities and the whole society to improve their quality of life." Finally, ISO 26000 (2010) denominates CSR as *"the responsibility for an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior*."

The ISO 26000:2010 also provides guidance on how businesses and organizations can operate in a socially responsible way (ISO, 2010). The ISO 26000 supplies globally relevance advice on:

- Definitions and concepts related to social responsibility (SR);
- Background trends and features of SR;
- Principles and practices related to SR,
- Fundamental issues of SR.;
- Integrating, implementing and promoting socially responsible behavior throughout the organization and, through its policies and practices, within its sphere of influence;
- Analyzing and engaging the stakeholders;
- Communicating commitments, performance and other information related.

Furthermore, ISO 26000 identifies seven core subjects of social responsibility: organizational, human rights, labor practices, environment, fair operating practices, consumer issues; and community involvement and development. As we can notice, in the point of view of the ISO, the SR is essentially oriented toward the social and environmental aspects of sustainability.

In Table 4, the EC brings attention to the impact of the CSR on the sustainability, competitiveness, and innovation of EU enterprises, but also for the EU economy and society (EU, 2017). Primarily, CSR is an overall view in how companies integrate stakeholders interesting in the business strategies.

Table 4. CSR importance for distinct stakeholders. Source: EU (2017).

IN THE INTEREST OF ENTERPRISES	IN THE BENEFIT OF THE EU ECONOMY	FOR THE SAKE OF SOCIETY
• Benefits in the risk management, • Cost savings, • Access to capital, • Customer relationships, • HR management, • Ability to innovate.	• Companies more sustainable and innovative, • The growth of a sustainable economy.	• Offers a set f values to build a more cohesive society, • Offers the base for the transition to a sustainable economic system.

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As the concept of CSR extrapolates companies' borders, the EC published a document called 'Green Paper' the internal and external dimensions of CSR. Inside the inner dimensions, it is possible to mention categories as human resources management, health, and safety at work, adaptation to change, management of environmental impacts and natural resources. For the external dimensions, it is possible to find: local communities, business partners suppliers and consumers, human rights and global environmental concerns.

7.3 The case of social responsibility of the universities

For universities, it is feasible to indicate four main ways of perceptions on how universities contribute to the societal transition toward sustainability[129] (Colucci-Gray et al., 2006; Ferrer-Balas et al., 2007; Karima et al., 2006; Lozano, 2006; Stephens, 2008).

- Local government: The government finances the university, and it is the government that implements the Agenda 21 at the territory level where the university is located. Furthermore, universities have potential to encourage local systems to integrate the various types of SD knowledge and to improve the application of social change knowledge to meet the Agenda 21 requirements;
- Companies: The University has strong relations with the private sector that develop their CSR strategies. The university is linked with companies through the trainee's admission for internship programs or dual education system[130], and it is related to providers' companies, as building management, cleaning, security, internet companies. All these companies have their own GSR strategy. Furthermore, when the CSR values are promoted inside the universities programs, through teaching and curriculum activities, future managers, leaders, decision-makers, and employees. All these actors will join companies, adhere and foster the CSR values, and promote sustainability challenges;
- University: University as an institution has its strategy to keep its integrity, in other words, before to be a model for society, universities should implement a sustainable behavior promoting sustainable practices on the campus;
- Society: Universities play a major role in society as stable, free and independent institutions. It influences the society by enhancing outreach engagement, and interactions beyond

[129] Local government, companies and universities are important pillars of society.

[130] A dual education system combines apprenticeships in a company and vocational education at a vocational school in one course (In French: *Formation par alternance*).

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individual faculty, students, and staff that are affiliated with the institution. Society pressure to the university is also a potential action to foster university changes.

Figure 40 represents all these strategic models that can be used by actors to transfer sustainability from a global to a local context.

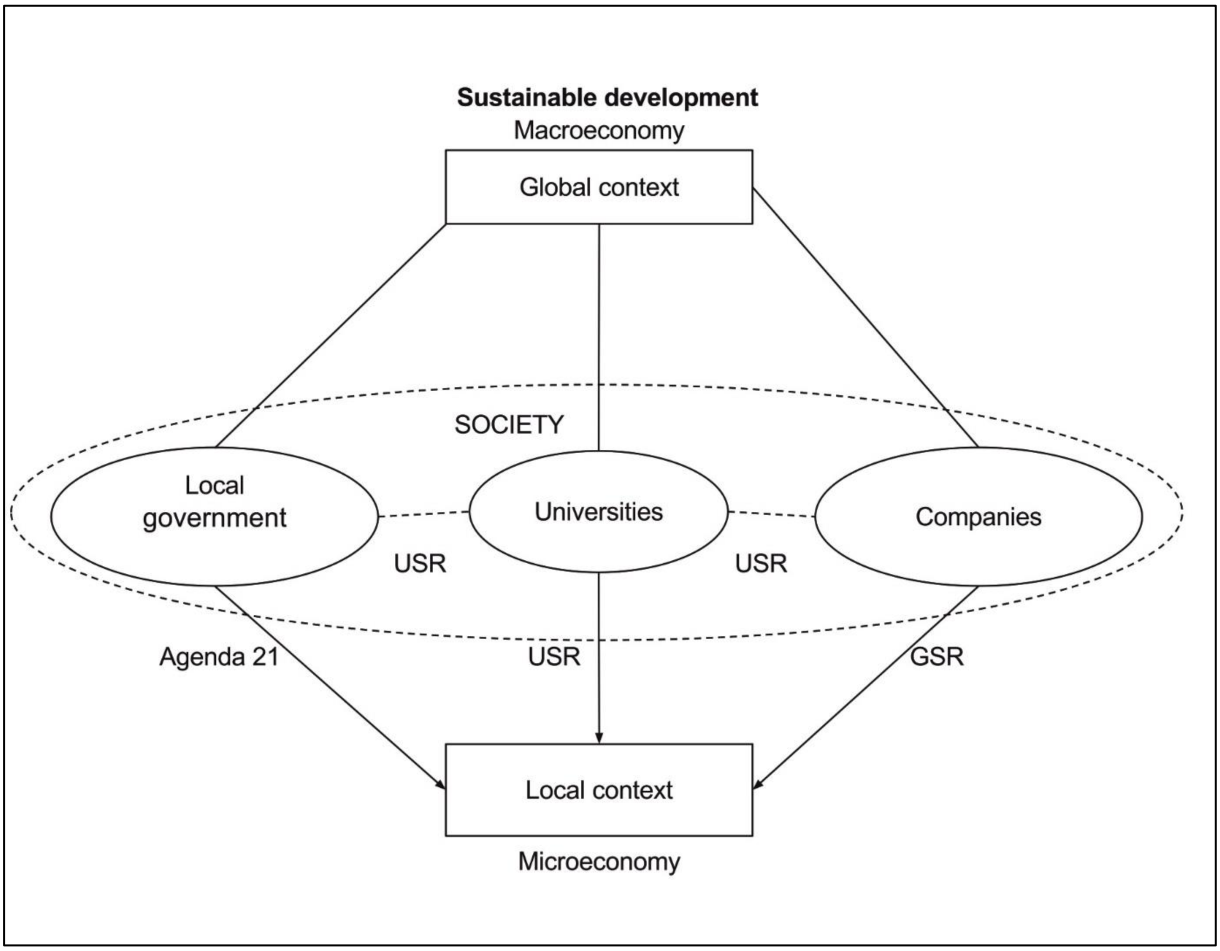

Figure 40. Strategic models that can be used by actors to transfer durability from a global to a local context.

The literature presents a significant amount of scientific publications on the question of the universities responsibility, obligations and roles about a societal transition toward sustainability. Orsu (2013) defined USR as the integration of all cultural, social, economic and environmental concerns in the universities' activities and their relationship with the local authorities and other components of society, for example, the companies.

Reiser (2008) defines the USR concept as:

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"a policy of ethical quality of the performance of the university community via the responsible management of the educational, cognitive, labor and environmental impacts produced by the University, in an interactive dialogue with society to promote a sustainable human development."

Karima et al. (2006), determined the axis of the USR's Triple Bottom Line (TBL) as (1) research and education, (2) society and (3) environment. The economic axis was excluded because the principal university activities cannot be found in the economic activities (see Table 5). On the environmental concerns, the main goal of universities is changing environmental behavior through the increase of environmental knowledge.

Pompeu et al. (2004) mentioned the impact of the USR on the creation and development of social capital[131] and human capital[132] that contributes to the local SD. As taken as a reference the Table 5, when universities provide superior education and research program related with the SD (see axis Education and Research from RSU), universities improve students 'human capital' enhancing their knowledge and competencies. It contributes also promoting the SD in the students' environment.

Table 5. Axis and main concerns of the CSR and USR. Source: Karima et al. (2006).

CSR	USR
ECONOMY • Close cooperation with stakeholders • Compliance • Providing superior products and services • Promoting entrepreneurial initiatives	EDUCATION AND RESEARCH • Close collaboration with stakeholders • Compliance • Providing superior teaching and research programs • Promoting academic, industrial and economic initiatives
SOCIETY • Human resources management • Health and safety at work • Local communities • Human rights	SOCIETY • Human resources management • Health and safety in education and research • Local communities • Human rights
ENVIRONMENT • Internal management of environmental impact and natural resources • Environmental concerns of local communities • Global environmental concerns	ENVIRONMENT • Internal management of environmental impact and natural resources • Environmental concerns of local communities • Global environmental concerns

131 Social capital is defined by the OECD (2001, pg.41) as "networks together with shared norms, values and understandings that facilitate co-operation within or among groups".

132 Human capital is defined by the Keeley (2009, pg. 29) "as the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being".

Regarding the RSU, the primary role of higher education institutions can be realized in two ways: universities can be perceived as a potential change agent, or universities can be observed as an institution that must be changed. We can take for instance the Figure 40, presented before. Universities interact to companies to promote the CSR and to local authorities to promote the Agenda 21, at this moment the university is interacting as a potential change agent, anyhow, to meet its RSU as the institutions have a unique position in society (Stephens et al., 2008).

7.4 Public policies that foster social responsibilities strategies elaboration

Public policies have a fundamental role in encouraging a great sense in higher education's social strategies for a transition to the SD. An important policy deserves attention: the 'Talloires Declaration.' As already stated before, the 'Talloires Declaration' is a declaration for sustainability, created for and by presidents of higher learning institutions. It can be considered as one of the most important documents to guide the universities in the sustainability challenge. 'Talloires Declaration' stated ten important actions to address the commitments of the universities with the SD:

- Increase awareness of environmentally sustainable development;
- Create an institutional culture of sustainability;
- Educate for environmentally responsible citizenship;
- Foster environmental literacy for all;
- Practice institutional ecology;
- Involve all stakeholders;
- Collaborate for interdisciplinary approaches;
- Enhance capacity of primary and secondary schools;
- Broaden service and outreach nationally and internationally;
- Maintain the movement.

Even with the significant number of signatures (i.e., 265 universities that signed the declaration) of the 'Talloires Declaration', there was a lack of engagement with a part of the universities that faced the signature as a momentary act. Despite this, many universities saw in the signature an opportunity to make efforts to address the sustainability challenge in the academic research, teaching, and service, and a framework to steady progress toward sustainability (Clugston and Calder, 1999).

The document presented the responsibility of the main universities role: the education. The education is the key to creating a sustainable future. On the other hand, students play an essential role as are the major actors for this process inside the society.

> *"Universities educate most of the people who develop and manage society's institutions. For this reason, universities bear profound responsibilities to increase the awareness, knowledge, technology and tools to create an environmentally sustainable future" (ULSF, 1990).*

In the French context, in 2007 the 'Liberties and Responsibilities of Universities' [133](LRU) Law or Pécresse Law[134], appeared as an attempt to increase universities financial autonomy and responsibility.

The LRU Law previewed that, by the 1st January 2013, all universities shall achieve autonomy in the budgetary matters and the management of their human resources. This Law also stated that all universities might become owners of their immovable property. This law is criticized by most of the student organizations and unions of teacher-researchers' due to budget strained. In reality, the government has shifted the management responsibility to the universities.

With the transfer of budgeting and human resources management skills to universities, the government intends to empower the actors and implement the conditions for improving the quality of their activities (Bouckaert, 2016). The LRU law previews the passage of universities to Extended Responsibilities and Competences (ERC)[135] that consists of these new budgetary skills and human resources management.

In what consists of RSU, due to the complexity of the subject, we cannot embrace all the roles of the university about the societal transition toward sustainability promotion. Hence, we decided to focus our study on the idea that university is an institution that needs to be changed. Only this way the university can provide the continuous collaboration to the society. In this sense, the adaptation of the university campus building concerning the energy transition and other environmental aspects must be considered.

Eventually, for the present thesis work, CSR strategies might be valuable for the universities' precondition when choosing construction companies to enroll in the building site, or for building

[133] In French: Loi relative aux libertés et responsabilités des universités.

[134] The bill was presented by the French Ministry of Higher Education Valérie Pécresse and was officially voted on 11 August 2007 by the Parliament.

[135] In French: Responsabilités et Compétences Elargies (RCE).

maintenance or building management. The LA21 is relevant likewise because of the local government significance involvement in the construction and renovation university buildings process. Furthermore, the adoption of the LA21 by the municipalities is a voluntary act and a way to increase awareness. The environmental education could mobilize local stakeholders to participate in the elaboration and implementation of the LA21.

8 CONCLUSION

The massif growth in the number of the students after the Reconstruction period resulted in deserted university constructions. Far from the city centers, these buildings had of integrated lack of urban planning concerns. More attention was given to this issue with the modernization programs that aimed to improve the urban connection between the campus and the city, enhancing student's quality of life. New universities were born with better quality in the architecture and urban planning.

This historical context assisted in the determination of the relations between the university campus and the city. The connection between the towns and the universities depends on their location (i.e., inside old city centers, peripheral universities or neither inside old city centers neither in the peripheries). The large spaces in the city that the universities required to develop their research, teaching and training activities, and the diverse mobility options are essential conditions to stablish a connection between the universities and the cities.

Regarding the architectural of the universities' buildings, we can conclude that the modern architecture had a significant impact during the 'Reconstruction Period' and the 'First Boom' period. Simplicity, rapidity, and low costs of the construction process were the main drivers. The contemporary architecture gained prominence after the 1990's with more cultural values approach. The current universities architecture should prepare the buildings' structure for a new environmental approach, with the energy efficiency promotion, reduction of the potable water consumption, waste management, and users comfort.

The search for a sustainable campus was driven especially due to numerous declarations and reports presented in this Chapter. Among these national and international documents, we can highlight the 'Taillores Declaration' as an important document that expresses the responsibilities and the roles of universities.

Regarding the sustainable campus, we can conclude that the concept of 'green campus' appeared as an important intermediary stage. Energy efficiency, transporting and commuting much contribute to the universities' carbon footprint. These issues were found by many authors to be the main challenges of the higher education institutions in their transition toward a sustainable campus.

The local actions implementation to promote energy efficiency and GHG emissions reduction are not an easy task. In the long term, universities must determine their strategies at their policy plans to pass through a sustainable university.

We concluded that universities could promote sustainable development in four particular ways: regarding the companies, local government, society and the university itself. For this thesis work, we decided to focus on the idea that the university is an institution that needs to be improved to continue to carry out its activities. Strategies can be applied to improve the universities buildings environmental impact, students' comfort, life quality, and the connection with the university campus, regarding urban planning and other issues that we will determine throughout this thesis.

SECOND PART

HOW CAN WE EVALUATE THE STRATEGY PERFORMANCE OF THE UNIVERSITY BUILDING RENOVATION PROCESS?

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Chapter III. A participative multi-criteria evaluation for the sustainability of university buildings

1 INTRODUCTION

In the previous chapters, we presented the definitions and origins of the SD and how this new paradigm induces the society to rethink the economic growth and the natural capital use. Cities and buildings are key elements to promote the natural resources conservation, social equity, and economic prosperity. This thesis work approaches the education as a significant driver to raise the stakeholders' awareness to collaborate on the achievement of the sustainable cities, buildings, and notably, the sustainable campus. Additionally, according to Cortese (2003), the education is one of the four dimensions of the university, together with the research, the campus operations, and the community outreach.

Universities have *"a profound, moral responsibility to increase the awareness, knowledge, skills, and values needed to create a just and sustainable future"* (Ibid., 2003, pg.17). Universities are a potential change agent but at the same time an institution that needs to follow the global societal transformation that sustainability implies (Bouckaert, 2016). The Green Plan and the Blueprint for a Green Campus highlight the importance of defining goals for the campus structure improvement. Both documents bring attention to the campus waste, energy efficiency, and responsible purchasing policies.

The physical structure of the university campus is a fragment of the city, fulfilled with urban elements, like buildings, parking lots, and green areas. The urban planning and the architecture issues are part of the university campus concerns. Hence, when determining the aspects of the sustainable campus, it is necessary to encompass the green buildings and the sustainable cities context, in the sense that all these aspects are related. Figure 41 presents a university campus' system containing the buildings, the neighborhood and the city. The arrows represent the various relations and the system exchanges.

Facing sustainability as a societal state, it is essential to acquire knowledge in the instruments that society can use to transfer the global policies goals into local strategies and actions. Assessments methods and tools have a crucial role to enhance sustainability in many sectors, and especially in the construction industry. The evaluations systems can determine the achievement level of an objective. They are useful to the settlement of the actions to be taken subsequently to improve the organizations' performances.

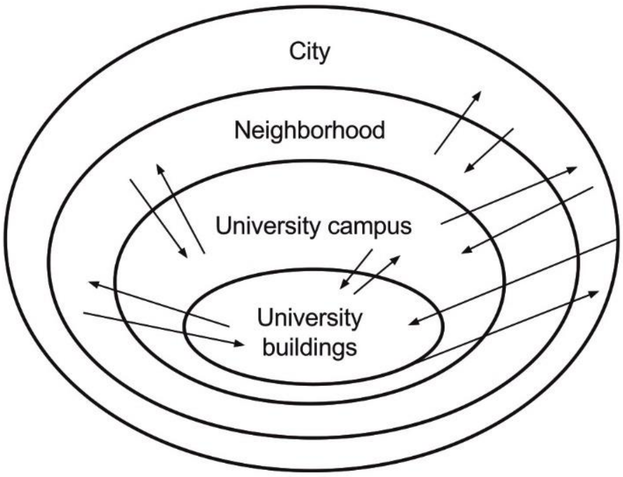

Figure 41. Hierarchical system of the university campus

This thesis work is about the sustainability assessment of the universities buildings' renovation process. We selected a case study to evaluate the strategy performance of the renovation process. We will focus in the renovation of buildings due to the enormous potential that this process possesses to reduce the energy consumption and other environmental impacts in France. The building design, construction, occupation and maintenance phases will be considered. We will introduce the main '*Aile Sud'* building as our study case and its main features. We will present the background of the UVSQ implementation inside the BN and the innovation potential of the building renovation process.

In a first moment, we will put our efforts to answer the question about « why we should evaluate? » as a prerequisite for our second question « how we can evaluate? ». We will present a general context of the evaluation systems, as, the fundamental elements of evaluation, the main goals, and the main methods.

To answer the second question « how we can evaluate? » we will be launching a review of the buildings and universities assessment systems for analyzing the limitations and the contributions of each tool and method. Also, we will present an urban innovation method that we will take as a reference method. Besides that, the main implications and limitations of each method and tool will be discussed.

A discussion on the concept of sustainability evaluation in the university buildings will be introduced, as well the essential elements of a sustainable assessment, and the evaluation through integrated methods highlighting participative methods. We will conclude this chapter presenting the INTEGRAAL framework and the ePLANETe platform as key elements that will support us in the construction of a new model.

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2 UNIVERSITY OF VERSAILLES-SAINT-QUENTIN-EN-YVELINES (UVSQ)

The University of Versailles-Saint-Quentin-en-Yvelines (UVSQ) was founded in 1991, inside the context of the U2000 plan from the relocated centers of the University Marie Curie (Paris VI) and the University of Paris X-Nanterre that went to Yvelines department [136]. This relocation was held to reply to the massif augmentation of the number of students that were from Yvelines department, but also to answer the real need to decongest Paris (i.e., '*Intra-muros*'). The government desired to integrate the universities with their deployment territory. The idea was to make them actors for the urban planning decisions but also, for the establishment of partnership (CNE, 2006).

The UVSQ was first implemented in five urban agglomerations of the Yvelines department: Rambouillet, Saint-Quentin-en-Yvelines, Mantes-en-Yvelines, Versailles, and Vélizy (Figure 42). In 2002, the University expanded the campus to the Hauts-de-Seine department, in Garches and Boulogne. The chosen territories have different socio-economy, industrial and cultural activities, and have the strong potentiality to set partnership. These territory characteristics influenced the project funding possibilities, the professional integration of students, and the opportunities for research. Furthermore, the UVSQ contributes with the regional dynamism (*Ibid.*, 2006).

The University most important principles are the multidisciplinarity; pedagogical, scientific, administrative and financial autonomy; and active participation (a democratic management with the interaction of all staff, students and external personalities). UVSQ's missions are the initial and continuing training; scientific and technological research; dissemination of culture, and scientific and technical information; international cooperation; orientation and professional integration; and participation in the construction of the European higher education and research context (UVSQ, 2016).

The several educational and scientific research axes confirm the multidisciplinary feature of the UVSQ. Currently, the UVSQ's educational axes are (*Ibid.*, 2016):

- Arts, Letters, Languages;
- Law, Economics, Management;
- Humanities and Social Sciences;
- Moreover, Science, Technology, Health.

[136] The University of Paris X opened its new center in Saint-Quentin-en-Yvelines in 1985; and the University Marie Curie opened its center in Versailles in 1987 (CNE, 2006).

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The scientific research axes are composed by (*Ibid.*, 2016):

- Climate, environment, sustainable development;
- Culture and Heritage;
- Genome, environment, cellular responses;
- Epidemiology;
- Handicap and aging; Institutions, organization, and public policies;
- Innovative materials: from their genesis to applications;
- And, modeling and simulation of complex systems.

Figure 42. UVSQ 's centers in France and their location regarding Paris. Source. Google maps.

The UVSQ is composed by about 20000 students and 1100 professors, teacher assistants and researchers, and 720 personal staff. These numbers are expected to grow with the foundation of the University Paris-Saclay where UVSQ is a founder member. The creation of this new university, inside the Plan Campus, is a truth endeavor to meet the global competition challenges for the teaching, research, and innovation. The goal is to raise the training and research to the highest national and international levels, and to brings both together in a single governance institution. The new governance should preserve the training and research identities, and coordinates their action in a shared vision of research, teaching, and innovation (*Ibid.*, 2016).

The University Paris-Saclay is composed by 20 educational establishment, called also *Communauté d'universités et établissements* (COMUE), as listed below:

- Two universities: the University Paris-Sud, the University of *Versailles-Saint-Quentin-en-Yvelines* and the University of *'Évry-Val-d'Essonne;*
- Ten 'grand écoles': the *'AgroParisTech'*, the *'CentraleSupélec'*, the '*École des hautes études commerciales de Paris'* (HEC), the *'École polytechnique', the 'École normale supérieure'* (ENS) Paris-Saclay, the *'École nationale supérieure de techniques avancées'* (ENSTA ParisTech), the *'École nationale de la statistique et de l'administration économique*' (ENSAE ParisTech), the 'Institut Mines-Télécom' (IMT), and the *'Institut d'optique Graduate School'* ;
- Seven research institutes: the *'Centre national de la recherche scientifique'* (CNRS), the '*Commissariat à l'énergie atomique et aux énergies alternatives'* (CEA), the *'Institut des hautes études scientifiques'* (IHES), the *'Institut national de la recherche agronomique*' (INRA), the *'Institut national de recherche en informatique et en automatique'* (INRIA), the *'Office national d'études et de recherches aérospatiales'* (ONERA), and the '*Institut national de la santé et de la recherche médicale'* (INSERM).

The UVSQ desires to engage the SD strategies inside the university through the research and training programs, student engagement promotion, social inclusion, and environmental impact campus reduction. The main strategies to reduce the environmental impacts inside the campus are eco-mobility promotion, preparation of an energy efficiency project and a responsible purchasing policy, implementation of a waste management policy and awareness activities for students and staff (UVSQ, 2011).

2.1 UVSQ's contributions for the SD on the campuses

The UVSQ became an international reference for the research, teaching and partnership activities in the fields of climate, environment, and sustainability. Many research laboratories, as the OVSQ (*Observatoire de Versailles Saint-Quentin-en-Yvelines*), the LATMOS (*Laboratoire Atmosphères, Milieux, Observations Spatiales*), the LSCE (*Laboratoire des Sciences du Climat et de l'Environnement*), and the REEDS center (*Centre international de Recherches en Économie-écologie, Éco-innovation et ingénierie du Développement Soutenable*[137]) contributed to this condition.

[137] International Centre for Research in Ecological Economics, Eco-innovation and Tool Development for Sustainability.

The University is also a French leader on the campus sustainability strategies as a result of its achievements and guidelines of the G2E-Campus[138] project, and its role in the University President Forum which manage national policy in France. Lanceleur and O'Connor described in their report 'Towards a Sustainable Campus Social Network Operational Design' others important sustainable campus initiatives in France (see Table 6).

Table 6. Sustainable campus initiatives of the UVSQ. Source: Lanceleur and O'Connor (2015, pg. A3).

SUSTAINABLE CAMPUS INITIATIVES
• Business-research partnership foundation Mov'eoTec (2008-2012), precursor for the creation of the national Institute for Low-Carbon Vehicles and Mobility Safety (VEDECOM) since 2013; • The Research and Higher Education Green Plan (Plan Vert des établissements d'enseignement supérieur et de recherché) adopted by the CPU (Conférence des Présidents d'Université) and the CGE (Conférence des Grandes Ecoles); • Conception and experimentation of the auto-evaluation tool EVVADES for applications across France (2009-2012) in the context of the Plan Vert; • Design and creation of Business-University « International Industrial Chairs » in concentration with the international research centre REEDS at the UVSQ, more particularly: (a) The ECONOVING Chair « Managing Eco-innovations » with Alstom, Gdf-Suez, Saur, Italcimenti, and the SNCF for the period 2008-2012; renewed in 2012 with financial support of the French ANR (National Research Agency) under the Business-University Chair Programme. (b) The « Sustainable Campus » Chair with Bouygues (2011-2015); • Piloting the obtaining of the European « Urban Living Lab » Label for the territories of Versailles and Saint-Quentin-en-Yvelines (2011/2013); • The pilot project SMART CAMPUS at the l'UVSQ, with funding from EUROGIA+, in partnership with Renault, for experimentation of a pooled fleet of electric vehicles with recharging from energy generated on the roofs of University buildings (2011-2014).

Between the laboratories of the UVSQ, there is one center that draws attention due to the establishment of several national and international partnership. The Center REEDS was an active actor of the creation of the Sustainable Campus Launching Customer[139] (CLC) France in the European Climate KIC[140] consortium, where UVSQ is a core partner (Lanceleur and O'Connor, 2015). Besides that, it is a founding member of the EURBANLAB project (see Table 6).

[138] Methodological guide for energy efficiency projects in universities.

[139] The CLC project has as main objective to facilitate and speed up the development of sustainable innovations in the campus and their regions. The main partners of this project were: Delft University of Technology, REEDS-UVSQ, University of Valencia, University of Debrecen, Utrecht University, TU Berlin, Wageningen University and Research Centre, and University of Warwick (CLC, 2017).

[140] Climate-KIC is one of three Knowledge and Innovation Communities (KICs) created in 2010 by the European Institute of Innovation and Technology (EIT). The organization integrate education, entrepreneurship and innovation resulting in connected, creative transformation of knowledge and ideas into economically viable products or services that help to mitigate climate change.

Furthermore, we can add here the student national challenge 'GreenTIC Cam pus' – a student contest on how to get better ICT use on the campuses for the SD, organized by FONDatERRA [141] (CLC, 2017).

3 THE HISTORY VALUE OF THE BERGERIE NATIONALE IN RAMBOUILLET

The *Bergerie Nationale* (BN) is located in the Yvelines department, in the Versailles' area, and in the heart of the *Parc du Château*, inside the *Domaine de Rambouillet.* The BN is a complex of historical heritage buildings. It occupies about 250 hectares of the *Domaine de Rambouillet* that has about 1.100 hectares.

Louis XVI founded the BN in 1783 to be a model farm for developing innovation in the agriculture and animal husbandry. The mission to become a training center appeared since the 18th century, with the construction in 1785 of the royal farm experimentation, and, 1794 with the opening of the shepherds' school. Over the centuries, the establishment has regularly renewed its primary role as a farm for the experimentation and training of agricultural professionals (BN, 2017).

In 1994, the BN's mission evolved. The establishment started to work within the support system of the public agricultural education, under the supervision of the General Education Directorate (DGER) of the Agriculture Ministry. The CEZ[142] - *Bergerie Nationale* was transformed in EPN[143]. Currently, the BN provides national support services for the agricultural education, and the field actors engaged in the SD. The BN's activities are based on two types of actions: training of trainers and resource centers in several skills domains. This is affirmed by its missions around agriculture, land use, education in environment and rural tourism over the years (*Ibid.*, 2017).

In 2012, these themes were reaffirmed, and, presently, are a part of the sustainable economic, social and cultural development of the rural and peri-urban territories in which the agricultural training system is involved.

Furthermore, since 2008, the BN is a Public Establishment Club of Sustainable Development's member (i.e. created by the Ministry of Ecology). In this context, it is involved in the coordination of a working

[141] FONDaTERRA, the European Foundation for Sustainable Territories (Fondation Européenne pour des Territoires Durables), "was a partnership structure set up initially in 2004 as an association and the, transformed in 2009 into a 'Partnership Foundation' comprising 4 founding members (EDF, Vinci, GDF-Suez, UVSQ) and thirty contributing members from the business community (SFR, Véolia, Bouygues, Aéroport de Paris, etc and others). The innovative actions of FONDaTERRA thus correspond to the full decade 2004-2014 and not just the 5-year period as a foundation" (Lanceleur and O'Connor, 2015, pg. A2).

[142] Centre d'Enseignement Zootechnique.

[143] Établissement Public National

group. This task force developed a clear methodological guideline. They adapted the methodological guideline to the public sector to help members to integrate SD into their policies and to measure their performance in the field.

3.1 Implementation of the UVSQ in the BN

In the context of the *Bergerie National*e restructuring (Figure 43), the French government launched a call to create a center of excellence and reference for the SD. The ministry of Agriculture, landlord of the BN, established a partnership with the UVSQ, which previewed a restructuration of the BN to install a center of research, technology[144], and training dedicated to the sustainable agriculture and the SD in the territory (BN, 2017).

Part of the team IACA of ex-C3ED (*Centre d'Économie et Éthique pour l'Environnement et le tSud*' building inside the BN. The team was later denominated REEDS - *Centre International de Recherches en Économie-écologie, Éco-innovation et ingénierie du Développement Soutenable*[145] (UVSQ, 2009).

Figure 43. Main entrance of the BN. Source: BN (2017).

Hence, a major renovation project for the '*Aile-Sud*' building took place in 2009, and it was completed in 2011. The building renovation works consisted of two main phases: the improvement of the exterior façades conditions, and the interior design modification. The building exterior works carefully preserved the 17th century's building architecture style (see the Annex 1). Special care was taken

[144] In French: ERT - Equipe de Recherche Technologique.

[145] The International Centre for Research in Ecological Economics, Eco-innovation and Tool Development for Sustainability.

during the demolition and construction phase not to damage the façade. Internally, a new layout was proposed to adequate the building to the research, training activities, and to the challenges of the energy transition

3.2 Presentation of the interior renovation works of the *'Aile-Sud'* building

The *'Aile Sud'* building has a total floor area of 1334m², and it accommodates teaching, training and research activities, divided into four floors. The renovation project has as main goals to provide a proper, healthy and functional interior design to accommodate all these activities, and the building energy efficiency improvement (UVSQ, 2009).

The *'Aile Sud'* building renovation project took inspiration in the passive house concept. The idea was to turn a historic building into an ultra-low energy building. The construction project priority was the reduction energy for space cooling and heating, but at the same type, respecting the external architecture of the 17th century. The buildings renovation process can be considered as a crucial adaptation and mitigation strategy to reduce the energy consumption and the greenhouse gas emissions globally.

We can summarize the renovation works of the *'Aile Sud'* building in the study phase and the project execution (Bittencourt et al., 2015):

- Study phase: Diagnosis, validation of the project design, project design conclusion, elaboration of a list of companies involved in the project, analysis of the offers, and contracts;
- Project execution: Asbestos removal, preliminary activities, and construction site activities (e.g., Unsealing and asbestos removal, facilities construction, and deconstruction).

In the meantime that the demolition and construction site took place, the BN’s activities continued to be developed as the BN was a site in exploitation. Hence, some impacts of the deconstruction and construction activities were anticipated to reduce the eventual nuisance for the users and the neighborhood.

A careful analysis was carried out to separate the demolition and construction site work flow of the *'Aile Sud'* building from the BN’s daily activities flow. The construction site access inside the *Parc du Chateau* was indicated (see the Annex 1). Beyond that, the project manager established a noise (e.g., Trucks, all power-driven engines, compressors, saws, all percussion tools, and others) dusty, and smell control (e.g., Sanding, demolition, abrasive removal) *(Ibid*., 2015).

3.3 Participation of the various project stakeholders

The participation of the distinct project stakeholders groups was a relevant feature of this renovation process. The *'Aile-Sud'* building is located inside the BN, where the Ministry of Agriculture is a landowner. The building was temporarily granted to the UVSQ to develop research, training, and teaching activities. As the BN is in Rambouillet, in the Yvelines department, the complex is supervised by the General Council of the Yvelines [146]. The General Council of the Yvelines financed this project in partnership with the *Ile-de-France* Department through the UVSQ[147].

All the building that has a historical value architecture, as it is the case of the *BN's* buildings, are under the responsibility of the *Association Nationale des Architecte des Bâtiments de France* (ANABF). The ANABF has as special mission the management and protection of the historical monuments and protected sites in France (ANABF, 2016)

The UVSQ was the project's client or owner, and it was represented by the dean. The dean delegated a project leader that was in charge of the project. The project leader represented the interests of the UVSQ in the concept design project, and during the meeting during the construction site works.

In France, the term '*maître d'ouvrage*' is used to determinate the client, which in our case study was the UVSQ. According to the law n° 85-704 of the 12 July 1985, the project owner or the '*maître d'ouvrage*' *"is the legal person (...) for which the work is built. He is the principal person responsible for the works, and in this role, he fulfills a function of general interest from which he cannot resign himself"* (Translation of the République Française, 1985, Article 2).

The director of the property assets department of the UVSQ was also involved in the project. This UVSQ's department deals with studies, works, maintenance, conventions, budget, and data related to the property's assets.

After being assured about the feasibility of the project, the project owner can determine the project location, the provisional timeline, the program, the financial plan, the process by which the work will be carried out, and the contracts for the study and works execution. The project owner follows the project during all the phases of the implementation.

[146] In French: Conseil Général Départemental du département des Yvelines (78).

[147] The digital network extension of the site was financed a half by the UVSQ and a half by the CCPFY.

The UVSQ hired aproject manager for the project implementation. The project manager was engaged in the project designing, coordinating and monitoring activities (in French: '*maître d'œuvre*'). In the case of the UVSQ-BN implementation, the project manager was an architecture firm.

According to the Article 7 of the law n° 85-704 of 12 July 1985, the main activities of the project manager are: sketch studies; pré-project studies; project studies; assistance in the contracts management; execution drawing; the management of the works contract execution; scheduling, management and coordination of the site; and the assistance to the client during the project reception and during the completion guarantee period (République Française, 1985). A company specialized in project management consulting was hired to adequate the project to functional, budgetary and time constraints (AT OSBORNE, 2009).

The law n° 85-704 also previews the mission of Scheduling, Management, and Coordination[148] that should be developed by an SMC coordinator which is a *"natural or legal person responsible for assuming the scheduling services, coordination and construction site management"* (Translation of AFNOR, 2000, pg. 15). The SMC Coordinator's main responsibilities are the analysis of the construction site tasks, the determination of their sequences, the harmonization in time and space of the actions of the various actors involved in the construction and the conclusion of the works. In the case of the *'Aile Sud'* building renovation works, the SMC coordinator is not the same company in charge of the project management, and it had a particular contract.

After 1st January of 1996, all the independent construction site must hire a company to be in charge of the health and safety (MTAS, 1996). The Health and Safety Coordinator (HSC)[149] is *"a natural or legal person designated in the contract documents, who is responsible, under the responsibility of the contracting authority, for the HS coordination"* (Translation of AFNOR, 2000, pg. 15). In the context of our case study, one company was delegated to coordinate the HS.

Moreover, a construction technical controller is necessary according to the law n° 78-12 of 4 January of 1978. The construction technical controller has as main goal the prevention of the various technical risks that may be encountered in the construction site works. The technical controller analyzes the risks and advises the client on the strength of the structure, the safety of persons, and verifies if the project elements are in accordance with the contract, but does not prescribe a solution. The

148 In French: Ordonnancement, Pilotage et Coordination - OPC.

149 In French: Coordonnateur en matière de Sécurité et de Protection de la Santé (CSPS).

contracting authority, or the client, decides on the follow-up to be given to these opinions (République Française, 1978).

In the building sector and public works, the engineering firm[150] is an actor of the project management team. It has as the main goal to assist the architect in the technical aspects of his other competence. The engineering firm's role in the case of the *'Aile Sud'* building renovation works was to support the work of all the areas of engineering, from feasibility to project implementation, to guarantee the costs, delays, and quality control.

The construction site works were divided into five groups of activities: (1) structure (e.g. Plastering, false ceiling, structural work, interior and exterior carpentry); (2) floor, walls, and painting; (3) heating, ventilation and plumbing; (4) electricity; and (5) elevator. For each group of activities, a company was hired.

Finally, is crucial to highlight that the main goal of an architectural project is to create healthy and high-quality spaces for the users' activities. In the case of our case study, the users are researchers, students, professors and UVSQ's staff. The architect role here was to provide a space where the all the users can keep the productivity of their activities.

3.4 The main outcomes of the *'Aile Sud'* building renovation

As mentioned before, the outside of the building was entirely renovated. A cleaning and painting process recovered the historical façade. Beyond that, the building entrance and the parking area were restored to provide adequate access to the building.

Internally, before the demolition works, a specialist investigation found asbestos in some parts of the building what resulted in the asbestos removal from all the interior spaces. Furthermore, a whole renovation and refurbishment process was held. The interior design project was elaborated to accommodate teaching, training and research activities. It was previewed a complete substitution of the electrical installations, providing quality and energy economy, and an improvement of thermal and acoustical isolation performance (Bittencourt et al., 2015). Besides that, an energy audit was performed to increase the energy efficiency, and to reach the requirements of the BBC label. Two essential elements were deeply studied: the thermal envelope and the technical equipment (*Ibid.*, 2015).

[150] In French: Bureau d'études techniques (BET).

For the thermal envelope improvement, walls, thermal bridges, and glazing were studied separated to maximize the passive solar heating (*Ibid.*, 2015).

- Walls: Thermal conductivity, insulation thickness and walls insulation materials[151] and ceiling were studied;
- Thermal bridges[152]: Four types of thermal bridges were studied and solved;
- Glazing: A study of the existed glazing system was carried on, and a modern glass system was installed without compromising the historical façade.

In the context of the technical equipment, the project team studied the heating, lighting and ventilation systems.

- Heating and cooling system: Installation of an aero thermal heating system. The heat pump drains the air calories and made a heat exchange through a refrigerant fluids air system;
- Lighting system: An efficient lighting system was settled. Occupancy sensors were installed in the rooms and corridors that turn on the light with the user's presence;
- Ventilation system: Double flow ventilation system with a heat recover up to 89% was installed.

Moreover, other strategies can be highlighted:

- Increase in the natural lighting use (especially in the offices where users stay longer) to reduce the energy consumption, and to provide users' visual comfort;
- Setting-up a building information centralization in a computer-based control system called BMS (Building management system) for monitoring the building's mechanical and electrical equipment such as ventilation, lighting, power, fire, and security system;
- Installation of electricity meters to measure and control energy consumption;
- Use of sustainable and resistant material;
- Installation of internal shading devices to improve the climate comfort during the summer;
- Healthy air quality strategies throughout the building, especially in the meeting rooms;

[151] During the renovation process, all the building was insulated to improve energy efficiency. Natural insulation as used. The system is composed by 70% of plume, 20% of polyester and 10% of sheep wool. Al the window's glazing were replaced by a Thermal Reinforced Insulation system which is composed by a double-glazing technology and inert gas to fill the cavity within a low-emissivity (Bittencourt et al., 2015).

[152]

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- Preference for a natural ventilation system.

Before the building renovation works, the energy consumption was 277.80 kWh/m². At first, the renovation project estimated to reduce the energy consumption to 80.5 kWh/m². However, after analyzing the energy bills, it is possible to affirm that the real building's energy consumption is 57.65 kWh/m². This is about 79.24% less than the initial values of energy use. The 'Aile Sud' building's diagnostic of energy performance (Figure 44) shows that the renovation process assisted in the achievement of the energy label category B, what is the recommended by the *Grenelle Environment*.

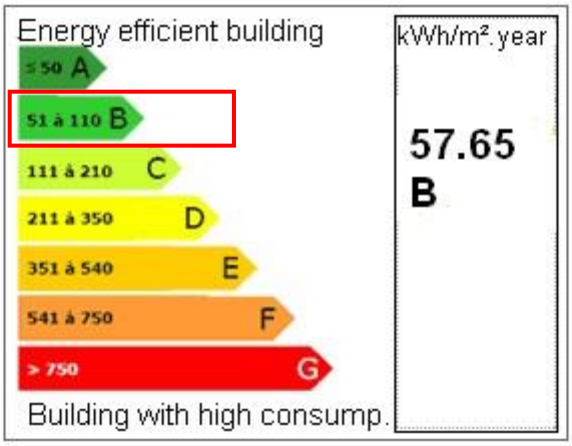

Figure 44. Energy label of 'Aile Sud' building.

The interior design project incorporated the spaces flexibility concept. The flexibility is seen inside the architecture as an important approach to reach sustainability. When spaces are flexible, they consider that users might have distinctive needs during the day. Also, in the same space, many activities can be developed. Moreover, the building could expand in the future; the space flexibility plays an important role because the less raw material is needed and less waste is generated to adapt the building to the occupants' needs. In other words, flexibility increases the building environmental performance (*Ibid.*, 2015).

The internal spaces divisions (e.g., dry walls) can be changed or expanded depending on the user's needs. Besides, lighting, thermal and electric systems can be modified to suit internal changes regarding the future building expansions. Hydraulic, electrical and heating systems are installed behind demountable structures that enable a full accessibility of the building systems. It also facilitates maintenance services (*Ibid.*, 2015).

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Accessibility can be highlighted as an important feature of the project. The corridors and doors are properly large to provide adequate circulation space for a wheelchair. Accessible toilets were designed to accommodate the people with physical disabilities. An elevator ensures the wheelchair users' access from the basement to the third floor. Besides that, the main building entrance has ramps to ensure the wheelchair users access to the building. The building is equipped with tactile paving close to the stairs to warn and to conduct the people visually with physical disabilities (see the Annex 1).

Another key aspect of this renovation is the building adaption to the digital transition. As shown in Chapter 2, the digital transition can influence the internal spaces disposition. A meeting room was whole equipped to allow video-conference. All the offices and spaces have a Wi-Fi connection as a result of the local internet network modernization. Previously, the BN possessed an ADSL internet connection that could not answer to the Centre REEDS needs, and the BN was not connected with the Royal Network (*Ibid.*, 2015).

The Royal Network[153] is a broadband network that connects 16 institutions from five partners (UVSQ, INRIA, INRA, Versailles Academy, l'IUFM of the Versailles Academy) and comports two pairs of dedicated optic fiber to interconnect all these partners (see the Annex 1). This network extension[154] allowed the Center REEDS to continue its work with the development, deployment, and operation of interactive multimedia systems in the research fields (e.g., interactive creations in virtual reality like VIVIANE, KerBabel systems for documentation and file catalog, ePLANETe, and others). This extensions network was co-financed by the UVSQ and the CCPY (*Communauté de Communes Plaines et Forêts d'Yvelines)*.

Before the BN restructuration, the site was mostly accessible by car or by combining train and walking. The Rambouillet train station is about 50km from the center of Paris and is 35 min from Paris by train and one hour by car. The BN is located inside the 'Parc du Chateau', about 3 km from the Rambouillet train center, or 38 min of walking distance. To deal with this distance issue, and at the same time, promoting eco-mobility, a new bus line was created, leaving from the Rambouillet train center, passing through the city center and the castle, arriving in 12 minutes to the BN (see Figure 45).

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[153] In French, it is denominated *'Réseau Royal'* that was financed 50% by the local government.

[154] The execution of this extension works was coordinated by the UVSQ and encompassed many stakeholders, as the 'Groupement ROYAL', 'EIFFAGE Connectic78', the '*Conseil Général des Yvelines*', the '*Communauté de Communes Plaines et Forêts d'Yvelines*', the Agriculture Ministry, the *'Commissariat à l'aménagement des Domaines Présidentiels*', the '*Service Départemental de l'Architecture et du Patrimoine des Yvelines'*, and the *'British Télécom Infrastructures Critiques*' (UVSQ, 2010).

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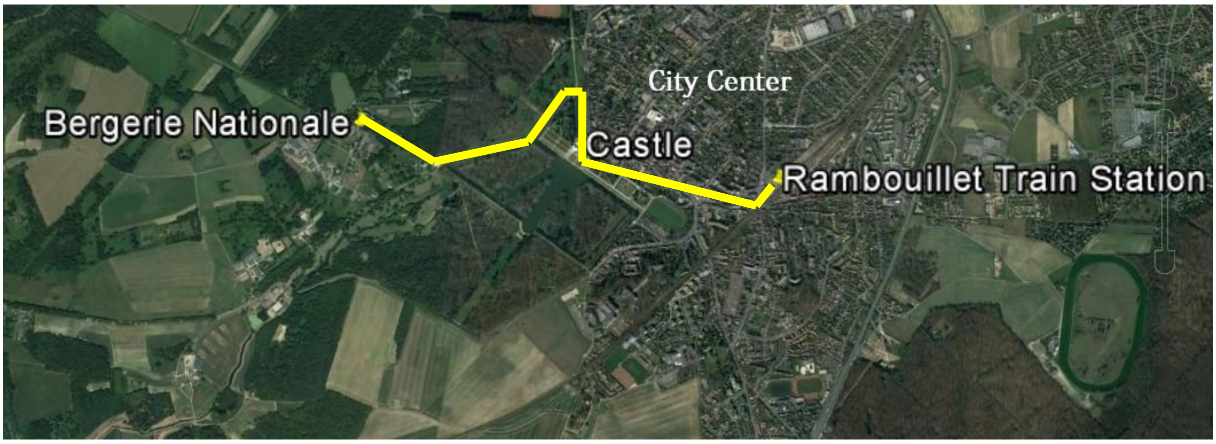

Figure 45. Google maps with the train station and the BN and the connection by the new bus line. Source: Google maps.

Inside the BN it is possible to find a local grocery shop and a restaurant. However, the city center where many commercial facilities are available is far 2km from the BN and accessible by car or bus.

In a general way, we can affirm that the *'Aile Sud'* building renovation has many environmental friendly significant features, but also it has urban planning targets to involve the local community, to promote eco-mobility, to create partnership and collaboration. The activities inside the building as a training center of the UVSQ, but also as the Center REEDS of research allowed the knowledge transfer regarding the GSR and SD approaches, and the development of international and national research in these domains of expertise.

4 THE GENERAL CONTEXT OF AN EVALUATION

In a first moment, a general background about evaluation appears pertinent to provide some clarifications. It might bring about the reasons of « why perform an assessment? » Thereon, in the next chapter section, we will focus on « how to perform an assessment? » of the university buildings.

4.1 Fundamental elements of an evaluation

We will present here two definitions of evaluations. For Behn (2003), evaluation is a process that can be divided into two stages: the measurement and the judgment. Indeed, the data generated by the measurement do not speak for itself. The data can acquire its meaning through a cognitive mechanism, often unconscious, by which the interpreter converts these results into relevant information. For Hadji (1989), the evaluation of an object is an act of judging the object's value (e.g., people, situation, action, project, and others) using a confrontation between two series of data, which are related to the real object to be evaluated and the ideal situation.

In our society, many 'objects' have been evaluating for several reasons: budgetary, quality of products, public service efficacity, buildings performance and others. However, the act of judging it does not comprise intervention either an improvement process. The evaluation is just a measure of judging, despite the enthusiasm it generates. As stated by Meirieu (1989, pg.13), "*the obsession with the thermometer never lowered the temperature"* (translation from French).

The act of evaluating is also to try to establish links between distinct reality levels while marking and underlining the distance that separates them. To perform an evaluation two ruptures are necessary. In a first moment, it is important to take some distance from the object on which the evaluator is about to speak, in other words, to introduce a break in the order of things and the immediate relations which they maintain.

After that, it is imperative to do the second rupture between the real and the ideal, typically represented by the norms. Inspired by this ideal, the evaluator should go through the problem of choosing a value. For adopting a value, the evaluator must elaborate one or plenty of ideas about the reality. The fundamental of the evaluation is a comparison between what exists and what was expected, a given behavior and a targeted one, and finally, between reality and an ideal model (Hadji, 1989).

To better explain the evaluation's elements, we will use as an example the hypothetical situation of the construction site's worker assessment by its supervisor. It is indispensable for the supervisor to speculate about the ideal conditions of the construction site employees to build a judgment. This will assist in the selection of the judging criteria, that in this case of the construction site employee, can be punctuality, attendance, efficacity, productivity, and others. The act of evaluation is an act of reading an observable reality with the help of the predetermined grid. It is a construction of the judgment (*Ibid.,* 1989).

Judgment is an act of the spirit by which people affirm or deny something. The value judgments are those by which one appreciates what the reality is worth. For this, it is necessary to define a value. In the broad sense, the value is the character that makes certain things deserve to be appreciated. Therefore, the evaluation judgment does not express a certainty.

Dispaux (1984) identified three types of judgment: the observer, the prescriber, and the evaluator. The subject, or the producer of the discourse, is committed in its statement. The evaluation statement reflects a kind of commitment. By the ‘observational’ statement ‘I assert that I see what I see.' By the ‘prescriptive’ statement, ‘I say how reality should be.' By the ‘evaluative’ statement, ‘I pronounce on what I see.' I appreciate things from the point of view that is transcendent. Hence, the evaluator is an intermediary position between the prescriber and the observer.

4.2 Evaluation’s objectives

Evaluations can have diverse applications. In some cases, they can be helpful to analyze past actions to make a descriptive of the results achieved. They can assist in the identification and the correction of the potential deficiencies. Also, they can help to draw useful lessons for future projects. In other situations, can be advantageous to help decision makers to make decisions (Bouckaert, 2016; Palumba and Wright, 1980).

Evaluations can be classified conforming their temporal orientation. For example, an evaluation carried out to support decision making will be done in a project upstream (*ex-ante*). Conversely, the past actions evaluations (*ex-post*) are intended to take stock of the results achieved. They identify potential deficiencies, propose solutions, and draw potentially useful lessons for future projects. This assessment pattern is similar to a management support tool (Bouckaert, 2016).

The universities buildings could take advantage of both evaluations type. On the one hand, the team building can use evaluations *ex-ante* to support and to clarify the decision-making process in the new constructions and renovation projects. The idea is to help the decision maker in making more informed decisions when dealing with multiple criteria. On the other hand, an evaluation *ex-post* can contribute to the social learning and with the buildings’ continuous improvement.

As we mentioned before, the renovation decision process is composed of a pre-design, design, and an operation phase (Nielsen et al., 2016).

4.3 Evaluation methods

Assessment methods can be separated into two broad categories: those that result in a single response through aggregation - such as cost-benefit analysis (CBA) and life cycle assessment (LCA) - and multidimensional evaluation, as the multi criteria analysis (MAC).

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4.3.1 *Cost-Benefit Analysis as a main monetary valuation method*

In a classical approach, dating back to the early 20th century, cost-benefit analysis (CBA) has often been used as a main monetary valuation method to measure the profit that a company can draw from its development projects. This approach is used, for instance, to evaluate proposals for public or private investment by comparing the expected benefits of the projects with their costs.

To assess the sustainability of development projects, the CBA measures the balance between social costs and the benefits of several investment solutions. Furthermore, the CBA expected benefits can be translated into monetary units. This monetization is often the subject of much debate, especially in the environmental field. (Gassama, 2016).

Some criticism can be noticed due to the single-criteria approach of the CBA. For some authors (Norgaard, 1989 and Hanley, 1992), the method fails in demonstrating the complexity of environmental and social systems when reducing all the parameters into economic value.

Janseen and Munda (1999) highlight that the simplification of each monetary value and the subsequent CBA implicitly assumes the complete replacement of the natural capital by the human-made capital. However, the substitution of the natural capital by another kind of capital can continue until the systems reach a critical natural capital[155] when the devastation amount to the environment cannot be compensated for by any quantity of alternative goods (Faucheux and O'Connor, 1998).

Inside this perspective, a CBA might conduct to unsustainable solutions (Janseen and Munda, 1999). Thus, to improve the elements needed to increase the political decision-making process, multicriteria approaches have also emerged (Gassama, 2016).

4.3.2 *Life cycle analysis approach to assist the environmental impact assessment*

The first studies performed on the environmental impacts date from the 1960s and 1970s. These studies were focused on the evaluation or comparison of products to consumers. They were limited to a small analysis of the use life cycle stage. The idea of life cycle analysis (LCA) emerged in the 1980s and 1990s with the growing importance of considering the product life cycle the transportation, production, and disposal stages (Guinée et al., 2011).

[155] For Chiesura and Groot (2003), the *"Critical natural capital (CNC) is commonly defined as that part of the natural environment, which performs important and irreplaceable functions".*

At the beginning of the 90's, the LCA was considered as the main tool to evaluate buildings' environmental performance. For Haapio and Viitaniemi (2008), LCA can vary according to many factors, as:

- the nature of the building assessed (e.g., existing buildings, new buildings, refurbishment works, building product or component, residential, office, another type);
- the diversity of users (e.g., professionals, producers of building products, investors, building owners, consultants, residents, facilities managers, researchers, and authorities);
- the several phases of the building's life cycle (e.g., production, construction, use and operation, maintenance, demolition, and disposal);
- the several needs and purposes of the assessment.

The LCA systems were developed to assist in the identification of the possibilities of improvement. The LCA can be integrated in the distinct moments of the building life cycle, and in the decision-making process. LCA is used to determine the environmental impact assessment (EIA) of building's products, and of the life cycle's stages, but is also used to provide a multi-scale and global overview of the environmental impacts on human health, ecosystem quality, and resources.

A correct definition of product life cycle was given by Rebitzer et al. (2004). According to the authors:

> *"Every product has a 'life' starting with the design/development of the product, followed by resource extraction, production (production of materials, as well as manufacturing/provision of the product), use/consumption, and finally end-of-life activities (collection/sorting, reuse, recycling, waste disposal)"* (Rebitzer et al., 2004, pg.701).

LCA has been applied at the various stages in the construction sector for particular reasons, such as decision making of building materials and products, or the whole building assessment (Bittencourt et al., 2012; Erlandsson and Borg, 2003).

Bribián et al. (2009) noted that architects, engineers, and consultants use the LCA in preliminary phases, early design (sketch) and design of a renovation project; for selecting products or process, to size a project, to set targets at the municipal level, and choose a building site. Furthermore, Arena and Rosa (2003) also highlighted that LCA could be implemented in buildings' project to identify opportunities to reduce energy consumption and negative environmental impacts during the operational building phase.

The building LCA implicates the collection and the evaluation of quantitative data on inputs and outputs of materials, energy and waste flow linked to the building's life cycle (Hikmat and Saba, 2009; Wang et al., 2005).

The building's life cycle encompasses all the processes from the natural resources extraction, material production, building construction, use, and demolition. All these activities consume natural resources and release substances into the natural environment. They also are responsible for substantial environmental impacts such as climate change, ozone depletion, eutrophication, toxicological stress on ecosystems and human health impacts and degradation of natural resources (ISO, 2006; Rebitzer et al., 2004; Wang et al., 2005).

Blengini (2009) divided the building life cycle processes and activities in 'pre-use phase,' 'use phase,' and 'end-of-life phase,' as presents the Figure 46. A review of building life cycle considering the refurbishment phase is introduced by Graham (2003). He links emissions to the various stages of a building's life in Figure 47.

LCA is a method regulated by the International Organization for Standardization (ISO), thought the ISO 14040, that standardizes the LCA into four major stages: goal and scope definition, life cycle inventory, life cycle impact analysis and interpretation of the results. In brief, the explanations of each phase are listed below:

- Goal and scope definition: This phase includes the definition of the product system and the functional unit. It establishes the context in which the analysis is to be made and identifies the boundaries and environmental effects to be reviewed for the assessment;
- Inventory or life cycle inventory (LCI): Includes data collection and the quantification of the relevant inputs and outputs of a product, like energy, water, and materials usage and environmental releases;
- Impact assessment or life cycle impact assessment (LCIA): Is the calculation and the interpretation of the indicators of the potential impacts associated with such exchanges with the natural environment;
- Interpretation: Evaluates the LCI and LCIA information, checking that the requirements of the application as described in the goal and scope of the study were met.

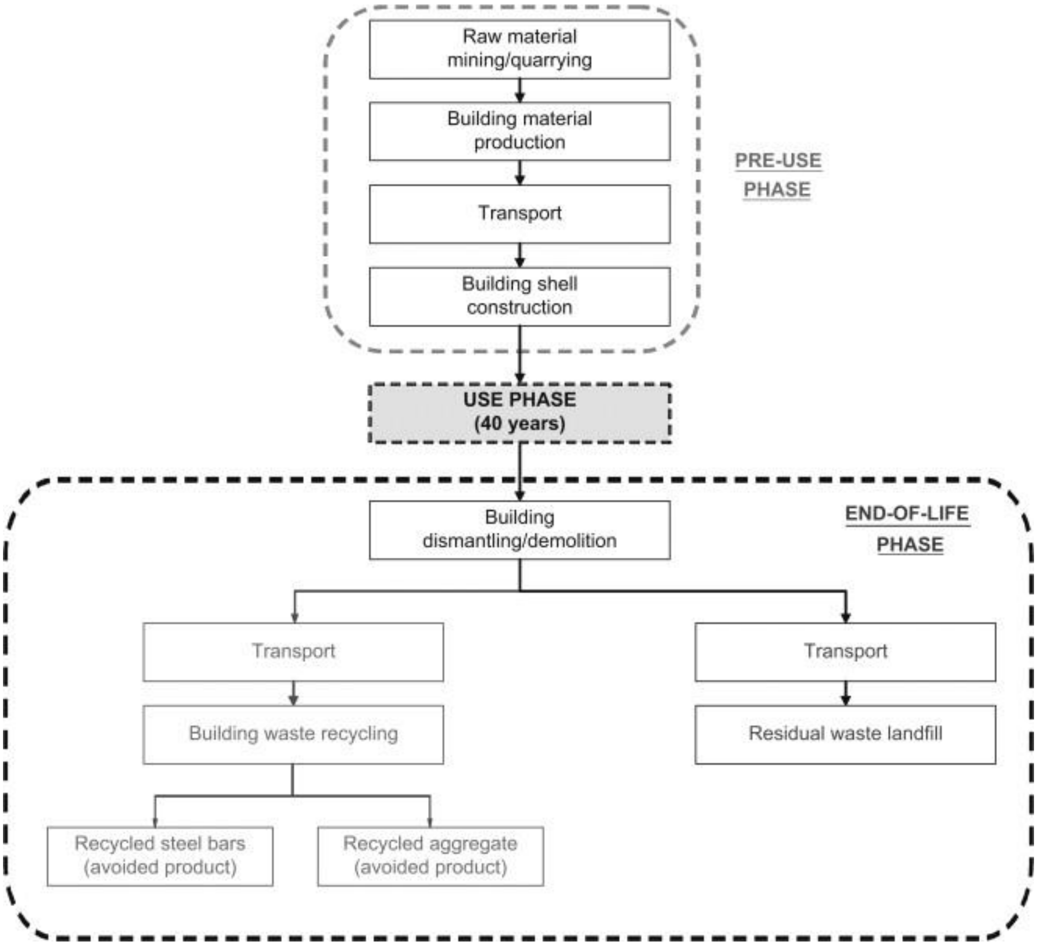

Figure 46. Building life cycle processes and activities. Source: Blengini (2009).

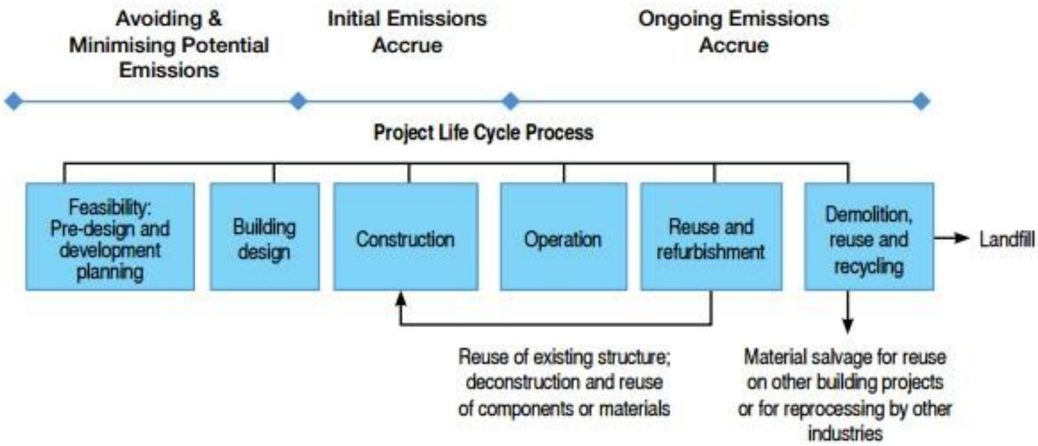

Figure 47. Building's Life-Cycle considering the refurbishment stage. Source: Graham (2003).

The assessment tools based on building's life cycle can produce significant benefits for owners and building occupants, such as reducing environmental impacts, creating more comfortable and healthier spaces, increasing user's productivity, reducing energy consumption, and greenhouse gases emissions. Also, they can assist in the decrease of the renovation costs and the building maintenance, when the various alternatives of the project are compared to select the one that maximizes savings net (Arena and Rosa, 2003; Hikmat and Saba, 2009).

Numerous LCA methods can be found in the present, Haapio et Viitaniemi (2008) present some popular LCA methods as the LEGEP, TEAM™, PAPOOSE, SimaPro, EQUER, ESCALE, REGENERS, EcoInstall, EcoPro and BeCost. Mateus and Bragança (2011) feature the LCA methods designed to evaluate buildings, for instance: Eco-Quantum, EcoEffect, Envest2, BEES, et ATHENA.

4.3.3 Multi-criteria analysis and decision-making support

A multi-criteria analysis decision analysis (MCDA) is a decision-making methodology that can be used when various alternatives must be evaluated according to a set of several criteria in a flexible manner of the structured and intelligible framework (Janeiro, 2011; Cinelli et al., 2014). The use of MCDA is recurrent even in simple daily life and personal choices, as selecting a new house. Relevant criteria can include access to public transport, price, and security. Every decision that we take in life demands the observation of multiple factors or criteria (Belton and Stewart, 2002).

For Belton and Stewart (2002, pg.2), multi-criteria decision analysis (MCDAs) are *“formal approaches which seek to take explicit account of multiple criteria in helping individuals and groups explore decisions that matter*.”

Exploring decisions is important when there is much information of a complex or conflicting nature, contrasting distinct points of view. In this sense, the main goal of the MCDA methods is to assist decision makers in the organization and synthesis of all the information to provide a certain and comfortable situation to decide. Decision makers should feel that all the factors have been considered and that they possess all the knowledge to make the most rational decision (*Ibid.*, 2002; Hopfe et al., 2013).

In the construction sector, MCDAs are essential tools to support decision makers to learn and to understand the main problems of the several phases of the buildings’ life cycle to guide them to identify actions (Mateus and Bragança, 2008). Many authors explored in their research the applications of MCDA methods in the building sector due to its complexity.

Jensen and Maslesa (2015) tested a multi-criteria tool that can be used as a decision support for the renovation projects in cases of study located in Denmark. Wang and Zeng (2010) presented a multi-objective decision-making process for the reuse selection of the historic buildings in Taiwan. The approach developed enables decision-makers to understand better the complex relations of the significant attributes in the reuse selection problems, which may subsequently improve the acceptability of the decision (see Figure 48).

Seddiki et al., (2016) proposed a multi-criteria group decision-making method for the thermal renovation of masonry buildings in Algeria. The main goal of the method is to rank various renovation solutions. Lizana et al. (2016) developed a multi-criteria assessment methodology for the environmental, economic and social evaluation of the various residential energy retrofit solutions in Spain. Govindan et al. (2016) created a hybrid multi criteria decision-making approach for sustainable material selection for the construction industry.

It is essential to highlight that MCDA assists in structuring the problem providing information for discussion. It does not desire to replace the intuitive judgment or experience that we mentioned previously. As highlighted by Belton and Stewart (2002, pg. 5), the main goal of the MCDA "*is to help decision makers learn about the problem situation, about their own and other values and judgements, and through organization, synthesis and appropriate presentation of information to guide them in identifying, often through extensive discussion, a preferred course of action*".

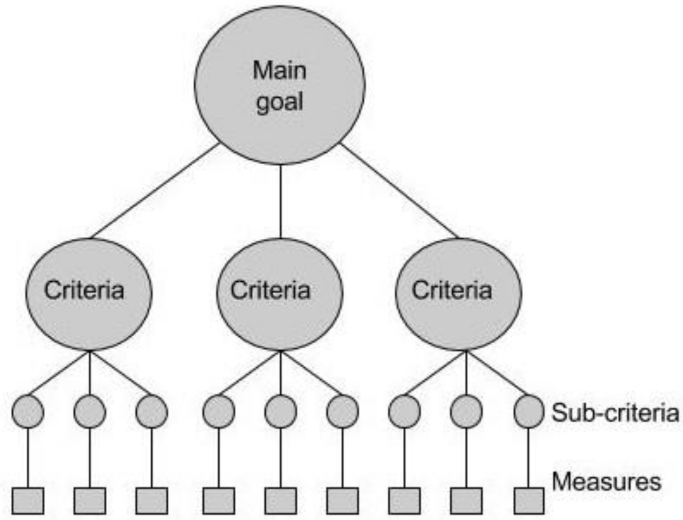

Figure 48. Ideal steps of decision-making process. Source: Adapted from Wang et al. (2005).

The ideal steps of the decision-making process were described by Wang et al. (2005) as (1) defining the problem; (2) identifying the objectives and the criteria, (3) the criteria weighting, (4) generation of the alternatives; (5) rating each alternative on each criteria, and (6) calculating the optimal solution.

Most of the cases of the decision-making process structure the criteria in a decision-three, where indicators help to evaluate in which way the alternatives meet the overall goal (Nielsen et al., 2016).

MCDA has been used extensively as powerful instruments to perform sustainability assessment. We can find many examples in the literature (Cinelli et al., 2014):

- For the utility-based theory: Multi Attribute Utility Theory (MAUT) and Analytical Hierarchy Process (AHP);
- For the outranking relation theory: Elimination and Choice Expressing the Reality (ELECTRE) and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE);
- For the sets of decision rules theory: Dominance based Rough Set Approach (DRSA);
- For the deliberation process (Deliberation Support Tool – DST): "Kerbabel for you" (K4U) and the KerBabel™ Deliberation Matrix (KDM).

K4U and KDM are deliberation support tools developed by the International Center REEDS. The K4U allows stakeholders to build a collaborative assessment of a specific case of study (e.g., buildings, mobility, and others) and to draw a final spider diagram.

The KDM is *"a highly didactic presentation of the process and outcomes of judgments offered by each category of stakeholders, for each of the options or scenarios under evaluation, with reference to a spectrum of governance or quality- performance issues*" (O'Connor et al., 2007a, pg.03).

Figure 49 presents the KerBabel™ Deliberation Matrix (KDM) with its three-comparison axis: The Governance issues, Categories of Stakeholders, and Scenarios of Possible Futures. By an angle of the matrix, for instance, it is possible to see rectangular arrays of cells, each being a layer of the matrix within which each row represents the evaluations provided by a group of stakeholders, of a given scenario. Alternatively, looked at from another angle, one obtains the evaluations by each stakeholder, of a given scenario

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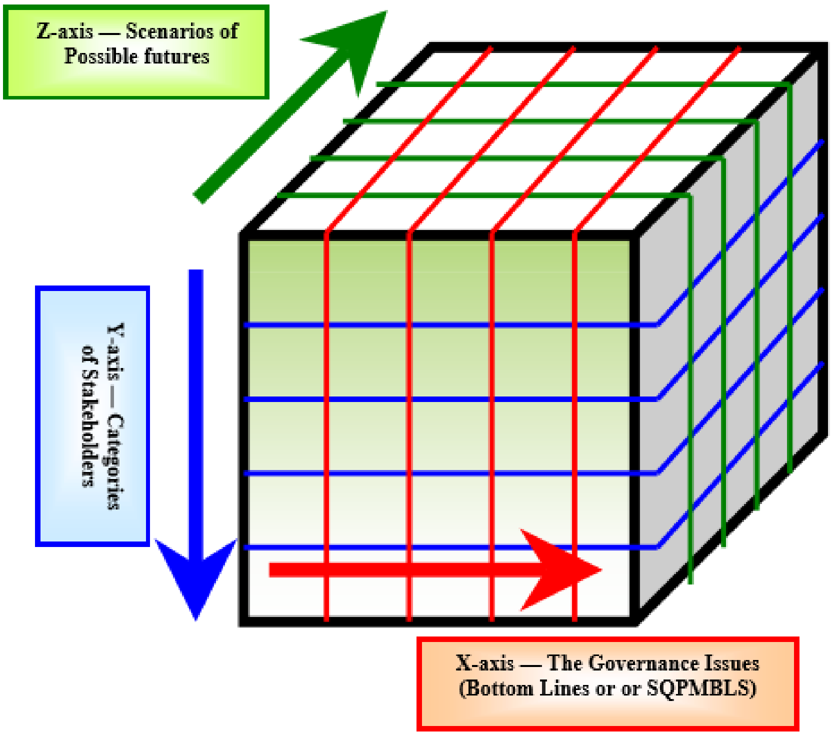

Figure 49. KerBabel™ Deliberation Matrix. Source: O'Connor et al. (2007a).

5 EXISTING METHODS AND TOOLS FOR ASSESSMENT OF BUILDINGS

A sustainability assessment (SA) of building renovation might include many criteria as energy performance, environmental impact, affordability, durability, and social benefit. Furthermore, they should incorporate the life cycle analysis principles (Mwasha et al., 2011).

Sustainable building evaluation should be a tool to encourage an open dialogue and learning process on relevant topics regarding the innovation of building design and practices. However, the existing sustainable building evaluation systems privileged the emergence of an environmental building design paradigm (Mateus and Bragança, 2011). Conte and Monno (2012) denominated this paradigm as a *building-centric* approach.

Inside the *building-centric* approach, we can mention the Green building rating (GBR) systems. The GBR systems are quantitative multi-criteria methods used to assist the building design concept. Based in a post Occupancy Evaluation (POE) approach, these tools evaluate the possibility of a building to receive a certification or label. Over the years, the GB systems went through many changes to answer the current and future requirements of the sustainable buildings.

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The GBR systems have as main goal to evaluate if a building is environmentally friendly or not (Wu et al., 2016). It can be used as a design concept and an operation guide to document progress concerning a design or operational performance target, and as a comparison method between two or more buildings (Wang et al., 2012).

The GBR tools encompasses several issues, including water, energy, IAQ, materials, waste management, materials, and others. A system composed of categories and indicators is used to assess all these aspects. The indicators received credit for the performance achieved. The total of these credits provide a sub-total points for each category and a total of points for the project. The sub-total points per category are used to indicate where the case study has better performance, and where it can be improved. The total points for the project allow the GBR's organisms to compare different case studies, but also to rate them in a system. The assessing standards can be different and depend on the buildings nature (e.g., scholar buildings, hospitals, hotels).

In general, these systems do not consider and integrate the several dimensions of sustainability. They give priority to the environmental perspective, the technological and the certificatory concerns instead of giving attention to explorative and experimental purposes (Cole, 2005; Ding, 2008). On the other hand, these systems have an important role in the diffusion of eco-innovations.

The evaluation of the GBR systems is normally made by an employee from the developer organism (i.e., USGBC, BRE) or a delegated professional that has the credential to perform this variety of evaluations. Consequently, architects, engineering firms, and buildings owners put their efforts to answer to the developer organism requirements.

Many GBR systems emerged over the years in diverse locations. We can mention here the Great's Britan Building Research Establishment Environmental Assessment Method (BREEAM); the Leadership in Energy and Environmental Design (LEED), from United States; Building Environmental Performance Assessment Criteria (BEPAC), from Canada; the Japan's Comprehensive Assessment System for Built Environment (CASBEE); Korea's Green Building Certification Criteria (KGBCC); Green Globes, from United States; GBTool, born from an international collaboration; and the *Haute Qualité Environementale* (HQE), from France. Furthermore, some certifications as BBC and Energy Star focus on the energy efficiency, but also in the durability, better comfort, and the reduction in the maintenance costs.

The emergence of all these rating systems simultaneously acts as a proof to demonstrate that there is no single worldwide standard, and many countries have more than one rating system. The existence of many distinct systems in the same country might act as a driver for innovation, which has positive effects.

On the contrary, many certifications systems imply in mixed messages that can confuse the market. Furthermore, a large number of different rating systems can bring the difficulty to the building owner that need to choose an adequate certification regarding time and costs (Cole, 2006).

Over the years many universities are renovating and constructing new buildings under GBR system conformities. The universities want to reach a desirable score in the certification as a strategy to improve their image and to meet their social and environmental responsibilities.

As there are several GBR systems, we will put some boundaries in our study for selecting the systems that are more suitable to our study subject. The first boundary is related to the building type. Our interest is to contribute to the renovation of the university building. We determined as interesting GBR all the systems that have a special category for the university buildings or schools, in the sense that they demand special requirements concerning the universities and schools[156].

Our second boundary is connected to the location. We will present here the methods and tools which have been used to obtain certifications in university buildings in France. Thereon, we will present the existing GBR systems for the university buildings in France. We will identify the main drivers and limits of these GBRs.

5.1 LEED

The LEED - Leadership in Energy and Environmental Design certification is a North-American GBR system which was developed by the U.S. Green Building Council - USGBC IN 1993. It encompasses a set of rating systems that were developed to address to all the nature of buildings (USGBC, 2017):

- LEED BD+C - Building Design and Construction: it applies to buildings that are being constructed or that are passing through a renovation process. This certification can be addressed to projects where the developer controls the design and construction of the entire mechanical, electrical, plumbing, and fire protection system — called the core and shell, higher education and non-academic buildings located inside the school campus, retail, data centers, warehouses and distribution centers, hospitality, and healthcare;

[156] It means that the categories, indicators and requirements of the method change in function of the nature of the building.

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- LEED ID+C - Interior Design and Construction: it applies to all kind of projects that focus on the improvement of indoor spaces. The certification can be addressed to commercial interiors, retail and hospitality;
- LEED O+M - Building Operations and Maintenance: can be applied to all projects that focus on the improvement of the environmental impacts of the existing buildings that can be retail, schools, hospitality, data centers and warehouses and distribution centers;
- LEED ND - Neighborhood Development: can be applied to new land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix;
- LEED HOMES - Homes: it applies single family homes, low-rise multifamily, or mid-rise multifamily.

The LEED certification has a significant adherence rate worldwide and is present in 164 countries and territories. The projects are evaluated in 8 categories: Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation, and Regional Priority (*Ibid.*, 2017). To succeed when getting the LEED certification, a project must first satisfy the LEED prerequisite items. After that, there is an amount of credits that the project need to try to reach for each LEED certification levels, by reaching the minimum points levels (Kibert, 2008).

The credits required for each category depends on the project or the building type (See Annex 2). Based on the points achieves, the project assessed can receive one of the four LEED label levels: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points) (USGBC, 2017).

The LEED certification has great popularity worldwide and also is the main research topic for many authors. Along the years, the authors have been analyzing its performance through the use of cases studies as a way to analyze if they are living up to expectations. In this sense, post-occupancy evaluations (POE) are applied to analyze the energy use.

Bittencourt et al. (2012) held a post-occupancy life cycle analysis (LCA) of a LEED gold building at the University of Western Ontario, in Canada. The objective was to investigate the environmental effects produced by the energy use. The results of LCA indicated that there are some environmental and human health impacts caused by the energy consumption of the LEED building. However, when compared to a conventional building, these ecological and human health impacts are lower.

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Diamond et al. (2006) evaluated the modeled and actual energy performance 21 LEED-certified commercial buildings. Billing data helped to determine the actual energy use. The modeled energy data was obtained from the LEED certification documentation that was submitted to the USGBC. For the group of 18 buildings for which they presented both modeled and billed energy use information, the actual consumption was 1% lower than modeling predictions. The number of LEED energy efficiency points did not correlate with actual energy savings.

Baylon and Storm (2008) examined the building and the energy performance characteristics of LEED's buildings in Washington, Oregon, and Idaho (US) and compared them to local non-LEED buildings. They found that the energy use per floor area (kWh/sq. ft) of 12 LEED buildings was 10% lower than 39 non-LEED buildings. The small results between non-LEED and LEED building are due to the new energy standards attributed to all buildings. Although, the authors stated that the study presents limitations due to the small sample selected.

Newsham et al. (2009) conducted a reanalysis of data supplied by the New Buildings Institute and the US Green Buildings Council on measured energy use data from 100 LEED-certified buildings to investigate if the LEED-certified buildings save energy. They found that, on average, the LEED buildings use 18–39% less energy per floor area than their conventional counterparts. However, 28–35% of the analyzed LEED buildings used more energy than their conventional counterparts. Also, the energy performance of the LEED buildings has a small correlation with the certification level of the building at design time. They concluded highlighting the importance of a POE in the sustainable performance control during the operational building phase.

Fowler et al. (2011) performed a POE in 22 administrative buildings, where 13 buildings were LEED-certified, 3 were LEED registered, 6 were Energy Star certified or under energy standards. They concluded that on average the aggregated operational costs[157]were 10% lower than the baseline. Energy performance average was 25% better lower than the regional average. Two-thirds of the buildings in the study used 11% less water than the baseline. Almost all occupants were satisfied with the LEED buildings. Nevertheless, some buildings' occupants were less pleased with the thermal comfort and acoustic quality. They concluded that when projects had incorporated sustainable design principles from the start and had included energy savings goals, the overall performance of the building was better. Despite the high performance of LEED buildings, they did not find a correlation between

[157] "The “aggregate operating cost” metric includes water utilities, energy utilities, general maintenance, grounds maintenance, waste and recycling, and janitorial costs" (Fowler et al., 2011, pg.12)

the measured water use and the LEED credits and neither a correlation between the measured energy consumption and the LEED scores.

In addition to the studies related to energy performance, many other studies relating indoor environmental quality (IEQ) in LEED certified buildings could be found. Green buildings should create a healthy and comfortable indoor environment for occupants and can contribute to worker's productivity.

Lee and Guerin (2010) held a study to compare thermal quality, IAQ, and lighting quality between five distinct office types. They compared private enclosed, private shared, open-plan with high cubicle, open-plan with low cubicle, and open plan offices with no partitions in LEED-certified buildings concerning workers' environmental satisfaction and their job performance. They found varied results for the influence of thermal quality, IAQ, and lighting quality for each distinct office types in the workers' environmental satisfaction and job performance. The authors suggested that a significant workplace design considering the height of partitions in LEED-certified buildings can enhance the user's satisfaction and the job performance.

Lee and Kim (2008) performed a comparative study of LEED-certified buildings and non-LEED certified buildings. Their conclusions showed that the users in LEED-certified buildings were more satisfied with the IAQ, the office furnishing, the cleanliness, and the maintenance. However, they were less pleased with the office layout, the acoustic quality, and the lighting.

Ravindu et al. (2015) explored the IEQ in diverse types of building and climate. They performed a study to investigate the IEQ of a green factory building, LEED platinum certified, in a developing country with a warm and humid tropical climate. They used the IEQ data of a conventional factory to perform a comparison study. According to their results, the ventilation, the thermal comfort, and the ability to control indoor environment were reported as being less satisfactory in the green factory. Others factors as, the lighting, the cleanliness, the privacy and the furniture had higher satisfaction in the green factory. Acoustics, indoor air quality, and work layout factors were not significantly distinct between the two factories. The study concluded that balance is required between the energy efficiency, the IEQ measures, and the climate responsive design for sustainable buildings.

5.2 BREEAM

As much as LEEDS, the BREEAM certification has been widely used globally since 1990. It was developed by the Building Research Establishment (BRE), in the United Kingdom to perform a sustainable assessment of projects, infrastructure, and buildings. It addresses many building life cycle stages such as New Construction, Refurbishment and in-use (BRE, 2017).

The BREEAM certification was designed to answer the needs of the commercial, the public, and the residential buildings. Inside the commercial sector, the BREEAM can be applied to the industrial units, the retail shops, the retail parks, and the restaurants. The certification can be applied to public buildings like the schools and the universities, the hospitals, and other community buildings.

The BREEAM measures the sustainable value of a building using ten categories (See Annex 3): Energy, Health and Wellbeing, Innovation, Land use, Materials, Management, Pollution, Transport, Waste, and Water. Each of these categories addresses several factors that are evaluated in the form of credits. When a building achieves some targets, it receives credits. The final total of credits determines the building's rating. The assessments are carried out on a scale of 'Pass,' 'Good,' 'Very Good,' 'Excellent' and 'Outstanding' (*Ibid*., 2017).

The certification is less exigent than LEED and HQE. This feature is guiding several projects toward the BREEAM certification (France GBC, 2015).

5.3 HQE

HQE has its roots as a French concept of environmental quality. This concept was born in the 1990's and was registered as a certification by the HQE association GBC in 2002. The certification HQE is a voluntary GBR system. It assesses the construction and the renovation of all variety of buildings (HQEGBC, 2015).

The HQE approach is structured around four main commitments: the life quality promotion, the environment respect, the economic performance, and the responsible management. Three French organisms are responsible for delivering the certification: the CEQUAMI, for the residential buildings; the CERQUAL, for the collective dwellings; and the CERTIVEA, for the commercial and institutional buildings. The CERTIVEA is responsible for delivering the NF HQE™ *Bâtiments Tertiaires - Neuf ou Rénovation*, NF HQE™ *Bâtiments Tertiaires en exploitation*, which can address the certification to corporate, educational, commercial and other industrial buildings; and the NF HQE™ *Equipements Sportifs - Neuf ou Rénovation*.

The HQE certification has a management project approach to obtain an environmental quality of construction or renovation process. Achieving the environmental performance of the building structure is as much a question of environmental management as an architectural and technical issue.

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Because of this, the most reliable method to achieve the environmental performance is to rely on an efficient and rigorous organization of the project. This is why the technical certification framework is structured in two parts: the Operational Management System (OMS) and the Environmental Quality of the Building (EQB). The OMS implementation makes it possible to define the environmental quality targeted for the building and to organize the operation to achieve it while controlling all the operational processes related to programming, design, and construction of the structure (Cetivèa, 2015).

The EQB concerns are represented by 14 objectives, or goals, which are divided into four categories: energy, environment, comfort, and health (See Annex 4). Each category can be evaluated on a scale from 0 to 4 stars. The total of all stars of the four categories is called global score that can be 'Good' (from 1 to 4 stars), 'Very good' (from 5 to 8 stars), 'Excellent' (from 9 to 11 stars) or 'Exceptional (12 to plus and with a minimum of 3 starts in the Energy category)' (*Ibid.*, 2015).

5.4 Contributions and limitations of GBR systems

GBR systems are valuable tools to improve the environmental, economic and social aspects in the buildings through the assessment of the current practices or the prevision of new solutions.

Over the years, they contributed to the way that buildings have been designed and constructed, improving their environmental sustainability beyond the existing regulations. Also, the voluntary certifications might help to drive the market to progress to higher levels of performance (France GBC, 2015).

Another positive aspect is related to the public and the private sectors collaboration and partnership that resulted in the development of indicators for the methods. The indicators presented in each GBR system can be useful for the formulation of several other methods that can address the sustainable assessment to other urban elements.

Reed et al. (2011) highlighted positive contribution to enhancing the environmental awareness among the actors of the building design and the construction process, and the users; sharing important sustainability objectives among professional stakeholders; disseminating the best practices and eco-innovations; and stimulating new laws and regulations.

However, we identify in the analyzed GBR three main limitations regarding the sustainability assessment of the university buildings: lack of the participation, the results visualization, and the indicator regarding the university campus and social issues. It was also noticed the prevalence of a "building-centric approach."

5.4.1 Lack of the actor's participation

As mentioned before, the renovation process of a building implies the participation of all stakeholders. Even with the existence of categories in the LEED, BREEAM, and HQE that significantly considered the IAQ, and included in their evaluation structure subjects as health, security, well-being, accessibility, and comfort, the building occupant's opinions are not involved in the assessment process. Usually, the actor engaged in the evaluation in GBR systems are the certified professionals.

During the building renovation process, the involvement of the building's users can give to the project team accurate information about their desires and opinions about the building interior environmental quality. However, as these quantitative multi criteria assessments are systems that rate THE environmental performance based on factors weighting, in other words, are based on numerical rules where the human factor is hard to measure (Sterner, 2011).

Hence, the buildings sustainability assessment should encompass both quantitative and qualitative data (Risholt et al., 2013). The occupants' satisfaction and participation in the evaluation should be understood as crucial parameters for a sustainable assessment. Furthermore, the involvement of the local community for the university campus implementation is essential and imperative.

5.4.2 Lack of the visualization of the results

After obtaining the certification, buildings owners receive a document to formalize the certification process. The LEED rating system provides a final credit card, the HQE, one conformity attestation, and the BREEAM, a final certification. All these documents present the final score of the buildings project with the partial scores of each category. However, any graphical representation of the information is provided. The graphical representation data might help to communicate the results and to perform a comparative analysis.

5.4.3 'Building-centric' approach

When a building receives a sustainable building certification by the many existing environmental assessment systems, it is implicit that an increase of sustainability will be perceived not just in the built environment, but also in the neighborhood, in the urban and in the global level (Conte and Monno, 2012).

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This ‘building-centric approach’ are limitations of the current GBR systems that often considers as evaluation element just the built environment. This restriction of the current GBR systems risk to promote the “wrong belief” that sustainable building practices can be achieved “by working at the margins.” Sustainable building practices might induce the reflections about the complexity of the relation between the building and the city. This reflection is a necessary element of the sustainable cities (Richardson and Cashmore, 2011).

When evaluating the building's sustainability inside the ‘building-centric approach,' it is possible to compare distinct building performances related to each built environment. In other words, the approach evaluates a sort of sustainability level of the individual building but does not evaluate the building contribution to the sustainability in the context where it is localized (Ding, 2008).

An integrated assessment of the building and the urban space is crucial. For instance, for a building renovation project, the more we renovate the buildings in a sustainable way and incorporating the eco-innovations, more we contribute to developing the sustainable cities and more we reduce the global environmental impacts (Conte and Monno, 2012).

We can affirm that, between the GBR systems presented, the HQE system integrates the relation between the building and the neighborhood. For this study, we considered that this integrated relation between the building and the urban environment is essential. It should answer the complex social-ecological interactions between the urban space, what in our case it can be the city but also the university campus, and the environment.

5.4.4 Lack of indicators and categories

Many issues of the university campus (e.g., adaptation to digital innovation, flexibility in the design of interior spaces, campus as a living lab, sustainable strategy, student life, raise awareness) and the social issues (e.g., social equity with the supply chain and worker’s satisfaction) are not represented by the indicators and categories of the GBR systems studied (See Table 7 for a framework of the GBR system’s categories and the Annex 2, 3 and 4, for the indicators of each method or tool). It is possible to find in some of the methods mentioned the general issues of the construction sites, like water use, workers’ well-being and health. Nonetheless, the construction management and the productivity issues are neglected.

Table 7. Comparative framework of the GBR systems regarding the categories.

CATEGORIES	LEED	BREEAM	HQE
Location and Transportation	X		
Sustainable Sites	X		X
Water Efficiency	X	X	X
Energy and Atmosphere	X	X	X
Material and Resources	X	X	X
Indoor Environmental Quality	X	X	X
Innovation	X	X	X
Regional Priority	X		
Health and Wellbeing		X	X
Pollution	X	X	X
Land use		X	X
Waste	X	X	X
Management		X	X

6 UNIVERSITY EVALUATION METHODS FACE TO THE IMPERATIVE OF SUSTAINABILITY

Even if the sustainability evaluation of the universities is not the specificity of our study goal, we also analyzed the existing tools to assess sustainability university. Our goal was to enhance or perception about the methods' goals, the criteria, and the indicators, especially regarding the campus buildings.

Nowadays, it is possible to mention many evaluation tools to measure the sustainable performance of the universities. These tools take varied forms. Some are conducted outside of the universities while others are linked to the internal steering and management processes.

During the 1990s, a series of initiatives that aimed to evaluate universities regarding sustainability emerged outside the academic spheres. Nowadays, these initiatives are increasingly successful but are subject to deficiencies that limit their potential to contribute to improving the universities sustainable performance (Bouckaert, 2016). Firstly, these devices focus mainly on the environmental externalities of the university campus. The multidimensional nature of the sustainability issues is therefore insufficiently considered, leaving a scenario for a potential improvement of the existing methods (Vaughter et al., 2013; Sammalisto and Arvidsson, 2005; Yarime and Tanaka, 2012).

From a general framework, we can find in the literature training accreditation tools that focus on the evaluation of the institutions' teaching activities. Inside this category of assessment, we can mention the European Quality Improvement System (EQUIS) and the Association to Advance Collegiate Schools of Business (AACSB) label for 'écoles' and business courses, or the SMBG classification of HE programs in France. Furthermore, we can mention the evaluations implemented by the university authorities in certain countries, as the AERES (now HCERES) in France (Bouckaert, 2016).

Many evaluations tools study the university in its entirely, and are used to compare the performance of the diverse institutions to learn from them. These tools can be grouped into three categories: the international rankings, the scientific assessments, and the tools for assessing sustainability (*Ibid.,* 2016).

6.1 International rankings

International rankings are evaluation schemes that emerged in the early 2000's. They were developed to differentiate global universities according to their level of performance. To do this, they use a set of indicators to aggregate the results to arrive at a single score for each institution.

Between these international rankings, we can highlight the Academic Ranking of World Universities (ARWU) developed by Shanghai Jiao Tong University and better known as the "Shanghai Rankings"; the THE (Times Higher Education World University Ranking) ranking of the British Times, and the QS World University Ranking of the British company Quacquarelli Symonds.

Overall, the various dimensions considered in the rankings are the research, the teaching, the internationalization, the exploitation of knowledge (through partnerships with private companies) and the reputation (*Ibid.,* 2016).

6.2 Scientific assessments

The scientific assessments are described here as the tools used in the specialized research projects. In general, these evaluations are profoundly heterogeneous, and almost all of them focus on the dimensions of the academic performance (*Ibid*., 2016).

For example, evaluations may include studies of the research outputs through bibliometric analyses (Gingras, 2014); the effectiveness of the research or teaching activities through statistical tools (Kuah and Wong, 2011); the regional economic impacts of universities (Kelly et al., 2004, Asheim and Coenen, 2008); the returns from their research incubators and partnerships with industry (Monjon and Waelbroek, 2003); or the degree of social engagement with the local communities (Hart et al., 2007).

The Programme for International Student Assessment (PISA) and Assessment of Higher Education Learning Outcomes (AHELO) studies conducted within the OECD are two characteristic examples of this variety of evaluation. PISA is a triennial international survey that aims to assess the education systems worldwide by testing the skills and knowledge of 15-year-old students. The AHELO feasibility study has as the main purpose to see if it is practically and scientifically feasible to assess what students in higher education know and can do upon the graduation (OECD, 2017a; OECD, 2014).

6.3 Assessment tools of sustainability in the higher institutional educations

The main goal of the sustainability tracking and the assessment tools for Higher Institutional Educations (HIE) is the improvement of the university's sustainable performance. These assessment frameworks correspond to the interests of our research because they encourage the development of SD initiatives in the university and inside their campuses.

Nowadays, between the most famous evaluation tools for sustainability we can quote: the Sustainability Tracking, Assessment and Rating System (STARS), developed by AASHE; the Auditing Instrument for Sustainability in Higher Education (AISHE), developed in the Netherlands by the Dutch Committee on Sustainability in Higher Education (CDHO); the Learning in Future Environments (LIFE), created in the United Kingdom by the Environmental Association for Universities and Colleges (EAUC); and the French EVVADES, the FONDaTERRA and a consortium of partners.

All these tools share the same methodology which is the multi-dimension comparative evaluation. They aim to provide to the HIE a possibility of appreciation of their performance and new opportunities for intervention. Normally, these methods use indicators around five broad categories: governance, education, research, campus operations, and outreach. Many of these assessment tools appear to be concentrated on the environmental issues (Yarime and Tanaka, 2012).

Another similarity between those methods is the complexity of each method, which encompasses in general about 150 indicators and relies on data collection facilities through self-reporting processes. For Bouckaert (2016), these factors are at the origin of several problems, such as the difficulties encountered by the members of the universities responsible for collecting information, or the impossibility of verifying the veracity of the data transmitted by the institutions, what can be a risk for the credibility of these tools.

As we delimited our area of study to the French territory, we will investigate the two main methods applied on the university campus in France to measure sustainability: the STARTS and the EVVADES.

6.4 STARS®

The Sustainability Tracking, Assessment & Rating System™ (STARS®) is administered by the Association for the Advancement of Sustainability in the Higher Education - AASHE. It is "*a transparent, self-reporting framework for colleges and universities to measure their sustainable performance*" (AASHE, 2016, pg.10).

The method aims to provide a sustainability framework of all the higher education's sectors, to encourage continual improvement toward sustainability, to help knowledge to share about the higher education sustainability practices and performance. It also desires to contribute to the development of a campus sustainability community and to empower meaningful comparisons over time and across the institutions (AASHE, 2017).

> *"STARS® wants to engage and recognize the full spectrum of colleges and universities—from community colleges to research universities, and from institutions just starting their sustainability programs to long-time campus sustainability leaders. STARS encompass long-term sustainability goals for already high-achieving institutions as well as entry points of recognition for institutions that are taking first steps toward sustainability"* (AASHE, 2016, pg.10).

The STARS® method is composed of five categories, each one with specific sub-goals (*Ibid.,* 2016):

- Academics (AC): with the sub-goals 'Curriculum,' and 'Research';
- Engagement (EN): with the sub-goals 'Campus Engagement,' and 'Public Engagement';
- Operations (OP): with the sub-goals 'Air and Climate,' 'Buildings,' 'Energy,' 'Food,' and Dining,' 'Grounds,' 'Purchasing,' 'Transportation,' 'Waste,' and 'Water';
- Planning and Administration (PA): 'Coordination and Planning,' 'Diversity and Affordability,' 'Investment and Finance,' and 'Wellbeing and Work';
- Innovation and Leadership (IN): 'Exemplary Practice,' and 'Innovation.'

An institution's overall score is based on the percentage of points it receives by pursuing credits across all the categories (Annex 5 presents a complete list of the indicators). Institutions can earn from 0 to 100 points with the credits inside the categories. They can also receive until 4 points with the

‘Innovation and Leadership’ category that are bonus points that institutions can have with exemplary practice credits (AASHE, 2017).

The method considers the diversity of all institutions, and because of this, some credits are flexible and open. For instance, inside the sub-category ‘Food and Dining,' the credits *Food and Beverage Purchasing* and *Sustainable Dining* are applicated just for the institutions that have on-campus dining services. By following this approach, institutions are not penalized when they fail to earn credits that they could not possibly earn due to their circumstances (*Ibid*., 2017).

After obtaining the overall STARS® score, institutions can be classified through the STARS® rating system to get the Bronze certification, for a minimum score required of 25; Silver, for a minimum score required of 45, Gold, for scores over 65; and Platinum, with scores over 85. Each level of certification represents important achievement and leadership (*Ibid*., 2017).

Furthermore, the STARS® community is composed of around 812 colleges and universities from 30 countries. All the complete cases evaluations are visible on the STARS® website, contributing to a social network system. For Lanceleur and Martin (2015):

> *“Participating in STARS, which entails gathering extensive data and sharing it publicly, represents in itself a commitment to sustainability. So, the system design does not permit aggressive or hostile criticism but seeks to encourage and reward its members’ participation at the same time as providing transparency in the institutions’ self-assessment declarations”* (Lanceleur and Martin, 2015, pg.12).

The STARS® contributes with the engagement of all the university campus’ actors in the development of the sustainability practices and performance. However, the STARS® evaluation does not open the possibility for parallel evaluations by several actors of the higher education institution (*Ibid.,* 2015).

6.5 EVVADES

The EVVADES (Acronym if French: *Outil d’auto-Evaluation du Développement Durable dans l’Enseignement Supérieur*) is a self-assessment tool for French higher education institutions in the field of sustainable development. The EVVADES tool was developed by FONDaTERRA and a consortium of partners, during 2009-2012, in parallel with the elaboration of the STARS® (FONDaTERRA, 2011b).

The tool was created under the scenario of the French Grenelle I law. The Grenelle I required efforts of all the higher education establishments in building up an SD strategy to address economic performance, social responsibility and environmental targets, formalized by the name of a 'Campus Green Plan,' previously mentioned in Chapter 2. The Grenelle Law's requirement was transformed into the operational Campus Green Plan scheme on 17 June 2010, via a self-assessment framework. The framework was developed by the partnership foundation FONDaTERRA on behalf of the two major higher education bodies: the *Conférence des Grandes Ecoles* - CGE and, the *Conférence des Présidents d'Universités* - CPU (Lanceleur and O'Connor, 2015).

EVVADES is a tool for controlling and monitoring the implementation of a Campus Green Plan for each higher education institution. The HEIs can evaluate and revise their action plans, commit to specific targets, and write and publish a sustainability report. It is described by Lanceleur and O'Connor (2015) as:

- A sustainable development and social responsibility educational method;
- A tool for communicating and sharing desirable practices;
- A strategic guideline (continuous improvement objectives at 1, 3 and 5 years) that is aligned with the aims of the Green Plan scheme and ISO 26 000;
- A self-assessment tool (strong and weak points, completed actions);
- A spreadsheet that tracks the approach for operational managements and SD advisors;
- Moreover, a database that supplies a basis for certification (Green Campus labeling).

EVVADES' latest version, dating from 2012, is composed of five key focus areas: 'Strategy and governance,' 'Training,' 'Research,' 'Social policy and regional presence,' and 'Environment.' These five areas are assessed on a logic of 5 'continuous improvement' levels, with the central level (Level 3 in the tabular set-out below) being a keystone or benchmark level representing legislative compliance or similar as shows the Table 8.

Each of the 5 Focus Areas contains between 3 or 5 'strategic' variables, which are then divided down into 'operational' variables. In the last version of EVADDES, there are 63 variables, 19 of which are 'strategic.' Strategic values represent the primaries challenges for higher education and are expected to remain stable over the time. Operational variables are defined by an action against a changing background (targets for National or European Strategies) (*Ibid.,* 2015). A complete list of all the focus areas and the strategic and operational values are presented in Annex 6.

The self-assessment with EVADDES is performed for a "Campus." It means a Geographic or Organisational Unit (in French: *Unite Géographique ou Organisationnelle*, *UGO*) designed to accommodate a variety of HEIs regarding the geographic location and the organization. An institution's (or UGO's) progress is monitored, within a context of continuous improvement, by the movement to the right across each row of the above EVADDES performance table, as it is presented in Table 8 (*Ibid.,* 2015).

Table 8. EVVADES' key focus areas and performance level. Source: *Ibid.* (2015).

Performance Level EVADDES / **Area of Performance**	**Level 1 AWARENESS**	**Level 2 INITIATION**	**Level 3 CONFORMITY TO GREEN PLAN SCHEME TARGETS**	**Level 4 CONTROL**	**Level 5 LEADERSHIP**
Strategy & Governance					
Training/Teaching					
Research					
Social policy and regional presence'					
Environmental management					

Institutions with numerous UGO are confronted with the problem of distinct assessment levels for a given variable as per the UGOs. This means creating as many 'focus area' reporting sheets as there are UGOs, to frame the Green Plan approach at the level of each Campus/UGO. The institution with numerous UGOs then can calculate its final rating using two options of weighting system (*Ibid.,* 2015):

- It may decide to consider all UGOs as the same; so, its overall score will be obtained simply by averaging the individual assessments of its UGO (weighting = 1);
- It may decide to determine the specific weighting for each of its UGOs in the overall rating; the latter thence represents a weighted average of the individual assessment of its UGOs.

Institutions have a free pass to choose its weighting system. Nonetheless, if it does decide to weight UGOs unequally, it is solicited to clarify the basis for the weights in the documentation sent to the reporting authority (that is, the joint *Conférences of the Universities* and the *Grandes Ecoles*). As the STARS, the EVADDES system, propose flexibility to accommodate the diversity of establishments. Not all operational variables have to be applied in reporting for an HE institution or its constituent UGOs (*Ibid.,* 2015).

6.5.1 EVVADES experience with the ‘Aile Sud’ building

In 2015, the implementation of the UVSQ in the BN was evaluated by the students of the Master’s MEDIATION M2 class in the REEDS center, in Rambouillet. The students were divided into five groups. Each group evaluated one EVVADES’ performance area through data collection and actor’s interview. The most important points mentioned by each group of students in a study of the implementation of the UVSQ inside the BN are presented below:

6.5.1.1 Group 1- ‘Strategy and Governance’:

The overall score for the theme ‘Strategy and Governance’ is 7.61 of 10. Despite limited financial resources, the budget allocated to the UVSQ unit in Rambouillet was optimized to provide a responsible and sustainable structure.

Integrated into the historical heritage of Rambouillet, this unit is concerned with the respect of environmental standards as well as the comfort and well-being of the staff. REEDS is committed to providing a structure that respects the principles of the sustainable development through voluntary investment by employees and students who have successfully met the challenge of building a productive and work-friendly environment.

The Center REEDS relations with the national and the foreign institutions have also contributed to the development of activities. Numerous internal and external projects have been launched in collaboration with European institutions. The formalization of the sustainable development strategy and CSR in the management policy of the UVSQ unit located in Rambouillet proved to be less efficient. The CSR approach, still in a young vision, is integrated into the context of the crisis that UVSQ was facing, which reduces the staff's ability to meet all the CSR requirements (UVSQ, 2015).

6.5.1.2 Group 2 - ‘Training and Teaching’

The overall score for the theme ‘Training and Teaching’ is 8.46 of 10. It can, therefore, be said that the UVSQ unit based in Rambouillet is proactive in the field of SD, regarding education and training. Indeed, it fully integrates the issues of SD and CSR within the training programs.

The REEDS unit in Rambouillet is also involved in the development of a knowledge base concerning the principles of the SD and the CSR in the company, notably through the ePLANETE system (Ibid., 2015).

6.5.1.3 Group 3 - *'Research'*

The overall score for the theme is 8 of 10. The REEDS center has worked on SD and SR research projects with the partners in the national and the international levels (i.e., more than 40) since 2010, resulting in a significant number of publications published in public each year.

Between These publications and projects include subjects in SD, sustainable research, innovation, and other scientific publications. The center also organized or participated about 520 conferences and published many publications since 2010 in the national and the international level with national and international partners (*Ibid*., 2015).

6.5.1.4 Group 4 - *'Social policy and regional presence'*

The overall score for the theme is 7.12 of 10. The parity and the diversity are not the subjects of a specific policy. However, it was observed that the principle is respected in practice and that there is a particular attention on the part of the management team. The management team has an inclusive attitude toward staff, regardless of their hierarchical position.

On the issue of the internal mobility and training, the management team has always encouraged the non-academic staff to take advantage of the vocational training system to acquire new skills. On the other hand, a specific budget is allocated to enable doctoral students to attend the international conferences (*Ibid*., 2015).

6.5.1.5 Groupe 5 – *'Environmental management':*

The overall score for the theme is 6.4 of 10. This index reflects the proven involvement of the stakeholders in a sustainable development approach both in the design and implementation of the project. The site is a leader concerning the energy performance, according to environmental and social criteria and relative to air quality. Nevertheless, although there is a real desire for continuous improvement, awareness of eco-gestures and eco mobility remains fragile (*Ibid*., 2015). A global evaluation of each area of performance of the implementation of the UVSQ/BN is presented in Table 9.

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Table 9. Global evaluation of the UVSQ/BN

AREA OF PERFORMANCE	GLOBAL SCORE
Strategy & Governance	7.61/ 10
Training/Teaching	8.46/ 10
Research	8.0/ 10
Social policy and regional presence	7.12/10
Environmental management	6.4/ 10

6.6 Contributions and limitations of the tools STARS© and EVVADES

The STARS© and the EVVADES have some similarities and are self-assessment tools for the higher education institutions. Both methods have as main goal the tracking and the assessment of the sustainability year by year for the continuous improvement. Both tools introduce some flexibility to accommodate the diversity of the establishments (see Table 10 for the main similarities and differences).

Table 10. General similarities and differences between STARS and EVVADES.

	STARS©	EVVADES
DEFINITIONS	Self-assessment by actions with indicators	Self-assessment by level with proposed actions/indicators
FEATURES	North American tool. Uses US norms, laws and programs	French tool based on French law and national context. Uses the Grenelle Law to fix institutions objectives.
DIVERSITY OF ESTABLISHMENTS	Flexibility	Flexibility
GOALS AND PERFORMANCE AREAS	5 categories: Academics; Engagement; Operations; Planning and Administration; and Innovation and Leadership	5 areas of performance: Strategy and governance; Training and teaching; Research; Social policy and regional presence'; and Environmental management.

Nonetheless, the STARS© is a self-assessment by actions with indicators, and EVVADES is a self-assessment by level with proposed actions and indicators. The rating system in the STARS© is

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represented by several categories of global performance (e.g. Bronze, Silver, and others). In the EVVADES system, the HEIs mark its advances for each Area – row by row and level by level. Some limitations as lack of indicators can be highlighted for both methods.

Analyzing the STARS© and the EVVADES methods regarding criteria for success in the university buildings assessment is possible to identify some relevant categories and credits for both approaches.

In the STARS© tool, most of the credits related to the university building's issues are in the categories 'Operation', and 'Planning and Administration.' Inside the category, 'Operation' we can mention:

- Sub-goal 'Air and climate': Greenhouse Gas Emissions and Outdoor Air Quality credits;
- Sub-goal 'Buildings': Building Operations and Maintenance and Building Design and Construction credits;
- Sub-goal 'Energy': Building Energy Consumption and Clean and Renewable Energy credits;
- Sub-goal 'Grounds': Landscape Management and Biodiversity credits;
- Sub-goal 'Purchasing: Sustainable Procurement credit;
- Sub-goal 'Transportation': Support for Sustainable Transportation credit;
- Sub-goal 'Waste': Waste Minimization and Diversion, Construction and Demolition Waste Diversion, and Hazardous Waste Management credits;
- Sub-goal 'Water': Water Use and Rainwater Management credits.

In the category 'Planning and Administration,' in the sub-goal 'Wellbeing and Work' it is possible to find the credit 'Workplace Health and Safety' that might evaluate the perception of the users of the building spaces.

In the EVVADES system, the main category pertinent to the environmental sustainability evaluation of university buildings is the 'Environmental management.' The main responses level found were:

- Strategic variables 'Develop a policy covering the reduction of the greenhouse gas emissions and the sustainable use and limitation of resource consumption':
  a) Limit emissions and practices that emit greenhouse gases;
  b) Implement and integrate environmental, social and use-related energy performance criteria into building specifications;
  c) Set up a responsible purchasing policy.
- Strategic variables 'Develop a policy for preventing and limiting the environmental impacts':
  a) Optimize the treatment of liquid organic effluents;

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   b) Optimize the sorting and recovery of waste mixed in with household waste;
   c) Optimize the treatment and reduction of W.E.E.E;
   d) Limit and optimize air pollution treatments
- Strategic variables ‘Develop a policy that promotes biodiversity’:
   a) Set up a sustainable management system covering cultivated the environments, green spaces and developed spaces (roads and car parks);
   b) Set up a sustainable management system covering the natural environments.

We conclude that both tools enter as valuable instruments to understand the parameters used for a global sustainability evaluation of the HEIs. However, we remarked the lack of indicators relating to the user’s comfort, the indoor environmental quality, the accessibility, the materials used, and the sustainable site. The building aspects approached by EVVADES and STARS are focused in the operational phase of the building life cycle. Both methods leave from behind important elements of the construction site, of the design and the conception phases, and regarding the building maintenance.

7 B4U

Before to present the B4U method, some clarifications regarding some definitions appear to be crucial to discerns “innovations,” “eco-innovations,” and “urban innovation.”

Innovations can be described as *“the implementation of a new or significantly improved product (goods or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*” (OECD, 2005b, p.46). They can be characterized as *“a change in economic activities that improves the overall performance of society across the economic, (social) and environmental dimensions of sustainable development”* (Huppes et al., 2008, pg.28).

Eco-innovations can be regarded as *“a change in economic activities that improves both the economic performance and the environmental performance of society*” (Huppes et al., 2008, pg.28) or *“all the technologies applied directly, in a preventive or ‘curative’ way, for preserving the environment in the classic sense of the term (i.e., water, air, soil, waste, noise, and others), energy efficiency, reduction of GHG emissions and renewable energies”* (Chambolle, 2006, pg.06). Eco-innovation, consequently, is a subclass of the innovation. The innovations that are not eco-innovations are characterized by environmental improvements with economic degradation or economic improvements with environmental degradation.

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The Uurban innovations can be identified "*as urban development projects that incorporate systemic innovations, in which new or modified concepts, systems, products and/or techniques are used, which contribute to low-carbon, climate resilient development on the scale of a neighborhood or upwards*" (EURBANLAB, 2017b).

B4U is a method for the urban innovation assessment. We decided to incorporate this tool in this analysis due to the significant relevance of the eco-innovations for this study but also for the achievement of sustainable products, process, buildings, and cities. Furthermore, eco-innovations are essential to meet the Goal 9 of the SDGs presented previously (UN-HABITAT, 2016).

The "Benchmark for You" B4U, developed inside the EURBANLAB project, is a comprehensive assessment methodology that has its fundamental principles in the environmental and the social sciences. The tool was designed to identify the urban innovations that contribute significantly to the sustainability of the urban environment, but also that have the potential to be widely applied in other locations (EURBANLAB, 2017b).

The method can be applied to the residential buildings, the business park, the public projects (e.g., libraries, universities), to new and retrofit buildings, and to transportation projects. It is composed of indicators that are classified in qualitative and qualitative. The B4U's indicators were developed in collaboration with the public, the private and the academic sector. The tool provides an assessment of the innovative concepts and the technologies in their local context in a triple level structure. The triple level structure combines what is referred to as Top-Goals, Sub-Goals, and Indicators (Bosch et al., 2013).

The Triple-P approach of sustainability, where 'People' determined a project's contribution toward the long-term attractiveness and liveability of urban developments, 'Planet' involves the low-carbon and the climate resiliency strategies, and 'Profit' evaluates the economic viability of the project for the neighborhood, for its users and its stakeholders. The Triple-P approach was extended in which way the projects have been developed, and how the innovations have been implemented.

Therefore, the 'Process and the 'Propagation' were also included as important parameters to assess the urban innovations. The political climate, the governance issues, and the quality of the development process are essential means of determining the factors of success in development. Once the project is completed, it is possible to analyze the possibilities for up-scaling and transferring new concepts or technologies that were applied, or in other words, the opportunities and conditions of the project propagation to other cities and countries (EURBANLAB, 2017b).

The Top-Goals or the 5Ps (People, Planet, Profit, Process, and Propagation) contains in the total 60 indicators (7 People, 15 Planet, 6 Profit, 14 Process and 18 Propagation) and some descriptive information to better understand the evaluation impact. The relation between the 5P categories is summarized in Figure 50.

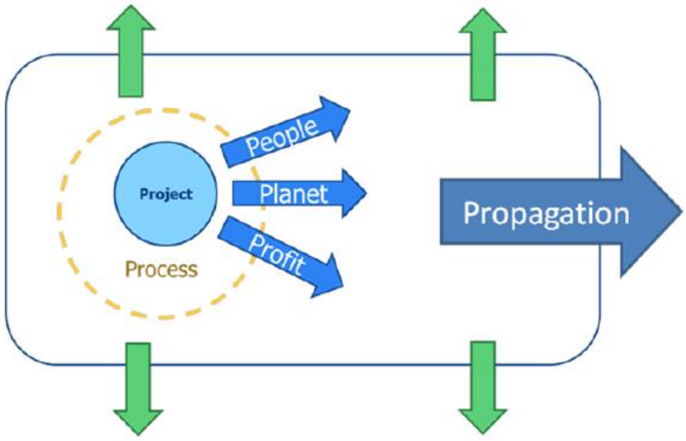

Figure 50. Impact of an innovative project. Source: Bosch et al. (2013).

Each indicator receives scores from 0 to 10. The raw values might pass by the normalization process[158] for some qualitative and quantitative indicators. For moving toward a one-score rating on the performance, it was necessary to give weighing factors to the various axes in the B4U-tool, based on the available literature and supporting research, ranging between 0 and 1 (Bosch et al., 2013). The weighting factor of each axis is presented in Annex 7.

At the end of the evaluation, every 'P' category have a sub-final score which is represented in a spider-diagram. The spider diagram of a project can be compared with another project in other to provide efficient and sustainable solutions that are currently available on the market. Furthermore, the method can be applied in distinct phases of the project to provide feedback about the innovations implementations (EURBANLAB, 2017b).

[158] To be able to compare indicators with widely varying units and scales, a normalization step is necessary, recalculating all indicator values according to standard procedures into a score on a 1-10 scale.

7.1 B4U method experience with the '*Aile Sud*' building implementation assessment

The B4U method was experimentally applied in the '*Aile Sud'* case study in 2014 by the REEDS Research Center inside the EURBANLAB project. The primary goal of this study was to test the method to provide some feedback on the experience and the improvement possibilities.

The first part of the study consisted of an exhaustive data collection about the implementation of the UVSQ inside the BN. All the documents, meeting reports, emails, architectural plans, technical building reports, energy and water bills were analyzed for the first part of the data collection. The second part of the data collection was consisted by interviews with the project actors like the project leader, the project manager, the building occupants and others.

The data collection allowed us to fill the 'Template' document presented in Annex 7 which consists in giving values to all the quantitative and the qualitative indicators. Every sub-goal will have a total of scores, and every goal will have a total of scores as well. The total scores from 0 to 10 of Each Top-Goal are placed in the Spider Diagram where the 5 P's are graphically represented.

During the data collection, the stakeholders were interviewed, however, after the data collection, the assessment is held by the delegated assessor. Thus, the evaluation has as primary sources the data collection and the interpretation by the delegated assessor.

The delegated assessor had a profile in the architecture and civil engineering, with a specialization in the building impact assessment. This actor worked inside the *'Aile Sud'* building for two years and also had the capacity to answer questions regarding the user's satisfaction in the post-occupancy phase.

7.1.1 Impact Assessment Results

The impact assessment showed us relevant information for each sub-goal. As the project is not a social dwelling, some indicators were judged not relevant to the project. It is the case of Fuel poverty, Affordability of housing and Social housing (see Figure 51).

The score of this Top-Goal is below the average[159] according to the spider diagram (Figure 56) that shows a total score of 6,2 for the 'People' category.

[159] The average was calculated according to the other European urban innovations that were evaluated by the B4U method.

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The results of the category 'People' assessment showed that the improvement of the building's comfort and quality were taken as priorities in the *'Aile Sud'* building renovation project. Attention was given to provide mobility and services to the building occupants, as seen in the *Availability of public amenities* and the *Availability of multi-modal mobility options* indicators. The indicator *Design of a sense of place* also had a significant score in the evaluation due to the building team efforts on creating a "sense of place" especially through the interior building design. The indicator *Connection to the existing heritage* also received a high score due to the strong connection with the existing cultural heritage (see Figure 51).

Analyzing the spider diagram (see Figure 56) of the final evaluation we can notice that the high score of 5 regarding the 'Planet' category. Even though renewable energy production was not applicable in this project, the *Climate resilience design* indicator contributed significantly to the total score of the 'Planet' Top-Goal (Figure 52), and it is correct to affirm that climate adaptation was a central concern for the project.

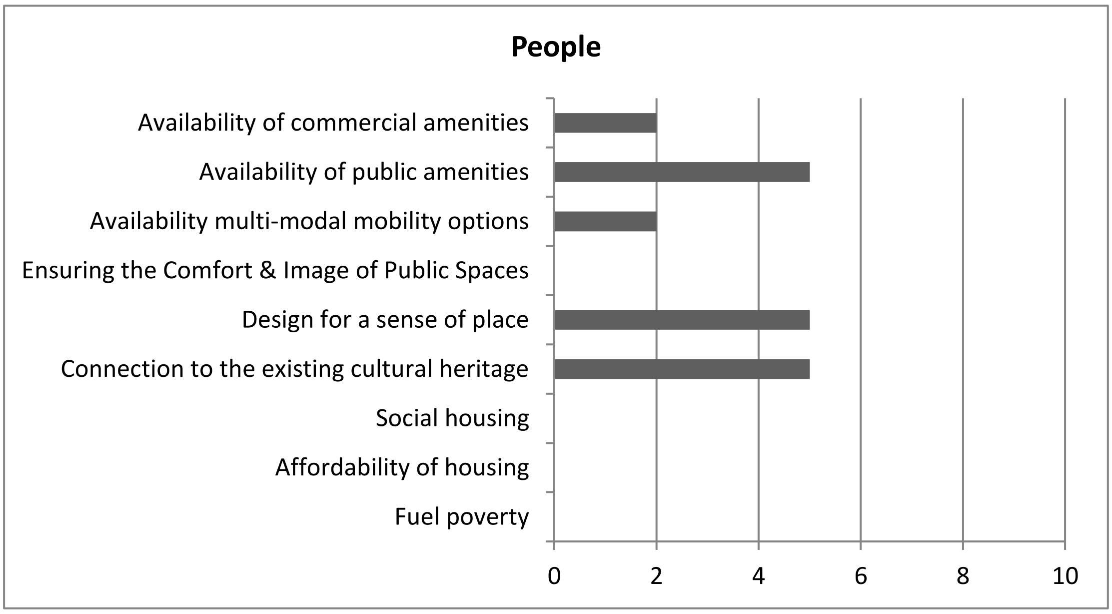

Figure 51. B4U assessment results from the Top-Goal 'People'. Source: Bittencourt at al. (2015).

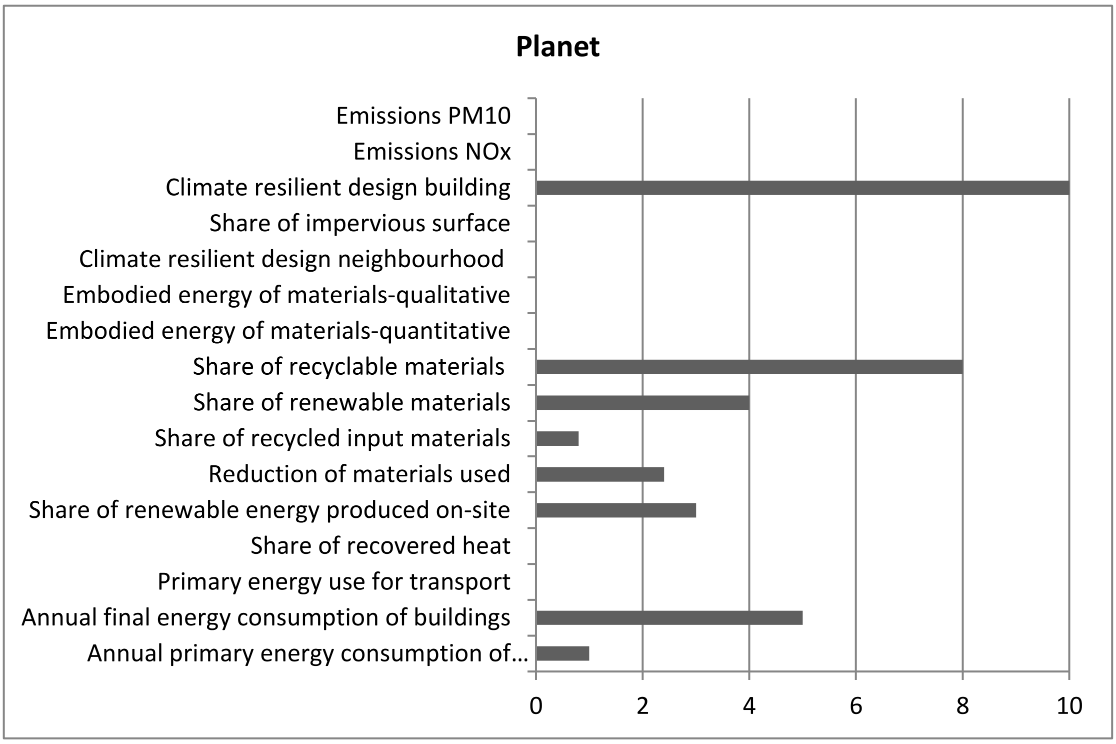

Figure 52. B4U assessment results from the Top-Goal 'Planet'. Source: Bittencourt at al. (2015).

The indicator *Annual final energy consumption* received a big score because of the significant efforts in the renovation of the building to improve energy efficiency. The *Share of recyclable materials* and the *Share of renewable materials* were highly scored. Windows' frame, existing furniture and one part of the building framework are made of wood which is a renewable material. The new furniture is made of wood certified by the FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification) labels.

The 'Profit' category received a score of 5.5 for the assessment of the UVSQ implementation in the BN (Figure 56). Indicators as *Payback period* and *Net present value* (NPV) were not considered in the assessment because the case study is an educational institutional with a financial context.

The indicator *Total cost savings for end-users* has a significant score in the 'Profit' Top-Goal and relates to the total cost savings with energy bills. Before the building renovation the energy bill was about €26 251.38/year and after the renovation, €14 645.94/year. The Use of Local Workforce has a considerable impact for the 'Profit' Top-Goal. This criteria was assessed regarding the companies that are situated in the same region of the project (Figure 53).

The communication between the stakeholders had a crucial role for the UVSQ/BN project conclusion. A restrict monitoring, and reporting plan ensured the project schedule and the budget during the project implementation. During the operational building phase, the energy consumption control much influenced the energy efficiency of the system (see Figure 54). The final assessment spider diagram of the UVSQ/BN case study pointed a score for the 'Process' category of 7.8 (see Figure 56).

The *Leadership* feature significantly contributed to the project achievement. As the UVSQ developed the project in a cultural site (Parc du Chateau) of the city of Rambouillet, the project leader succeeded in creating the right connections to support the project development.

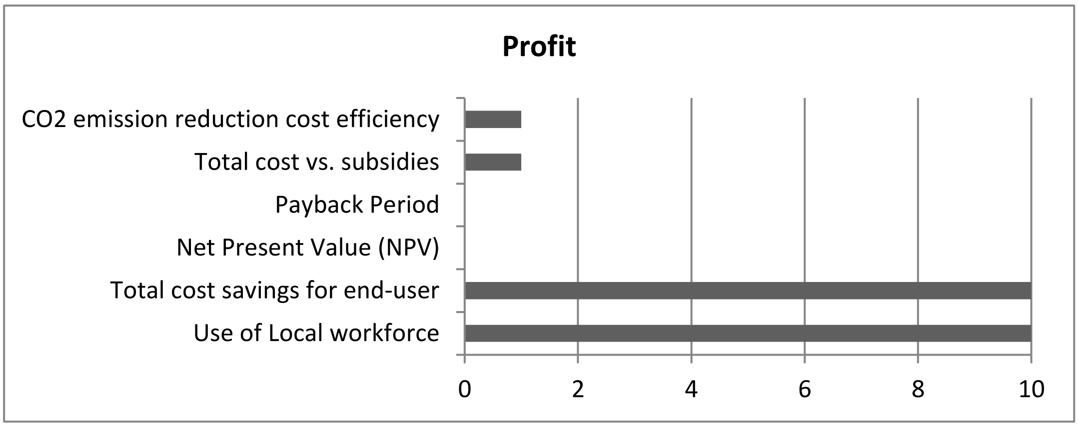

Figure 53. B4U assessment results from the Top-Goal 'Profit'. Source: Bittencourt at al. (2015).

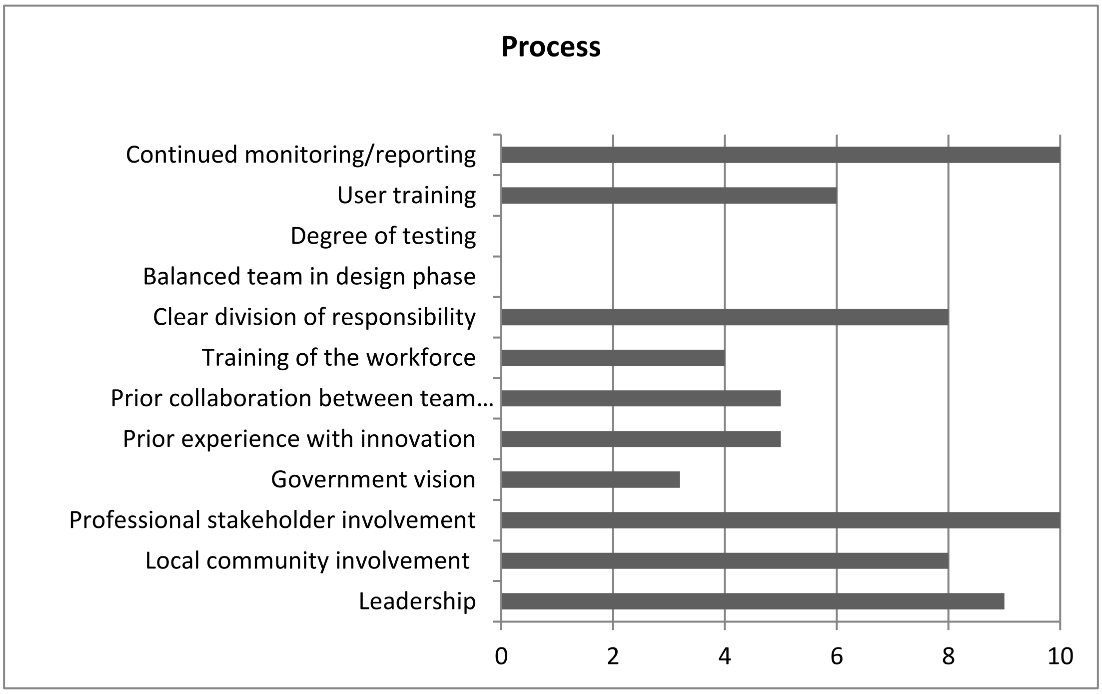

Figure 54. B4U assessment results from the Top-Goal 'Process'. Source: Bittencourt at al. (2015).

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Every planning and development meeting required the presence of at least one representative of the department, the regional council, the city hall, the BN, the UVSQ, the project manager, and the construction companies. Because of this, it is possible to find high scores for *Professional stakeholder's involvement* and *Local community involvement*. *Continued monitoring/reporting* was appreciable during the project implementation.

The Propagation Top-Goal's final score reached 7.1, representing a score above the average (see Figure 56). Relatively high scores are represented in by *Diffusion of products, concepts and technologies to other locations*, *Solution to development issues*, *Visibility of results* and *Current market demand for the solution* indicators (see Figure 55).

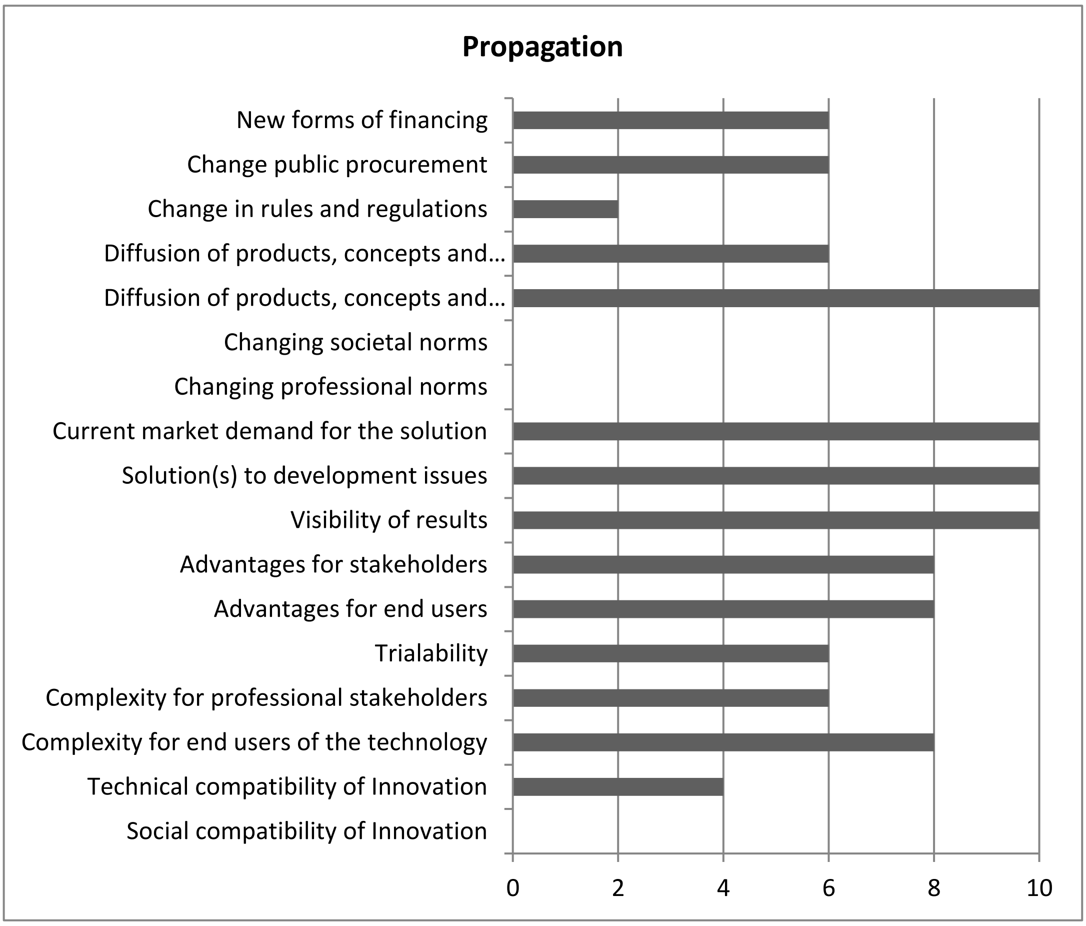

Figure 55. B4U assessment results from the Top-Goal 'Propagation'. Source: Bittencourt at al. (2015).

This happened because the innovation implemented is highly visible to external actors. All the building was renovated internally - the walls were painted, the lighting system was modernized, and all the interior design and the visual identity was remade (see Figure 55).

Furthermore, the project offers a solution for the common problems to most European cities that is the building retrofit, the building energy efficiency improvement, and the GHC emissions reduction. It is possible to affirm that there is a widespread market demand for the offered solution. Despite all these indicators that contributed to a high score in the Propagation Top-Goal, lower scores were identified in the *Technical compatibility of innovation* and *Change in rules and regulations* (see Figure 55).

7.1.2 Final Assessment

The spider diagram presents the scores of all the Top-Goals of the evaluation of the renovation project of the 'Aile Sud' building and its implementation in the BN (Figure 56). The project is above the average for the 'Planet,' 'Process,' and 'Propagation' categories. The top-goals 'People' and 'Profit' are a little bit below the average. This can be explained because some indicators were not considered in the study since we were evaluating a research center building and not a social dwelling.

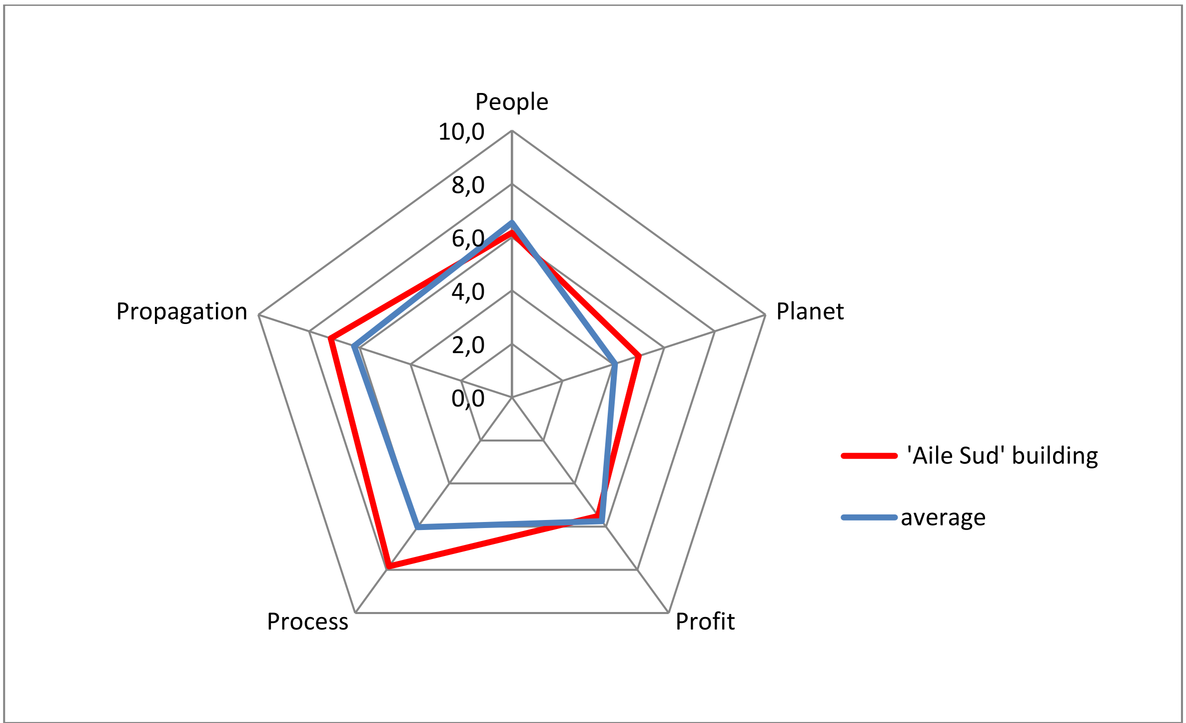

Figure 56. Spider diagram of the UVSQ/BN assessment with the B4U method. Source: Bittencourt at al. (2015).

7.2 Contributions and limitations with the B4U experience

With the B4U method application in our case study, it is possible to conclude that the method has an interesting structure to measure urban innovations. The 'triple P' structure that added the 'process' and the 'propagation' categories can have positive aspects for a sustainability assessment. We believe that the B4U method might increase the value regarding the GBR system and EVVADES and STARS methods.

Inside the EURBLANLAB project, once the results of the 5P are available, the assessment can be published in a platform online in a collaborative learning process. Inside this learning community, the accent is placed on comparative evaluation and thus, learning from others' experiences (Lanceleur and O'Connor, 2015).

Nonetheless, the main limitations of this method are presented by Lanceleur and O'Connor (2015) in their report *'Design Concepts: Towards a Sustainable Campus Social Network'* but also was experienced with the BN/UVSQ assessment with the EURBANLAB's project method. The method is limited regarding flexibility, mainly due to two main reasons:

- The variation of the innovations that the method can address is limited because the indicators cannot be added or removed, to fit for the case of study purpose;
- The lack of the diversity of judgment for the innovation in the sense that one assessor delegated is responsible for the whole evaluation.

Even having interesting indicators regarding the five categories, inside our limited try to evaluate the UVSQ/BN case of study we can affirm that many indicators were retained for the case study assessment and many indicators were not used for some reasons:

- Indicators were not relevant for the case study;
- The information needed to measure the case study was not available or was hard to find;
- Besides that, the indicators were not appropriated for the university building issues.

There is a lack of indicators related to the building issues as the water use, the waste management, and the indoor air quality improvement. Furthermore, it is relevant to mention the lack of the indicators to represent the specific concerns of the university campus. As significant concerns for the university building, it is possible to mention the adaptation to digital innovation, flexibility in the design of interior spaces, campus as a living lab, sustainable strategy, student life, raise awareness between building occupants.

Even with the limitation of the tool regarding the performance indicators, there is a possibility for the implementation of the B4U to access the university buildings. This requires a fit for the purpose of the B4U tool to adapt to the universities buildings issues. Furthermore, more flexibility would be needed when adding and moving indicators to the tool.

The fit for the purpose of the B4U tool would require active participation from the diverse actors of the case study analyzed. The involvement of the actors would help in the decision of which issues are relevant for the case study, for then propose ways to measure the performance through the indicators candidates.

The role of the actors is also essential for the evaluation. Currently, the B4U limits the assessment process to one point of view, which is the delegated assessor. The delegated assessor interprets the answers that the actors gave during the data collection. Inside the B4U context, the delegator assessor will provide results inside an expert system. It is not the role of the delegator assessor the organization of deliberation and mediation meetings between the actors.

On the contrary, many actors highlight the importance of the actor's participation. For Sala (2015), 'Broad participation' is an important principle of sustainable assessment to strengthen legitimacy and relevance (Sala et al., 2015).

8 DISCUSSION ON THE CONCEPT OF THE SUSTAINABILITY EVALUATION OF THE UNIVERSITY BUILDINGS

After analyzing the existing methods for assessing buildings and universities, we concluded that any method or tool presented can represent the performance strategy assessment of the renovation process of the university building. It is necessary to create a new approach that will help stakeholders to analyze the real situation to focalize in the ideal situation. In this study, the ideal situation can be interpreted as a sustainable building inside a sustainable campus connected and integrated with the sustainable city.

The main objective of a sustainability assessment (SA) is to improve the decision-making process, by (Bockstaller et al., 2009; Gasparatos et al., 2008):

- Integrating the sustainability spheres, taking their interdependencies in mind;

- Incorporating the intragenerational and the intergenerational discussions;
- Supporting constructive discussions among the stakeholders;
- Accounting for uncertainties and adopting a precautionary approach;
- Improving the monitoring process and the communication between all the actors involved.

Over the years, one of the major challenges faced by the scientific community was to develop efficient and reliable tools for performing the SA. To meet this challenge, the assessment of sustainability has evolved rapidly in recent years. In this section, we will review the various approaches developed in the literature and the distinct modalities of the SA.

8.1 The basic elements of a sustainability assessment

The rise in the interest in the 'sustainability' and the 'sustainable development' concepts in the last 20 years brought attention to the challenges to the way that the impact assessment was traditionally conceived (Pope et al., 2004).

Many definitions of the policy-oriented in the SA can be mentioned. Devuyst et al. (2001, pg.9) define SA as a methodology *"that can help decision-makers and policy-makers decide what actions they should take and should not take in an attempt to make society more sustainable."* For Verheem (2002, pg.9), the SA *"is defined as a structuring of the decision-making process so that administrators can develop projects and plans from a sustainability perspective (the 'internal' aspect) and justify them on the grounds of their contribution to sustainable development (the 'external' aspect)."*

However, for Frame and O'Connor (2011), in a sustainability context, decision-makers and policy-makers cannot decide alone without a system that integrates theorizing and practice and stimulates broad participation.

> *"SA is an emergent terrain of theorizing and practice, that incorporates deep fuzziness with the importance of developing operational skills for articulating and negotiating challenges of building common futures that reconcile potentially competing claims to be sustained while attempting to maintain a common heritage"* (Frame and O'Connor, 2011, pg. 1).

Kates et al. (2001, pg.262) proposed a set of core question of sustainability science with a view toward the promotion of the research advance. One of these questions was focused on the integrative dimensions of the evaluation: *"How can today's relatively independent activities of research planning,*

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monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?".

This question highlights the need to better integrate environmental and social issues into the scope of the SA. The aim of the SA is, therefore, to provide decision-makers with tools for a better integration of nature-society systems in a short- and long-term perspectives to help them to become more efficient in achieving sustainability objectives (Gassama, 2016; Devuyst et al., 2001).

The SA includes several approaches: Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Social Impact Assessment (SIA), and Health Impact Assessment (HIA). Even if the sustainable assessment thinking has been much developed by EIA and SEA practitioners once we acquire some knowledge in the link between the instruments for the impact assessment and the sustainable development, it becomes evident that impact assessment on its own will not conduct us to a sustainable society.

EIA and SEA can make a valuable contribution toward the sustainability. However, it is evident the necessity to study others instruments for environmental management (e.g., as the LCA mentioned in the previous section), tools to measure improvements toward sustainability goals, and the link between these tools and policy-making, planning, and decision-making process (Devuyst et al., 2001; Sadler, 1999; Gibson, 2001).

A meeting of an international group of researchers, organized by the International Institute for Sustainable Development (IISD), and supported by the Rockefeller Foundation, took place in Bellagio, Italy, in 1996. This meeting created the Bellagio Principles, which are essential to guide the development of any tool for SA (Table 11).

The Principle 1 is essential, and it represents the starting point of any assessment – establishing a vision of sustainable development and clarifying goals that provide a practical definition of that vision in terms that are significant for the decision-making unit in question. The Principles 2 until 5 are about the content of any assessment and the need to merge a sense of the overall system. The Principles 6 until 8 deal with essential issues of the assessment process. Finally, the Principles 9 and 10 highlight the necessity for determining a continuing capacity for assessment (Hardi and Zdan, 1997).

Sala et al. (2013) added to the Bellagio list some other challenges as moving from the multidisciplinary, via the interdisciplinarity toward the transdisciplinary, calling attention to the social learning and feedback, having a normative function, and dealing with the uncertainties.

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Table 11. The Bellagio Principles for Assessment Toward Sustainable Development. Source: Hardi and Zdan (1997).

BELLAGIO PRINCIPLES

PRINCIPLE 1: GUIDING VISION AND GOALS

Assessment of progress toward sustainable development should be guided by a clear vision of sustainable development and goals that define that vision

PRINCIPLE 2: HOLISTIC PERSPECTIVE

Assessment of progress toward sustainable development should:

- Include review of the whole system as well as its parts;
- Consider the well-being of social, ecological, and economic sub-systems, their state as well as the direction and rate of change of that state, of their component parts, and the interaction between parts;
- Consider both positive and negative consequences of human activity, in a way that reflects the costs and benefits for human and ecological systems, in monetary and non-monetary terms.

PRINCIPLE 3: ESSENTIAL ELEMENTS

Assessment of progress toward sustainable development should:

- Consider equity and disparity within the current population and between present and future generations, dealing with such concerns as resource use, overconsumption and poverty, human rights, and access to services, as appropriate;
- Consider the ecological conditions on which life depends;
- Consider economic development and other, non-market activities that contribute to human/social well-being.

PRINCIPLE 4: ADEQUATE SCOPE

Assessment of progress toward sustainable development should:

- Adopt a time horizon long enough to capture both human and ecosystem time scales thus responding to needs of future generations as well as those current to short term decision-making;
- Define the space of study large enough to include not only local but also long-distance impacts on people and ecosystems;
- Build on historic and current conditions to anticipate future conditions - where we want to go, where we could go.

PRINCIPLE 5: PRACTICAL FOCUS

Assessment of progress toward sustainable development should be based on:

- An explicit set of categories or an organizing framework that links vision and goals to indicators and assessment criteria;
- A limited number of key issues for analysis;
- A limited number of indicators or indicator combinations to provide a clearer signal of progress;
- Standardizing measurement wherever possible to permit comparison;
- Comparing indicator values to targets, reference values, ranges, thresholds, or direction of trends, as appropriate.

PRINCIPLE 6: OPENNESS

Assessment of progress toward sustainable development should:

- Make the methods and data that are used accessible to all;
- Make explicit all judgments, assumptions, and uncertainties in data and interpretations.

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PRINCIPLE 7: EFFECTIVE COMMUNICATION

Assessment of progress toward sustainable development should:

- Be designed to address the needs of the audience and set of users;
- Draw from indicators and other tools that are stimulating and serve to engage decision-makers;
- Aim, from the outset, for simplicity in structure and use of clear and plain language.

PRINCIPLE 8: BROAD PARTICIPATION

Assessment of progress toward sustainable development should:

- Obtain broad representation of key grass-roots, professional, technical and social groups, including youth, women, and indigenous people - to ensure recognition of diverse and changing values;
- Ensure the participation of decision-makers to secure a firm link to adopted policies and resulting action.

PRINCIPLE 9: ONGOING ASSESSMENT

Assessment of progress toward sustainable development should:

- Develop a capacity for repeated measurement to determine trends;
- Be iterative, adaptive, and responsive to change and uncertainty because systems are complex and change frequently;
- Adjust goals, frameworks, and indicators as new insights are gained;
- Promote development of collective learning and feedback to decision-making.

PRINCIPLE 10: INSTITUTIONAL CAPACITY

Continuity of assessing progress toward sustainable development should be assured by:

- Clearly assigning responsibility and providing ongoing support in the decision-making process;
- Providing institutional capacity for data collection, maintenance, and documentation;
- Supporting development of local assessment capacity.

8.2 Evaluation through integrated methods

Over the years, the field of Integrated Assessment (IA) increased in credibility and recognition. Despite the several definitions about the IA, two elements are presented as common ideas: the interdisciplinary and the decision support. In this sense, IA can be described as *"a structured process of dealing with complex issues, using knowledge from various scientific disciplines and/or stakeholders, such that integrated insights are made available to decision makers"* (Rotmans, 1998, pg.155).

Due to the complexity, IA is based on a range of scientific disciplines, or in other words, a multidisciplinary analysis of environmental issues with the explicit goal of supporting policy development (O'Connor, 2006; Rotmans, 1998; Gassame, 2016). Scrase and Sheate (2002) contributed to the literature presenting 14 methods for integration with a wide discussion about the potential synergies and the conflicts among them.

Rotmans (1998) divided the integrated assessment methods into two groups. On the one hand, the scenario-based analytical models and the risk analysis, with their origin from the natural science. On the contrary, the participatory analyzes, from the social sciences, that organize the dialogue, the communication, the exercise of governance and the social learning.

Analytical methods include model, risk and scenario analysis, which are hypothetical sequences of events, built to focus attention on causal processes and decisions. This approach considerate an analysis of systems that integrate the nature and the society while examining possible futures (Ibid., 1998; Gassama, 2016; Kahn and Wiener, 1967).

Participative analyses are interactive and deliberative. They are *"continuing process, where integrated insights from scientific and stakeholder community are communicated to the decision-making community, and experiences and learning effects from decision makers form one input for scientific and social assessment*" (Rotmans, 1998, pg.155). Both methods, analytical and participatory aim to facilitate the IA process. Participation of stakeholders is a vital element that gives access to the practical knowledge and the experience, highlighting that 'participation' differs from 'consultation.'

Participatory methods are diverse and might involve techniques as panels of experts, Delphi methods, gaming, policy exercises, voting, focus groups (*Ibid.,* 1998; Twigger-Ross and Smith, 2000; Gassame, 2016). Scrase and Sheate (2002) brought attention to several reasons for the participation of stakeholders:

- Democratic reasons for the participation based on convictions that those who stand to be impacted by the decisions must have a voice in the deliberations;
- The instrumental view that input from a more several ranges of actors will enhance the decisions by introducing options or evaluation criteria that might otherwise be neglected;
- The view that social values must inform the decision-making more precisely;
- The participation can conduct to the transformation in the people's values through the engagement in the process itself.

The main participatory methods were determined by Rotmans (1998) as:

- Dialogue methods: is used when actors are considered a source of information indispensable for the analyst to perform the evaluation;
- Policy exercise methods: flexible structured process projected as an interface between policy makers and scientist in which a simpler system represents a complex system with significant

behavior similarity where decision making is part of the human participation (Toth 1988; Parson, 1995);

- Mutual learning methods: when the stakeholders and the citizen participation contribute to the assessment by several perspectives, skills, and competencies.

The stakeholders' participation is essential to reach legitimate decisions. Nevertheless, the challenge, given the wide variety of viewpoints, is to represent divergent and often contradictory interests of relevant stakeholders (Gassama, 2016). Aligning analytical model and participative analysis is rather the most efficient and legitimate way to perform assessments. In this sense, integration can be understanding as a process and as an ambition to look for the reflexivity and the public dialogue, or in other words, through deliberation that involves a voluntary engagement (Frame and O'Connor, 2011).

The problem of social choice can only be solved by the consultation and the use of a multiplicity of points of view and therefore of criteria. The need for public participation is thus increasingly recognized within the framework of multi criteria evaluation methods, which has led society to consider not only the multi criteria but also the participatory analysis. These multi criteria participatory evaluations can be developed through a mediation process (Da Cunha, 2010).

8.3 Theory of democracy and the several aspects of deliberation

Dryzek and List (2003) present in their study two distinct approaches to democratic theory: the deliberative and social choice theory. For deliberative democrats, *"the essence of the democratic legitimacy is the capacity of those affected by a collective decision to deliberate in the production of that decision"* (pg.03). Deliberation implies the debate between individuals, where they can change their preferences influenced by other persons. Claims for and against actions need to be justified to the others in terms they can accept.

On the other hand, in the social choice theory, *"the democratic problem involves aggregation of views, interests, or preferences across individuals, not deliberation over the content" (Ibid.,* 2003, pg.3). For List (2003, pg.01), "*the social choice theory is the study of collective processes and procedures. It is not a single theory, but a cluster of models and results concerning the aggregation of individual inputs (e.g., votes, preferences, judgments, welfare) into collective outputs (e.g., collective decisions, preferences, judgments, welfare)".*

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Dryzek and List (2003) proposed a reconciliation between both theories. They argued that the social choice theory point to the functions that the deliberation can perform in making collective decisions both amenable and meaningful, providing an important service to the deliberative democracy.

Sustainable development is par excellence a social choice problem (O'Connor, 2007) because its purpose is how the groups can make joint decisions logically by the revelation of their views, interests or individual preferences in group decisions. Deliberation has an important role here since it can cover informational, argumentative, reflective and social aspects, as is showed in Table 12.

Table 12. Deliberation aspects. Source: Dryzek and List (2003, pg.09)

INFORMATIONAL	Confront people with new facts, new information or new perspectives on a given issue, as well as corroborate or falsify previously believed facts, information or perspectives.
ARGUMENTATIVE	Draw people's attention to new arguments about the interdependence of issues, confirm or refute the internal consistency of such arguments, make explicit previously hidden premises and assumptions, and clarify whether controversies are about facts, methods, and means, or values and ends.
REFLECTIVE	Induce people to reflect on their preferences, in the knowledge that these preferences have to be justified to others.
SOCIAL	Create a situation of social interaction where people talk and listen to each other, enabling each person to recognize their interrelation without a social group.

8.4 Evaluation: mediating knowledge

In the evaluation process, we have several actors' categories that have diverse understandings about the problem and the solutions to the sustainability issues to be studied. Thereat, it is essential to organize and structure the knowledge discovery and its mobilization within the evaluation framework.

In a first moment, the most important is the collective construction of the issue and not the decision-making process itself, in other words: « Sustainability for what, why and for whom? » (O'Connor et al., 2006) Once these preliminary questions are answered, the process then requires mobilizing the actors and their knowledge.

From this mobilization, it will emerge the need for a mediation process to establish the dialogue and the deliberation, in other words, an exchange of perspectives in a constructed dialogue. In this logic, the process determines a basis of legitimacy that will act as a common basis for the decision-making (Gassama, 2016).

The knowledge brokerage has become a strong driver in the current sustainability speech, with several parts in the literature encompassing multiple scientific areas. It has as main goal the promotion of the knowledge sharing and transfers as a way of breaking down barriers that retard the interaction, the healthy communication, and the collaboration. Knowledge brokerage is associated to how distinct social networking structures actuate in the ability of the organizations to determine knowledge transfer, access, and innovation (Sheate and Partidário, 2010).

In the present, several evaluation methods based on positivist and rationalist assumptions argue that providing more information to the decision-making process significantly improves the decision-making (Thérivel, 2004; Fischer et al., 2009). However, many authors believe that assessments are more likely to influence in the decision-making if those decision-makers are sharing and acquiring knowledge, and not just information (Nilsson and Dalkmann, 2001

'Knowledge' involves information that has been developed by learning to be capable of being recalled and so create understanding and insight. Furthermore, it is a prerequisite to be able to synthesize, analyze and evaluate. (Bloom et al., 1956).

The use of these methods in the appropriate circumstances can provide an active link and an exchange mechanism to help to strengthen the ability of the decision-makers to use assessment instruments with more effectiveness. This conduct the decision-makers to be more open to the multiple values expressed by society and to make social decisions. The social commitments can change sustainability issues in the various sectors of the society (Gassama, 2016).

The strategic evaluation methods, such as the Strategic Environmental Assessment (SEA) and the Sustainability Assessment (SA), and the techniques that they use (e.g., stakeholder engagement, use of objectives and indicators, and others) possess the potential to act as platforms to produce knowledge (Sheate and Partidário, 2010). Learning in the context of the sustainability can be interpreted as a process whereby a key element of public policy (e.g., such as problem definition, outcomes, stakeholder strategies, and others) need to be refined and adapted to address the complexity and inherent uncertainty of the sustainability issues globally (O'Connor, 2006).

Sheate and Partidário (2010) affirmed that a significant challenge of the knowledge brokerage is therefore how strategic and technical approaches can be used to communicate to decision-makers the essential information about the choices between the alternative strategies, the pressures associated with the issues and the environmental and social consequences of sustainability (Sheate & Partidário, 2010). Public participation in the sustainability assessment requires new forms of knowledge production. Knowledge brokerage has the potential to generate more participatory attitude to this initiative (Gassama, 2016).

8.5 The assessment by the deliberative process: Sustainability Assessment

As the previous definitions of sustainability assessment (SA) presented are generic to describe a broad range of diverse process, Pope et al. (2004) invite for a reflection in this term. He categorized SA approaches in environmental impact assessment (EIA) driven integrated assessment and objectives-led strategic impact assessment (SEA) integrated assessment.

EIA-driven integrated assessment tends to be applied after the identification of social, economic and environmental impacts of a proposal, but also to compare these impacts with the baseline conditions (Pope et al., 2004). George (2001) mentioned a significant potential for identifying the mitigation measures in EIA driven integrated assessment, where adverse impacts can be minimized or prevented.

The objectives-led integrated assessment reflects a motivation to achieve a vision or outcome defined by integrated environmental, social and economic objectives. It evaluates the extent to which the implementation of a proposal cooperates to this vision, in opposition to the EIA-driven integrated assessment, that aims to guarantee that triple bottom line (TBL) impacts of a proposal are acceptable in comparison to baseline conditions. The mentioned approach reflects the meaning of sustainability as a goal aspired by society (Pope et al., 2004). For Gibson (2001):

> *"Adopting contributions to sustainability as a key objective and test in environmental assessment clearly implies that minimization of negative effects is not enough. Assessment requirements must encourage positive steps – towards greater community and ecological sustainability, towards a future that is more viable, pleasant and secure"* (Gibson, 2001, pg.01).

Different from the EIA-driven approach, that aims to minimize adverse impacts, the objectives-led integrated seeks to maximize the objectives.

Taking in consideration that the concept of sustainability is about positive change and not just the minimization of impacts, it is possible to affirm that objectives-led integrated assessment surely has more potential to contribute to sustainability than EIA-drive integrated. However, both approaches tend to limit themselves to measuring if a proposal represents a positive or negative contribution to the sustainability in a sort of 'direction to the target' where the target is a sustainable society.

Questions as «how long to achieve the goal?» and «how to reach the goal?» should also be integrated (Pope et al., 2004).

One of the main challenges of the strategic sustainability assessment is to enable the stakeholders to communicate with the major decision makers on essential information about the choices between the alternative strategies, environmental pressures, social issues and sustainability consequences (Sheate and Partidário, 2010).

The knowledge exchange between the stakeholders and the main decision makers contributes with the development of action plans with the information received. The co-construction of the actions planc might influence the models of representation and the social values expressed. This helps to solve the existing social problems, which is the desired aim of any public policy (Gassame, 2016).

8.6 The new assessment: Assessment for the Sustainability

As a conclusion of the both approaches presented before, Pope et al. (2004) presented a new conception for the sustainability assessment:

> *"SA can be defined as a process to determine whether or not a particular proposal, initiative or activity is, or is not, sustainable, and therefore effectively becomes a yes/no question. Instead of asking: Are we heading in the right direction? The alternative process allows us to ask: Are we there?" (*Pope et al., 2004, pg.607).

This new conception of 'assessing for sustainability' implies that sustainability is a societal state, with particular features or conditions, designated by sustainability criteria. This notion can be potentially applied in several circumstances as: an alternative for EIA and SEA, in the conclusion of the decision-making process; proactively, during the decision process to assess the sustainability of the many options suggested to meet a series of sustainability criteria; and to evaluate existing practices and activities (Pope et al., 2004).

It is a matter of observing the direction of the objective to be reached, where the position of a sustainable state is unknown but desired. The extent to which an assessment achieves its purpose depends primarily on the objectives chosen to define the concept of sustainability. It is not enough that environmental, economic and social objectives are combined, they must be objectives by which a desired form of sustainability can be defined (Gassama, 2016).

Comparing with the other methods, 'Assessing for Sustainability' is more compatible with the concept of sustainability because it assesses the contribution of a set of objectives defined by groups of actors through a performance criteria. The principles used to define a sustainability situation will depend on the prevailing view of sustainability in the context of the assessment (Pope et al., 2004). For instance, it may involve questioning the sustainability of the university buildings inside the campus.

One of the main implications of the sustainability assessment process is that it requires a clear understanding of what sustainability means. This vision must be translated into the sustainability criteria specific to the context and the territory. An approach based on the sustainability principles emphasizes the interdependencies and the commitment between pillars rather than promoting conflict. Therefore, a new approach could avoid some of the limitations inherent in the triple approach of the environmental, social and economic performance (Gassama, 2016).

There are two global approaches to the development of the sustainability evaluation criteria (Pope, et al., 2004). One approach generates criteria by speculating that the simultaneous achievement of a series of environmental, social and economic goals, or objectives, determines a state of sustainability. This is effectively a 'bottom up' approach in the sense that objective is defined in relation to the baseline conditions.

The major problem with this kind of approach is to know how to judge whether a criterion has gone far enough to achieve its sustainability goal. Another approach assumes a 'top-down' generation of criteria. It starts with the concept of sustainability as a state to which society desires and then moves on to define this state concerning the sustainability criteria.

Besides that, another approach is to consider the interrelationships between the three dimensions of sustainability to be truly integrated. It is recognized that *"the combined impacts, positive and negative, of the sets of measures as a whole, are likely to be more than the simple sum of the impacts of their constituent measures because of synergistic effects"* (Lee & Kirkpatrick, 2001, pg.396). If the assessment process is not integrated effectively, then this form of 'integrated' assessment is reduced to three separate impact assessments, which each of the evaluations will produce data on a specific dimension of sustainability (Pope et al., 2004).

The question then arises as to whether the performance-based approaches of each of the sustainability spheres considered in isolation are acceptable. O'Connor (2006) illustrates the complex nature of the relationship between the sustainability dimensions. Sustainability is represented as a coevolution of the social, economic and environmental systems that respect a TBL. The system regulation and governance characterizes a fourth fundamental category: the political sphere. The sustainability governance cannot be achieved without a diagnosis of all the dimensions involved and their articulations. Hence, the participatory governance, that underpins sustainability in natural resource management, through the social choice approach, should lead to a four-dimensional model, named the Tetrahedral Model of Sustainability (see Figure 57).

In this sense, the assessment for sustainability (O'Connor, 2006)*:*

> *"Must bring focus on the interfaces, the interactions, and the interdependencies between the economic, social and environmental spheres, on the characterization of principles of performance and quality in each sphere, and on the principles of rights, respect of responsibility proposed for one sphere in relation to another. The political sphere has the role of the "referee" that arbitrates in relation to the different claims made by actors of the social and economic sphere for themselves and with regard to other spheres"* (O'Connor, 2006, pg.286).

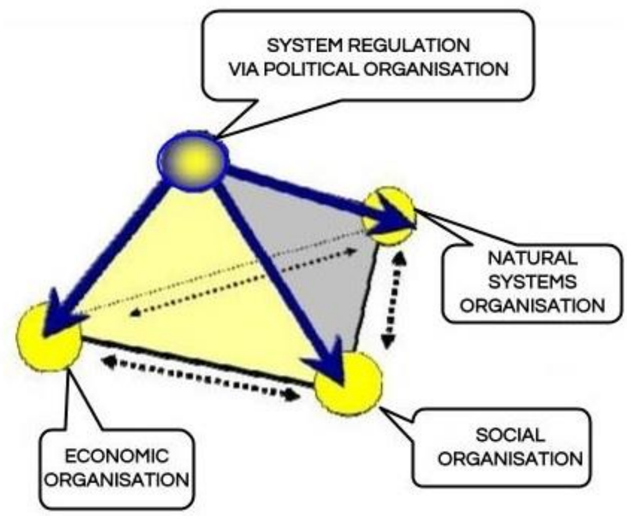

Figure 57. Tetrahedral Model of Sustainability. Source: O'Connor (2006).

When considered in pairs, the cross-section of the dimensions gives much more information on the sustainability elements to be considered in a sustainable management approach (see Table 13).

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Table 13. The four spheres of sustainability and their interface. Source: O'Connor (2006).

	SOCIAL	ECONOMIC	ENVIRONMENTAL	POLITICAL
SOCIAL	Forms of Collective Identify and Community: THE SOCIAL SPHERE			
ECONOMIC	OPPORTUNITIES AND IMPACTS: "The economy versus the community"	Performance, Products and Output: THE ECONOMIC SPHERE		
ENVIRONMENTAL	LIVING WITH (IN) NATURE Meanings, Values and Risks: sustaining what and for whom?	ENVIRONMENTAL FUNCTIONS: Pressure and service of the environment	Energy, Matter, Nature Cycles and Biodiversity: THE ENVIRONMENTAL SPHERE	
POLITICAL	SOCIAL POLICY: (Capacity of communities: citizen/public participation)	ECONOMIC, POLICY: (Shaping the rules and limits of markets)	ENVIRONMENTAL POLICY: (Regulation of what counts as an environmental value)	Coordination, Power, and Governance: THE POLITICAL SPHERE

8.7 The INTEGRAAL framework for the sustainability assessment

As already stated, the complexity of the SA added to the necessity to provide a path toward the achievement of a sustainable future. In the context of this study, the sustainable future is a sustainable building inside an environmental-friendly, with social equity and economic growth conditions; in a structured, transparent and reliable way. MCDA can contribute positively to this objective (Cinelli et al., 2014).

However, as we stated before, the limitations of the traditional problem-solving strategies of the analytical process brought attention to the importance of the stakeholders' participation in the integrated assessments. The stakeholders' involvement might be a possibility to align criteria, values, legitimacy, and effectiveness (Clark and Majone, 1985). An integrative analysis of the environmental assessment in a deliberative perspective appears to be the adequate combination to provide legitimacy and effectiveness of the evaluation results.

For the implementation of our multi-criteria participatory evaluation, we will use an innovative framework called INTEGRAAL. This framework is a result of about many years of research of the Center

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REEDS. The INTEGRAAL respond to the growing need for tools and approaches to the challenges posed by the SD paradigm (Da Cunha et al., 2011).

The INTEGRAAL approach is a meta-method belonging to the family of the mediation processes that can be defined as processes in which the participants in a debate or a controversy seek to identify their differences and the potential solutions in discussions with the help of a neutral third part.

The aim of this framework is to enable the actors to start a process of learning and deliberation that allows them to understand the arguments of the others. It helps in the promotion of the debates to find solutions that best satisfy all the actors. The information about the actor's interests and priorities will be determined and discussed. The INTEGRAAL framework consists of six steps, guiding the process of multicriteria and multi-actor assessment and deliberation as shows the Figure 58 (Association ePLANETe Blue, 2017).

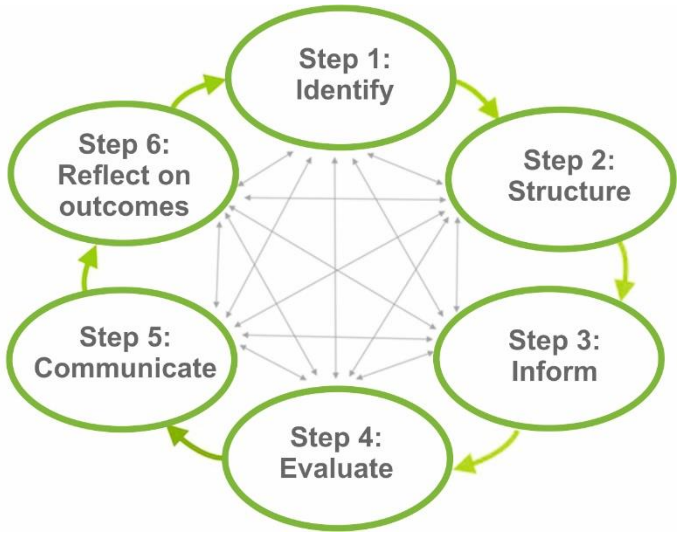

Figure 58. INTEGRAAL framework. Source: Association ePLANETe Blue (2017).

- Step 1. Identifying the problem: describing the problem, territory, project, scales, beneficiaries, and partners;
- Step 2. Structuring the problem: defining the categories of actors, the performance issues and the alternatives through an iterative process of documentation and appropriation of the problem studied, based on the consultation of the actors concerned;
- Step 3. Representing the system: identifying and mobilizing tools to represent the system in which the problem arises;

- Step 4. Evaluating and deliberating: evaluating alternatives from a multi-criteria and multi-stakeholder perspective;
- Step 5. Analyzing and communicating: communication of the study results and the recommendations;
- Step 6. Reflect on the outcomes

A whole description of each step can be found in many rapports of the Center REEDS, but also in some thesis work. Da Cunha (2010) experimented the INTEGRAAL framework to understand how the environment, including biodiversity, can be considered in agricultural activities. Gassama (2016) evaluated the preferences of the actors considering the sustainable forest management. Both experiences were used as references for this thesis work. It is important to highlight here that the INTEGRAAL framework is not a rigid linear process. It is possible to return to any stage during the multi criteria participatory evaluation, if necessary.

8.8 The implementation of our model in the EPLANETE BLUE

The ePLANETe Blue platform[160] was developed at the Centre international REEDS. It is simultaneously (1) a modular "Knowledge Gateway" with a spectrum of collaborative learning support functions; (2) an innovative approach to the "integrative" and participatory modeling of "ecolo-socio-economo" systems; and (3) a "deliberation support tool" (DST) simplifying the appraisal of sites, scenarios or other situations related to multiple criteria (O'Connor and Lanceleur, 2015).

Many modules are composed by the CMS (Content Management System) programming tools, to furnish galleries of many 'objects' of particular types. Examples of the object types are profiles of people of members of a 'user community', profiles of partners, presentations of ideas for green economy innovation, or reports of performance assessments of a 'Project' or 'Action' relative to CSR or sustainability criteria. The ePLANETe Blue is an online "Collaborative Platform" oriented toward the social learning and the deliberation support addressing sustainability challenges *(Ibid.*, 2015).

The ePLANETe Blue platform will allow us to implement the performance strategy assessment of the university buildings renovation process within the INTEGRAAL framework. In other words, in the context of this thesis it is a modeling system that will assist us in the representation of our tool in a digital platform.

[160] See https://proxy.eplanete.net/portals/eplanete/.

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The platform is composed by six distinct 'Doorways' (i.e., Top levels) relating, in a didactic way, to the "four spheres" of the 'Tetrahedral Model of Sustainability' (i.e., social, environmental, economic, and political) presented previously. The six 'Doorways' are presented in the Table 14 and more information about the platform is presented in the Annex 08.

The core of the ePLANETe as a portal is the provision of the structured knowledge within the galleries, each offering a catalog of digital objects. These galleries can be classified as a 'simple type': for example, catalogs of objects such as indicators, and actions. These objects are documented from a metadata profile and discovered in the gallery using filters.

Some other galleries can be classified as 'complicated type', in which a variety of objects are presented from the cognitive paths to discover the object themselves and the component elements of the object in question.

Table 14. ePLANETe Blue Doorways. Source: EPLANETe Blue (2015).

EPLANETE BLUE DOORWAYS
TALIESIN— BUILDING KNOWLEDGE PARTNERSHIPS FOR SUSTAINABILITY It proposes the discovery of training programs and teaching aids carried out within and outside the University of Paris-Saclay.
VIRTUAL ECO-INNOVATION FAIRGROUND (THE ECONOMIC DIMENSION) It offers the opportunity to discover the eco-innovations, evaluate their performance and the challenges of the governance of the green economy and the circular economy.
TOUTATIS (THE SOCIAL DIMENSION) This doorway aims to present the members of the communities and the partners as well as the activities. These Communities are organized and presented via Profiles in three cross-linked galleries, using complementary logics of identity: Persons; Partners (institutions, or operational units within an institution); and the User Communities themselves.
CAMELOT — JUSTICE & ENVIRONMENT (THE POLITICAL DIMENSION) It brings together the approaches to a problem of social choice, mobilizing, in particular, the tools to help the deliberation, to address issues related to the socio-environmental conflicts, unequal ecological distributions.
MERLIN — ACCENT ON OUR BEING-IN-NATURE (THE ENVIRONMENTAL DIMENSION) The Doorway 'Merlin', by its name, connotes a desire to establish a mediation between society and its environment. The aim is to discover the environment through the virtual gardens, biosphere cycles, environment-economy accounting systems, and economy-environment models.
KERBABEL It is composed of the galleries that provide a body of knowledge pieces, objects which will be mobilized in other galleries of the other Doorways.

Finally, the advanced galleries are proposed and are denominated 'complex galleries'. Deliberation tools such as the 'Representation Rack', the K4U performance evaluation system or the 'Deliberation Matrix' are called 'complex galleries'. They mobilize objects from 'simple galleries' and rely on the development of distinct algorithms to provide quantitative and qualitative results. Table 15 summarizes the articulation between the Doorways and the galleries organized in Thematic Spaces.

Table 15. Articulation between the Doorways, Thematic Spaces, and Galleries

DOORWAYS	THEMATIC SPACES	GALLERIES	NATURE OF THE GALLERIES
TOUTATIS	"Showroom"	Collaborative Activities	Simple
		NewsReels	Complicated
	EPLANETe Communities	People	Simple
		Partners	Simple
TALLESIN	RCE (Learning Resource Centre)	The Forest of Broceliande	Complicated
	Teaching Activities & Programmes	Yggdrasil	Complicated
FAIRGROUND	Dagda's Garden	Ideas&Action	Simple
		Virtual Garden	Complicated
		Food baskets	Complicated
		C&C	Complicated
MERLIN	Dagda's Garden	Ideas&Action	Simple
		Virtual Garden	Complicated
		Food baskets	Complicated
		C&C	Complicated
CAMELOT	Dagda's Garden	Ideas&Action	Simple
		Virtual Garden	Complicated
		Food baskets	Complicated
		C&C	Complicated
	Evaluation	DST v5 – Worksite list	Complex
		Eco Innovation Terrains	Complex
KERBABEL	Panoramix	Babel² Gardens	Complicated
	Indicator Bazar	The KIKs	Simple
	Tool Kit	TTT	Complicated
	Deliberation Support Tools	DST v5 – Tools list	
	Babel² Garden		

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To represent the system in the INTEGRAAL's Step 3, we will use the various galleries presented. To perform this step, we will use the KIK gallery which is associated with the Gallery of Tools, and the KRR.

- KIK (Kerbabel™ Indicators Kiosks) Gallery: presents an indicators collection in the various contexts of interest to the 'User Communities' in ePLANETe;
- Gallery of Theories, Tools, and Terrains: presents a collection of methods and tools;
- Gallery of Deliberation Support Tools (DST): access to the Kerbabel Representation Rack (KRR)

Four main axes compose the KRR: the 'knowledge carriers'; the 5Ps of the B4U Eurbanlab's method (i.e., People, Planet, Profit, Process, and Propagation) and each sub-goal; the case of study, also called 'worksite'; and the methods and tools.

The 'knowledge suppliers' are composed of the methods, tools, and the 'knowledge carriers'. The 'knowledge demand' is consisted by the 5Ps and the worksite. The KRR will allow us to make the connection between the 'knowledge suppliers'.

The KRR allows the 'knowledge carriers', to choose the indicators that will be used in the assessment of a worksite. This selection is made by a pertinence analysis to construct what we call 'indicators candidates'.

The 'indicators candidates' are weighted by an index of pertinence, in the range of 1, 2 or 4. In this sense, 1 means low pertinence, 2 means medium pertinence, and 4 strong pertinence. Each 'knowledge carriers' can discuss the pertinence via a Forum. The indicators that are judged as strong pertinent for the worksite will be forming the 'indicator of the K4U.

The Stage 4 'Evaluate and Deliberate', is going to be held with the support of the K4U. The K4U allow us to give values to the 'indicators candidates' as is a tool of performance issues representation. Doing a K4U means building an assessment for a particular case study. A specific algorithm converts and aggregates each indicator value to draw a final spider diagram that weights each Top-Goals.

Figure 59 presents the main elements of the ePLANETe Blue platform that we will be used to construct and implement our model.

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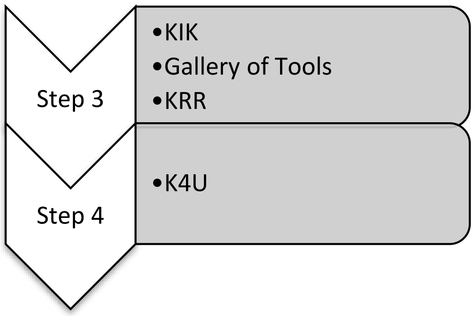

Figure 59. Relation between the INTEGRAAL framework and ePLANETe

9 CONCLUSION

The Chapter presented the case study selected to assist us in the interpretation of the problems faced by the university building toward a sustainable context. In a first moment, we presented a whole description of the '*Aile Sud*' building, the main features of the implementation process, the project phases, the stakeholders involved, and the primary outcomes.

In a second moment, we presented the general context of the buildings assessments, to answer the question « why we should evaluate? » We concluded that the evaluation is an act of judging an object's value. Regarding the assessment objectives, we concluded that we are particularly interested in the evaluations ex-ante. The assessment ex-ante helps to clarify the decision-making process in the university building renovation process. After presenting the main evaluation methods, we decided to base our study in the multi criteria methods due to the complexity of our research.

After that, we presented the existing methods and tools for the university buildings assessment to answer another crucial question: « how we should evaluate? » Three GBR systems were analyzed - the LEED, HQE, and BREEAM. Thereon, the STARS and the EVVADES were analyzed as recognized evaluation systems of the universities. An assessment with the EVVADES system performed by the UVSQ's students about the UVSQ/BN implementation was presented. Lastly, an evaluation with the B4U with the case of study UVSQ/BN was demonstrated.

Positive aspects were found in the GBR systems regarding the assessment of the university buildings. However, there is still a lack of the actor's participation, in the visualization of results, and in the indicators and categories to express performance issues of the university buildings. Furthermore, the GBR systems are strongly connected to the 'building-centric' approach.

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Considering our experience with the sustainability tracking and assessment tools for higher education, it is possible to conclude that both tools are valuable to understand which parameters can be used for a global sustainability evaluation of the higher education institutions. However, we remarked the lack of indicators relating to the user's comfort, indoor environmental quality, accessibility, materials, and sustainable site. Also, the building life cycle considered in the both methods are limited to the operational phase.

Taking into consideration the B4U method, it is possible to affirm that the method has an unusual structure to measure the urban innovations since the method uses a 'triple P' structure and added the 'Process' and the 'Propagation' concerns. The 5P approach can have positive aspects for a sustainability assessment and can be interpreted as a factor that increases the value of the B4U method when comparing to the GBR system, the EVVADES, and the STARS methods. Notwithstanding, the method rest limited and inflexible.

The conclusion after the methods and tools analysis is that a new tool for evaluating the performance strategy of the university building's renovation is necessary. The new tool could present the current state of an analyzed building for confirming its previous state (real) toward a better and future condition, or the ideal situation. Inside this context of assessing for sustainability, this new tool will be used to assist the decision-making process.

This new model fits in the multi criteria and participative approach. To answer to these requirements, we will use the INTEGRAAL framework. The ePLANETe Blue system will be used to implement this new performance strategy evaluation of university building's renovation.

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Chapter IV. Defining an evaluation approach for the performance strategy of the university building's renovation

1 INTRODUCTION

Our objective in this chapter is to mobilize tools to represent a model assessment for the performance strategy of the '*Aile Sud*' building renovation process. This model assessment aims to answer the question « in which way the '*Aile Sud*' building's renovation process satisfied the SD goals? »

We denominated our model as C4U, which is an acronym for the « Construction for You » that has its provenance in the B4U. We use the B4U as a reference method due to the crucial value that the eco-innovations have for this thesis. The eco-innovations can strongly contribute to the improvement of the buildings sustainable performance.

We will use as reference the structure of the B4U to evaluate urban innovations: the 5P – People, Planet, Profit, Process, and Propagation. We also will present the three first steps of the INTEGRAAL framework which consists in the (1) identification of the problem, (2) structuration of the problem, and (3) representation of the system.

In the first step of the INTEGRAAL framework, a delimitation of our field of study will be presented. We will also justify our choice of case study and clarify some points about the sustainability scale of our study.

A calendar containing the primary activities will be introduced. Secondly, we will present some points of our literature review, the context description and the actors' analysis of the case study.

Also, we will identify the main performance issues to evaluate sustainability in the university buildings. Lastly, we will detect and mobilize indicators to assess our case study.

2 STEP 1 OF THE INTEGRAAL FRAMEWORK: IDENTIFICATION OF THE PROBLEM

Goal: The main purpose of this step is to describe the field of study selected, the case study, the main performance issues, the actors related to it, and the problem of the evaluation to avoid any misunderstandings. This step corresponds to the first step of the INTEGRAAL framework as is presented in Figure 60.

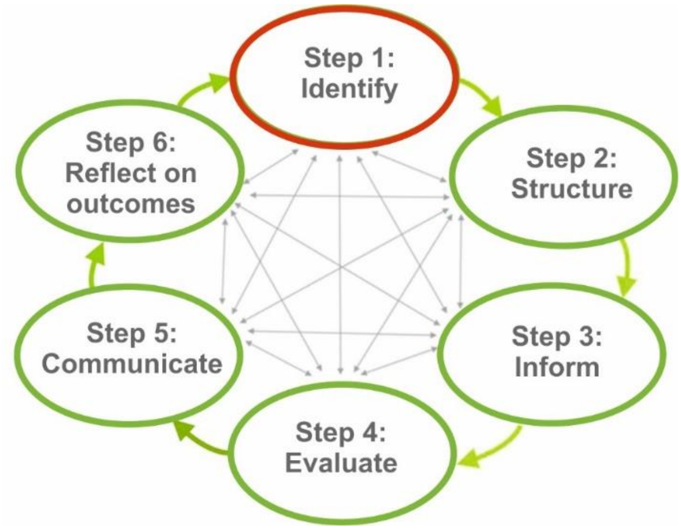

Figure 60. Step 1 of the INTEGRAAL framework.

2.1 Delimitation of a field of study: The French university asset

The determination of a macro study (i.e., considering distinct countries) to analyze the implantation of the physical structure of the university campus is an interesting approach to learn more about the project governance. Furthermore, it is an opportunity to understand the influence of the regional, the national policies, and the culture in the project. However, for this thesis work, we decided to establish geographic boundaries. We delimited our field of study to the context of the buildings of the university campuses located in France.

As presented previously in Chapter 3, the assessment of the SD in the higher education has many aspects. In the context of the AASHE STARS Framework sustainability assessment is assured by the 'Academics,' 'Engagement,' 'Operations,' and 'Planning and Administration' aspects. For the French EVVADES framework, is assured by the 'Strategy and Governance,' 'Training and Teaching,' 'Research,' 'Society and Territory', and 'Environmental Aspects.'

As the C4U is a tool for the sustainable evaluation of the university buildings, we will limit the C4U'S performance issues, and we will select the candidate indicators related to the physical structure of the university campus, in other words, the buildings. The relations between the constructions and the campus, and between the constructions and the urban space was considered.

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The 'Estate Guide: Optimizing and renovating university buildings' (French: *Guide patrimoine: Optimiser et rénover le patrimoine immobilier universitaire) is a report from the Conférence des Présidents d'Université* (CPU), supported by the Ministry of Higher Education and Research and the Deposits and the Consignments Fund[161]. It is a relevant report, launched in 2014, that analyzes the French university estate. According to the report, around 40% of the French university estate is composed of buildings built during the first boom period (i.e., the 1960s and 1970s), resulting in total 18 million m².

These buildings represent a significant historical, architectural, and functional diversity. Nevertheless, even if it is possible to find some high-quality buildings, the general overall situation is degraded. A large part of these buildings is outdated, sometimes marked by non-compliance due to lack of maintenance, and low energy-efficiency (CPU, 2014).

In 2008, a study from the General Direction of the High Education concluded that 15% of the French university buildings are not adequate for performing the research and teaching activities (*Campus Responsables*, 2013).

Building new constructions to accommodate the universities campus activities is important. Nonetheless, to neglect quality and comfort requirements of the buildings from the 1960's and 1970's, is not the most appropriate solution.

As already affirmed in Chapter 2, the renovation works in the university campus increases the value of the interior spaces. They can improve the buildings' attractively and acceptation by users. In the case of the French universities, an urgent call for action is required. Other targets for the French university estate include (*Campus Responsables*, 2013; CPU, 2014):

- Optimization[162] of the HEI buildings for better adaptation to the diverse uses[163] and to respond the imperatives of the energy transition;
- Increase in the climate resilience through an "Eco-campus" approach;
- Improvement of the University campus connection with the city to avoid the universities isolation;

[161] The *Caisse des dépôts et consignations* (CDC), or just Caisse *des dépôts* it is a French financial public institution founded in 1816.

[162] We understand here by optimization "*the process of finding the best solution and can be applied to all problems that are quantifiable*" (Nielsen, 2012, pg.47).

[163] A big part of the real estate costs is directly proportional to the square meters occupied (CPU,2014).

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- Boosting space sharing between the university campus and the city, in the sense that many university spaces are empty during the weekends and vacations. It might contribute for making feasible the idea of sharing the universities' interior spaces with other actors and municipalities;
- Improvement of the University campus functionality to enhance user's quality of life;
- Increase the life on campus by promoting socialization spaces and meeting points;
- Prioritization of eco-mobility options when it is possible;
- Improvement of the flexibility of the university buildings interior areas to attend users activities requirements;
- Adaptation of interior spaces to answer the new digital pedagogical design's challenges;
- Conformity with the security, accessibility, risks prevention and environmental performance of norms and regulations (e.g., Grenelle Law 1, RT2012, RT2020).

From an economic point of view, it is possible to affirm that old university buildings with a lack of maintenance and low energy-efficiency, result in high energy bills. The energy cost is expected to grow extremely over the years. Renovation works can increase the energy efficiency and reduce 15-20 % of the energy costs in a short period.

The lack of flexibility and optimization of spaces raises the global building costs because increase the square meters occupied. The optimization of spaces in the design concept can reduce in 20% the operating and the maintenance costs.

University campus is a segment of the city and a part of the city. Higher educational institutions have their environmental impacts related to distinct scales, cities, neighborhood, buildings, and users. Water consumption, waste management, energy use, pollution and GHG emissions are classic environmental impacts related to the towns, community, and buildings. Lack of information, communication, education, and awareness are related to the users' environmental implications.

The 'Energy - CO2 mapping of the French university estate' (In French: '*Cartographie Energie-CO2 du patrimoine universitaire français*)' was launched in 2010 by the CPU in partnership with the Deposits and the Consignments Fund.

This report presented a synthesis of the energy use and the CO2 emissions of 372 buildings (from 5000 university buildings), 302 sites (from 600 university sites), and 50 universities (from 83 universities), and 13 *'Grand École',* representing a total of 13 million m² that participated in the data collection.

The report denounced a total annual energy consumption of 3 905 500 MWh.PE[164] and a total annual emission of CO2 of 405 630 tons of CO2 for the 372 buildings analyzed (*Caisse des Dépôts* and CPU, 2010).

The national average corresponds to 300 kWh.PE/m². Year and 31 kg.CO2/m ². Year. Regarding the 'Energy Performance Diagnosis' (French: *Diagnostic de Performance Énergétique* -DPE [165]) for public buildings, it corresponds to a D level for the energy consumption, and for the CO2 emissions (Figure 61). Briefly, we can affirm that the results of the National University buildings efficiency extrapolate the limits of the energy use and the carbon dioxide emissions defined by the Law Grenelle.

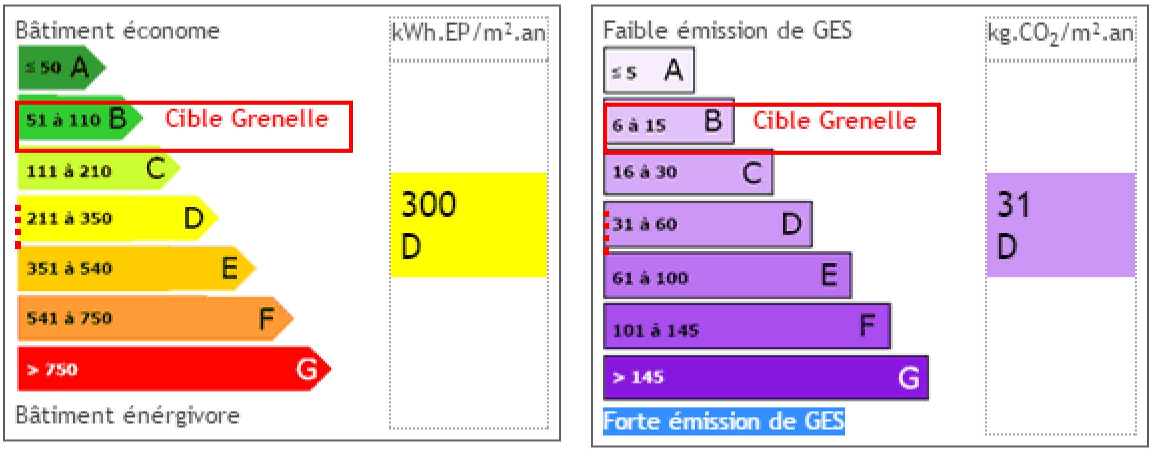

Figure 61. Results of the primary energy consumption and the GHG emitted label for the buildings analyzed. Source: *Caisse de Dépôts* and CPU (2010).

About the energy consumption of the university buildings by French region, it is possible to conclude that a total of 10 regions have the university buildings consuming more energy than the national average (Figure 62). The CO2 emissions results by region are even more disappointing, indicating that 13 regions have university buildings have the carbon dioxide emissions higher than the national average (Figure 63).

[164] 1 MW.h/yr = 1 000 kWh/yr. PE= Primary energy (In French: EP= *Energie primaire*)

[165] The Diagnostic de Performance Énergétique provides information on the buildings energy performance. It assesses energy consumption and impact regarding greenhouse gas emissions of the buildings. Two labels with seven classes from A to G (A corresponding to the best performance, G to the worst) composes the diagnostic.

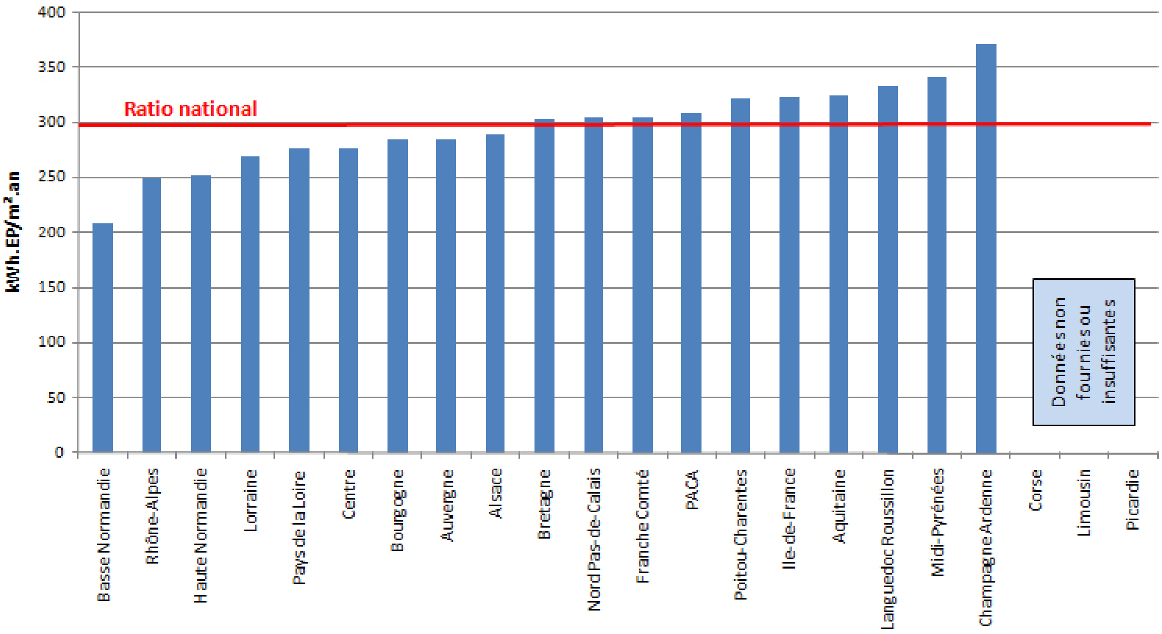

Figure 62. Energy consumption results of the university buildings by French region. Source: *Caisse de Dépôts* and CPU (2010).

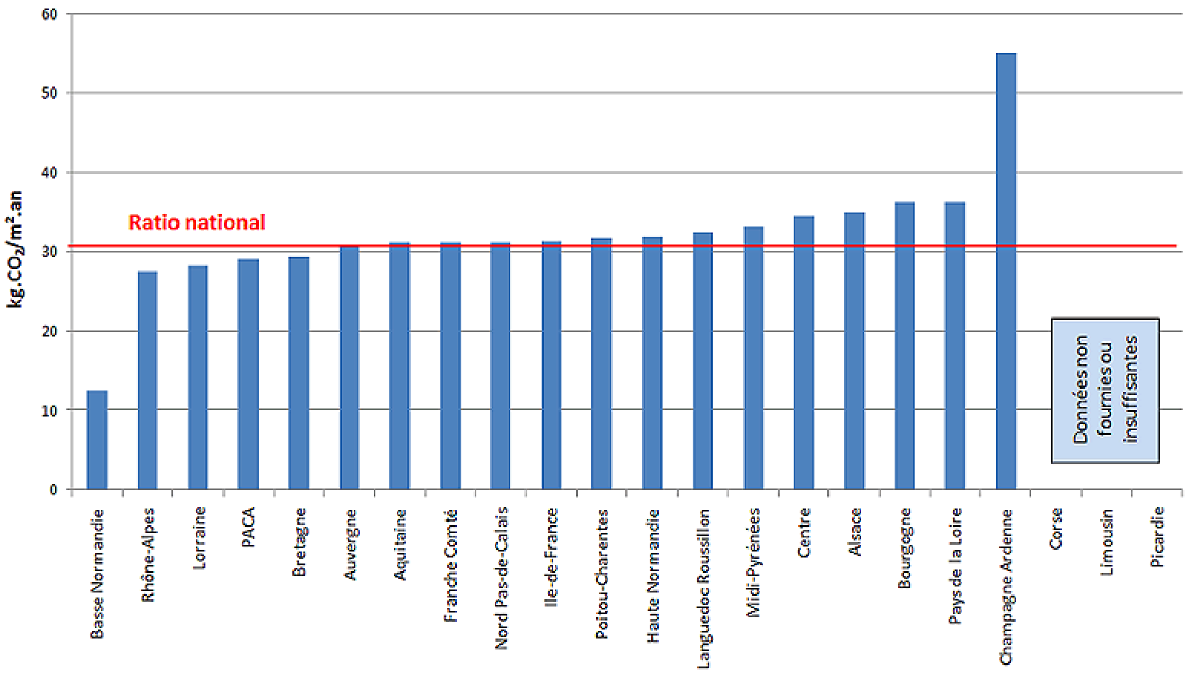

Figure 63. CO2 emissions results of the university buildings by region. Source: *Caisse de Dépôt* and CPU (2010).

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The primary source of CO_2 emissions of the French university campuses is related to the people displacement (between 30% and 70%). The people displacement has a substantial impact on the international travel of the students and researchers but also on the 'home-campus' travels, particularly in the campuses that are located out of the cities and poorly served by the public transportation. The energy consumption (e.g., heating, air conditioning, equipment) is the second main reason of the carbon dioxide emissions. All these evidences reinforce the idea that the situation in the French university campuses is critical (*Campus Responsables*, 2013).

The French university campus needs to achieve the objectives described in the new regulations and laws. The Grenelle I Law requires the buildings renovations process reach a reduction of 38% in the energy consumption, and 50% of the GHG emissions until 2020 (*République Française*, 2009a).

The Thermal Regulation of 2012 (RT2012) imposes better energy performance: 80kWh/m²/year (primary energy) for the renovation of the university buildings, and 50kWh/m²/year for the new buildings (MEDDTL, 2011). The Thermal Regulation of 2020 (RT2020) determines that public buildings should undergo renovations. RT 2020 demands a renewal rate of 3% of public buildings/year.

Another major environmental problem is due to the University campus isolation from the city, especially on the campus of the 1960's and the 1970's. These campuses are often in outskirts of the towns and sometimes in nonurbanized areas without any facilities or even without student's residence. It is common that students use personal vehicles to go into town or to travel between cities. Also, often monofunctional, these campuses do not fully utilize their facilities and do not share them sufficiently with the local community actors (*Campus Responsables*, 2013).

In a general context, we can affirm that the high-energy consumption, the CO_2 emissions, and the lack of the integration with the city are the major problems that French universities are facing. Furthermore, many university's buildings are not within the standards of the norms or the new 17 SD goals presented before as the new global agenda for 2030.

A performance assessment appears to be necessary to make efforts to enhance the performance of these buildings and meet the strategies of the new agenda. The outcomes of a performance evaluation are required to verify the actual state.The assessment results are also essential and to establish targets to reach the future that we want for these structures. In other words, before to answer, « how university buildings can be improved? » it is important to answer « "where these buildings are, regarding their performance? »

2.2 The *'Aile Sud'* building as our case study

Even if the case study methods remain a controversial approach to perform the data collection, they are globally recognized in the social science studies for a deep analysis of the social behavior and complex issues (Zainal, 2007).

The case study is recognized as a research method and emerged to answer the limitations of the quantitative methods. Through case study methods, a researcher can surpass the quantitative statistical numbers and understand the behavioral conditions found in the actor's perspective. By including both quantitative and qualitative data, case study assists in explaining the process and outcome of a phenomenon by full observation, reconstruction and analysis of the cases under investigation (Tellis, 1997).

Yin (1984) presented three categories of case study: exploratory, descriptive and explanatory. The exploratory case study explores any phenomenon in the data which serves as a point of interest to the researcher. Descriptive case studies set to characterize the natural phenomena that take place within the data in question. Moreover, the explanatory case study analyzes the data closely both at a surface and deep level to explain the phenomena in the data. The '*Aile-Sud'* building is characterized as an exploratory and descriptive case of study.

Inside the case study research, Yin (1984) determines three important questions to be answered: (1) How to define the case "being" studied? (2) How to determine the relevant data to be collected? And (3) what do to with the data, once collected?

We took a basis the universities buildings in France for the field study determined, to define our single case study. We selected that our case study will be the *'Aile Sud'* building due to its interesting features, as:

- The building was renewed to improve the energy efficiency, the thermal comfort, the user's accessibility, and to properly conduct the research and the teaching activities;
- The building renovation is part of the implementation process of the UVSQ in the cultural site of the Bergerie Nationale (BN), in Rambouillet;
- The implementation of the UVSQ in the BN reinforces the concept of the Campus as a Living Lab. The activities inside the building as a training center of the UVSQ, but also as the Center REEDS of research allowed the knowledge transfer of the GSR and the SD issues, and the development of international and national research in these domains of expertise;

- The project is inspired in the BBC, HQE certifications, and is an urban innovation[166].

After determining our case study, we needed to determine which data are critical to the assessment. We collected information about the whole project of implementation of the UVSQ in the BN site (i.e., many of this data were presented in Chapter 3).

Furthermore, we collected information about the architectural and the other complementary projects of the building renovation; building description report, meetings report; and project presentation documents. Extra information was collected during the visits in the '*Aile Sud'* building (Figure 64). During the field visits we organized the first meeting to interview the actors involved in the project to clarify of some points of our investigation. All the data related to the building before and after the renovation is relevant.

Figure 64. '*Aile Sud'* building in the Bergerie Nationale, Rambouillet

Thereon, once we collected all the data, we conducted a second meeting with key actors of the project renovation process and for the implementation of the UVSQ in the BN. This meeting was essential to understand some points of the renovation and implementation project as a part of an exploratory study. For instance, qualitative questions about the renewal project management as « how often the meetings took place during the project renovation process? » or « how the sustainable strategies were implemented at the construction site? » can provide further examination of the phenomenon observed.

[166] Are definied as urban (re)development projects that incorporate systemic innovations, involving new or modified concepts, systems, products and/or techniques, that contribute to low-carbon, climate resilient development, on the scale of a street or upwards (Bosch et al., 2013).

2.3 Definition of the of the sustainability's scale

As stated by Hadji (1989), before to evaluate something it is important to reflect on the ideal situation desired. This ideal situation in our case of study is the sustainable university building, inserted in a sustainable campus, which is integrated into a sustainable urban community. It is important here to highlight our concern to run from the 'building-centric' approach presented before. We believe, as stated by Conte and Monno (2012, pg.31) that buildings can be the "*active entity contributing with the resilience of the urban matrix"* and inside this context, the university campus represents an interesting research field.

As mentioned in Chapter 1, sustainable buildings can reduce the need for energy, raw materials and water; and at the same time, reduce the GHG emissions, environmental releases and waste. In this sense, the SA should overcome the boundaries of the built environment and consider its relation between the urban space, and in our case, with the university campus as well.

Considering that sustainability is a societal state (Pope et al., 2004) with features designated by performance issues, when assessing the sustainability of the university buildings we had to take in consideration the performance issues of the buildings, the urban spaces and the universities, going from a micro-scale to a macro-scale.

2.4 Definition of an evaluation

Once we defined the field study, the case study, and the ideal situation of the sustainability in the universities buildings, we still needed to solve the problem of the evaluation. After analyzing the main requirements of the evaluation method desired (i.e., multi-criteria decision-making analysis and actors' participation) and the main existing methods analyzed (i.e., LEED, HQE, BREAAM, EVVADES, STARS and B4U) we finished for concluding that a new assessment tool was required to measure the strategy performance of the university buildings.

As we were confronted with the complexity, a multi-criteria decision-making analysis was recommended. Our goal with this new assessment tool was to help stakeholders to learn about the problem situation. The problem, in our case is the university building's precarity regarding the thermal and the acoustic comfort. In addition, the problem is also the nonconformity of these establishments to the new sustainable development agenda (i.e., as for instance the 17 SDGs of the UN) and to the digital transition. Through the implementation of our tool, we were expecting to propose some recommendations and to support the stakeholders to achieve their goals.

The participative aspect of our assessment might allow the various groups of stakeholders to establish an environment of trust between the various actors and obtaining some legitimacy and acceptability, regarding both, the decision-making process and the resulting decision (Froger, 2005). The participation was privileged in many moments of the decision process, as when mobilizing and choosing the indicators candidate for the new tool, or when giving the values to the indicators during the assessment.

We will validate our assessment tool with the case study selected, and at the same time, we will assess the performance strategy of the building renovation toward a SD. Table 16 presents a calendar of our activities to perform the INTEGRAAL implementation.

Table 16. Schedule of the activities for the INTEGRAAL framework implementation

DATES	ACTIVITIES
06/2014 – 12/2014 (Step 1)	• Determination of the case study, data collection, and data analysis; • Two meetings with the actors: (1) to clarify the *'Aile Sud'* building project, and to (2) to delineate the data analysis – exploratory study.
01/2015 – 01/2016 (Step 2)	• Literature review about the sustainability construction, university buildings, methods, and tools; • Identify and structure the performance issue; • Meeting with the actors to discuss the performance issues.
01/2016 – 10/2016 (Step 3)	• Tools, methods, and indicators inventory; • Send a blueprint with a list of indicators to the actors.
10/2016 – 02/2017 (Step 4)	• Expert evaluation; • Meeting with the actors for the deliberation.
02/2017 (Step 5)	• Send a document with the results of the assessment.

3 STEP 2: STRUCTURING THE PROBLEM

Goal: Defining the actors' categories and the performance issues through an iterative process of the documentation and the appropriation of the problem studied, based on the consultation of the actors concerned. This step corresponds to the second step of the INTEGRAAL framework as is presented in the Figure 65.

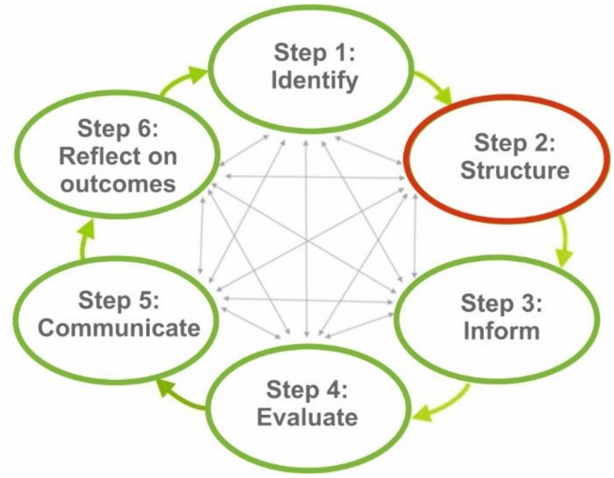

Figure 65. Step 2 of the INTEGRAAL framework

3.1 Literature review

To conduct our literature review, we followed the methodology proposed by Arlene (2014):

- Adopting research questions: It is essential to state precisely the main question that will guides the review. To our study, the predefined research's questions were « how can we improve the performance of French university buildings toward sustainable development? » and « Did the *'Aile Sud'* building renovation process succeed? » It is interested to highlight here that an extensive 'pre-literature review' was held to precise the research question to avoid the risk of the generality;
- Selecting bibliographic or article databases, Websites and other sources: For covering all the research themes, an extended list of articles from recognized platforms as 'Science Director', 'Elsevier', and other channels were consulted;
- Choosing the search terms: As our research subject encompasses seven main elements - buildings, urban space, universities, assessments, global social responsibility, sustainable development, sustainability - linear researches were conduct for each element but also the interrelation between these themes, for instance: sustainable buildings, sustainability in the urban space, or university buildings;
- Employing practical screening criteria: Preliminary literature review might result in several articles, but only a few articles are really relevant. Some criteria of inclusion and exclusion of the review were set. We included in our scientific review works in French and English. The source was also a factor of exclusion and inclusion in the sense that just reliable works were considered;

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- Applying methodological screening criteria: Includes criteria for assessing the adequacy of a study's coverage and its scientific quality;
- Doing the review: Includes the help of a standardized form for abstracting information from articles;
- Synthesizing the results: Interpretations of the articles analyzed.

Several laws, regulations, and norms were also included in our literature review, as the Grenelle Environment, the Procurement Contract code, and the Energy Transition Law for the Green Growth. We also cited some reports, mainly from the ADEME regarding the thermal, acoustic insulation, and energy efficiency.

3.2 Context description

The *'Aile-Sud'* building is located inside a complex of buildings called 'Bergerie Nationale' (BN), where the Ministry of Agriculture[167] is a landowner. A special agreement between the Ministry of Agriculture and the UVSQ resulted in the permission for the UVSQ to explore the *'Aile-Sud'* building. The UVSQ and the BN have common research and teaching interests in the domain of the environment and sustainable development.

As the BN is situated inside the Yvelines department, that is under the responsibility of the General Council of the Yvelines (GCY). The GCY financed this project in partnership with the Ile-de-France Department through the UVSQ.

The *'Aile-Sud'* building has a significant and unquestionable cultural and historical value. In addition, the building is located in a conservation site. The building is a historical heritage and is protected by the *Association Nationale des Architecte des Bâtiments de France.*

3.3 Identify and structure the actors

Before starting the participatory process, it is necessary to identify all the actors involved and to present a pragmatic classification by categories. In a second moment, we will select the actors that will be included as participants in the study. In a multi-criteria evaluation participatory approach, the number of actors must remain small enough to enable deliberation. Table 17 presents the categories of actors and the stakeholders group which they belong to. Taking as reference the studies about the

[167] Specifically the *Direction Générale de l'Enseignement et de la Recherche* (DGER).

CSR reporting (e.g., Faucheux and Nicolaï, 2004; O'Connor and Spangenberg, 2008) we divided our actors into three main groups: internal stakeholders, traditional external stakeholders, and external extended stakeholders.

We defined that internal stakeholders are all the categories of actors that were directly involved with the renovation project, in other words, everyone that participate in the planning, the construction, and the management of the activities. The traditional external stakeholders represent the project partners, everyone that contributed indirectly, and that is affected by the project renovation. External extended stakeholders all the category of actors that played a role in collaborating and regulating.

Table 17. Stakeholders group and actor's categories

STAKEHOLDERS GROUP	CATEGORIES OF ACTORS
INTERNAL STAKEHOLDERS	UVSQ: University dean, project leader, and the director of property assets Project manager (i.e., '*maître d'ouvrage*', architecture firm) Project manager consulting SMC coordinator Health and Safety Coordinator Construction technical controller Engineering firm Center REEDS representative
TRADITIONAL EXTERNAL STAKEHOLDERS	Construction site workers Final users (i.e., researchers, students, professors, staffs). Ministry of Agriculture Bergerie Nationale Local community *Ile-de-France* Department
EXTERNAL EXTENDED STAKEHOLDERS	*Association Nationale des Architecte des Bâtiments de France* *Conseil Général Départemental du département des Yvelines*

3.4 Discussion with the actors

We decided to select the UVSQ group of actors to participate in the discussions. Two actors of this group participated in the debates section: the project leader, and the director of the property assets of the UVSQ during the implementation of the UVSQ in the BN

The project leader represented the interests of the UVSQ in the project implementation process. He assisted in the determination of project location, (i.e., '*maître d'ouvrage*', architecture firm), the provisional timeline, the project program, the financial plain, and the contracts elaboration before the renovation process. During the renovation works, he followed the project during all the implementation phases. He had a major role when articulated financial and administrative partners for the project. The project leader also contributed in the decision-making of the interior design project. He also represented the Center REEDS as a director of the REEDS.

The director of the property assets of the General Office of Infrastructures (UVSQ) was responsible for the University's building management. He had an active role in the orientation of the architectural project development, and in the management and the coordination of the site's activities. He participated actively in the renovation project herewith the project manager and the project management consulting.

3.5 Identifying the performance issues

The literature review resulted in the identification of the performance issues. In a first moment, all the sustainable construction performance issues were identified. We took into consideration that the performance issues of a building also encompass its connection with the city and the university campus. We determined as a key question here: « What are the sustainable performance issues of a renovation process of a university building? »

A first debate with the actors took place. We analyzed the evaluation of our study case with the B4U tool for the identification of the central incoherence related to the B4U sub-goals. The actors argued about the relevance of the B4U sub-goals. The results of this discussion are available in Annex 9. The relevance assessment of the B4U sub-goals was also valuable to define the performance issues of this thesis work. We identified a total of 31 performance issues for our research problem after completed the literature review and the discussion with the actors (see Table 18). The performance issues were divided in the 5P's categories.

Table 18. Performance issues identified

5P	CODE	PERFORMANCE ISSUE NAME
PEOPLE	**P1.1**	Comfort
	P1.2	Indoor environmental quality
	P1.3	Health and security
	P1.4	Work conditions
	P1.5	Ensuring a livable area
	P1.6	Land design for sustainable urban development

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	P1.7	Promotion of a feeling of community/home
	P1.8	Social justice
PLANET	**P2.1**	Energy
	P2.2	Biodiversity
	P2.3	Soil
	P2.4	Water
	P2.5	Pollutants emissions into the atmosphere
	P2.6	Climate system
	P2.7	Waste
	P2.8	Materials and resources
PROFIT	**P3.1**	Creating local value
	P3.2	Creating value for the sector
	P3.3	Time optimization
	P3.4	Costs
	P3.5	Adaptability and flexibility
	P3.6	Constructive choice for the accessibility during maintenance works
PROCESS	**P4.1**	Governance model
	P4.2	Strategy
	P4.3	Maturity of the process
	P4.4	Sustainable sites
	P4.5	Water and energy management
	P4.6	Interior air quality and temperature control
	P4.7	Sustainable teaching and research
	P4.8	Public engagement
	P4.9	Campus engagement
PROPAGATION	**P5.1**	Complexity
	P5.2	Relative advantage
	P5.3	Dissemination
	P5.4	Standards evolution
	P5.5	Mimetic processes
	P5.6	Ability to bring about change
	P5.7	Innovation characteristics

3.6 Performance issues of the category « People »

The performance issues in this category refer to the feeling of community and integrate aspects of the social equality, justice, and quality of life.

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This category refers to three types of stakeholders: the university campus building's occupants, the construction site workers, and the local community actors. The first group is composed of all the universities campus users that can be students, professors, administrative staff, or visitors. These actors must feel comfortable, healthy, and safe to be able to accomplish their tasks. Furthermore, the building as a part of a university campus should entertain the daily life activities.

Workers on the construction site represent the second category of actors. These actors had to keep the site productivity and quality to avoid delays or mistakes during the construction site. Their performance and satisfaction depend on the capacity of the construction company to provide a comfort, healthy, and secure work environment. The third category encompasses all the local actors which are directly and indirectly affected by the implementation and the operational phase of the university campus building.

3.6.1 Comfort

Thermal, acoustic and visual comfort have a substantial impact on the physical comfort of the buildings' occupants, promoting well-being and health quality. Many studies have been conducted in the energy-efficient buildings focusing on the users' experiences (Hauge et al.,2010; Paul and Taylor, 2008; Thatcher and Milner, 2012; Shahzad et al., 2015; Heerwagen, 2000b). The Energy-efficient buildings just can be considered as successful cases when in the design strategies they intend to provide users comfort in the sense that people satisfaction must be the primary building construction goal.

Thermal comfort is a frequent topic regarding classrooms, workspaces, libraries and other university spaces. Lack of thermal comfort inside classrooms might affect learning and student's health. The ASHRAE Standard 55-2013 - 'Thermal Environmental Conditions for Human Occupancy' defines thermal comfort, or human comfort, as "*that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.*"

Thermal comfort is hard to measure because is highly personal. It depends on the air temperature, humidity, radiant temperature, air velocity, metabolic rates, and clothing levels. Adding to this, diverse people experiences might provide distinct sensations depending on their physiology and residence country.

The evaluation of thermal comfort measures the users' satisfaction in the operational phase. However, the building or renovation design project should determinate the improving thermal comfort strategies. When the construction team works in de development of the building design, it is recommended to deeply study all the space activities, the occupation rate and the possibility of spaces flexibility. For the renovation works, it is suggested to effectuate an energy audit aligned with a users survey to elaborate final solutions to improve thermal comfort. In both cases, heating, ventilating, air-conditioning (HVAC) systems need to meet the requirements of the ASHRAE Standard 55-2013 mentioned before (USGBC, 2014).

For universities this minimum thermal comfort must be ensured during the whole year with an exception for vacations period defined by the Thermal Regulation - RT2012 (15 days in February, April, and December, 31 days in July and August, and 8 days in November). The daily occupancy is from 8 am to 6 pm, and regarding the weekly basis, the building is expected to be busy five days on seven (MEDDE and ADEME, 2011).

The acoustic comfort is also considered a crucial matter for the universities building users. The acoustic comfort means having the right level and quality of noise to use the space as intended. Occupants are more productive and satisfied when they are not distracted by noises from outside or from surrounding areas or other occupants, especially students. Design strategies are important because they can provide barriers and sound breaks between sources of noise.

Even if we can measure the acoustic insulation of a room or a building (considering the parameters related to the acoustic behavior of the envelope), the acoustic comfort measures the user's satisfaction about the sound in the interior spaces (i.e. noises, reverberation, and sound reflection).

The article 5 of the Law of 25 April 2003 on the limitation of noise in the educational establishments (Legifrance, 2003) gives a reference to noise acceptance in the universities. Regarding the noise control for classrooms and labs, the law establishes that the average reverberation time (Tr) of a classroom or workspace equipped and not occupied, is calculated based on the octave centered on 500, 1000 and 2000 Hz. For classroom or workspace with a volume bigger than 500m³ is required an accurate acoustical study to respect the average reverberation time requirements.

The last component of the comfort group is the visual comfort. Lighting is an important issue to reduce the overall energy consumption (Waide and Tanishima, 2006). Maintaining the visual comfort through an efficient lighting system means ensuring that people have enough light for their activities. Insufficient light reduces the ability to see objects or details clearly (Leech et al., 2002).

Areas can be too dim or too bright, and these levels depend on the task. Corridors for instance, are areas of passage and in general do not need too much brightness, from 100 to 150 lux. However, a

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workplace requires in average 500 lux of illuminance (AFNOR, 2011; IES, 2013). Table 19 provides a list with further information about recommended luminance levels.

Natural light or day lighting use must be considered to improve building visual comfort, reduce overall energy consumption of lighting, and is one of the design aspects of architecture. Daylighting, as defined by the Illuminating Engineering Society, "refers to the art and practice of admitting beam sunlight, diffuse skylight, and reflected light from exterior surfaces into a building to contribute to lighting requirements and energy savings through the use of electric lighting controls" (IES, 2013).

The LEED certification sees in the day light a possibility to increase the humans visual comfort, but also a necessary connection with the building occupants and the buildings outdoors. Interior and external spaces are connected by windows, skylights, atrium, and others. However, the daylighting depends on other factors, for instance, the room floor area, the window geometry, the visible light transmittance of glazing, orientation, and others (USGBC, 2014).

Table 19. Recommended luminance levels for diverse tasks. Source: IES (2013).

STANDARD MAINTAINED LUMINANCE (LUX)	CHARACTERISTICS OF ACTIVITY	REPRESENTATIVE ACTIVITY
50	Interiors rarely used for visual tasks (no perception of detail)	Cable tunnels, nighttime sidewalk, parking lots
100 - 150	Interiors with minimal demand for visual acuity (limited perception of detail)	Corridors, changing rooms, loading bay
200	Interiors with low demand for visual acuity (some perception of detail)	Foyers and entrances, dining rooms, warehouses, restrooms
300	Interior with some demand for visual acuity (frequently occupied spaces)	Libraries, sports and assembly halls, teaching spaces, lecture theaters
500	Interior with moderate demand for visual acuity (some low contrast, color judgment tasks)	Computer work, reading & writing, general offices, retail shops, kitchens
750	Interior with demand for a correct visual acuity (right color judgment, inviting interior)	Drawing offices, chain stores, general electronics work
1000	Interior with demand for superior visual acuity (accurate color judgment & low contrast)	Detailed electronics assembly, drafting, cabinet making, supermarkets
150 - 2000+	Interior with demand for maximum visual acuity (low contrast, optical aids & local lighting will be of advantage)	Hand tailoring, precision assembly, detailed drafting, assembly of minute mechanisms

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3.6.2 Indoor environmental quality

Another factor that influences user's satisfaction and well-being is the indoor environmental quality (IAQ). Many researchers highlight the importance of the indoor environmental quality (IAQ) for the increase of the comfort, health, and productivity of the users (De Giuli et al., 2012). People spend about 80–90% of their time indoors (ASHRAE, 2010) and studies have indicated that a range of comfort and health-related effects are linked to building characteristics (Al horr et al., 2016).

Two strategies building designs are known to enhance the IAQ: increase the ventilation rate and reduction in the air pollutant (Daisey et al., 2003). The ventilation rate can be improved mechanically or through the natural ventilation improvement. The implementation of low-emitting materials acts in the reduction of the interior air pollutant.

Concentrations of many Volatile organic compounds (VOCs)[168] are consistently higher indoors than outdoors. The VOCs are emitted by a range of products, as the building materials, furnishing, paints, sprays, and others. Since many people spend much of their time indoors, the long-term exposure to VOCs in the indoor environment can contribute to some health implications. The main well-being effects are eye, nose, and throat irritation; headaches, loss of coordination and nausea damage to liver; and kidney and central nervous system problems. Some organics can cause cancer in animals, and many might cause cancer in the humans (EPA, 2017).

The LEED rating system (USGBC, 2014) establishes five requirements to reduce the indoor air contaminants:

- All adhesives and sealants used on the interior of the building must respect the VOC content limits listed;
- Adhesives and sealants shall contain no carcinogen or reproductive toxicant components present at more than 1% of total mass of the product;
- Paints and coatings used on the interior of the building shall not exceed the VOC content limits;
- Carpet and all hard surface flooring installed in the building interior shall comply with the testing and product requirements;

[168] Volatile organic compounds (VOCs) are organic chemicals that have a high vapor pressure at ordinary room temperature. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air, a trait known as volatility.

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- Composite wood and agrifiber products[169] used on the interior of the building shall contain no added urea-formaldehyde resins.

In France, 'The National Environmental Health Plan' (*Plans nationaux santé environnement* - PNSE) takes account of the problem of the indoor air quality. The PNSE established from the period of 2009-2013 the introduction of the materials labeling for construction, decoration and certain dangerous goods and the implementation of the indoor air quality monitoring (*République Française*, 2009b).

The emergence of the building low-emitting materials drove the appearance of the buildings with organic components or Bio-based buildings. The French decree of 19 December 2012 establishes the *Bâtiment Biosourcé* certification's definitions and conditions. According to this decree, bio-based materials are "*any material derived from vegetable or animal biomass can be used as raw material in building or design products and as a construction material in buildings*" (Legifrance, 2012, pg. 01). It is possible to mention as bio-based materials used in the construction the wood and its derivatives, hemp, straw, plume or sheep wool.

Certivèa launched the *Bâtiment Biosourcé* certification where it establishes three distinct certification target level depending on the minimum rate of bio-based material incorporation (Table 20).

Table 20. Distinct certification target level and the lowest rate of the bio-based material incorporation allowed. Source: Certivéa (2014).

Target Level	**Minimum rate of bio-based material incorporation of the *Bâtiment Biosourcé* certification in kg/m² of floor area**	
	Commercial buildings, sports equipment and universities	**Industry, logistics and transport service**
Level 1	18 kg/m²	9 kg/m²
Level 2	24 kg/m²	12 kg/m²
Level 3	36 kg/m²	18 kg/m²

3.6.3 Health and security

The workers' health and security and their work conditions are important issues relating the actors inside the construction site. The construction site is the place where many activities are performed mutually and are much susceptible to accidents. Accidents on the building site are connected to the

[169] Composite wood and agrifiber products are defined as particleboard, medium density fiberboard (MDF), plywood, wheat board, strawboard, panel substrates and door cores

life expectancy of construction site workers. We found in the literature inspiration in the 'Healthy life years' and the 'Life expectancy at birth.'

The 'Healthy Life Years' is a European indicator that "*shows the number of years a person of a given age can expect to live without disability*" (European Commission, 2016). The 'Life expectancy at birth' is a Better Life Index indicator from OECD (2016) that investigates "*how long, on average, a newborn can expect to live, if current death rates do not change*."

Some factors can improve the life expectancy at birth, including rising living standards, improved lifestyle and better education, as well as greater access to quality health services. The life expectancy at birth in France is 82 years, higher than the OECD average of 80 years. The life expectancy for women is 86 years, compared with 79 for men (OECD, 2015; OECD, 2016).

Despite the accidents rate, many parameters might affect the life expectancy of works inside the building site. The European Observatory of Working Life from the European Foundation for the Improvement of Living and Working Conditions emphasises that the "*working conditions in certain sectors can lead to serious health problems among employees*" (Anxo et al., 2012). We can affirm that this applies directly to the construction site workers, that need to have a minimum of health and security conditions, as mentioned anteriorly, to have a high quality of work that will reflect in the quality of life and also in the life expectancy.

This performance issue is strongly related to the indoor environmental quality, in the sense that choosing the right of building products can help to limit health impacts, but also the possibility of the existence of VOC and formaldehyde. This might impact the construction site workers but meanly the building occupants that will have daily contacts the building products.

3.6.4 Work conditions

As regarding the users, we already explained their built environment satisfaction using the performance issue ‘comfort’, this performance issue is related to the job quality inside the construction site. This quality is associated with the salary, the security level, the work conditions and the workplace.

3.6.5 Ensuring a livable area

As we stated in Chapter 2, universities campuses buildings should promote the students’ life and their contribution to the local community. In this sense, ‘Ensuring a livable area’ relates to the idea of promoting the public and the commercial amenities for the building user’s and at the same time, contributing to the local economy.

Universities campuses must contribute to keep user's quality of life providing, restoration, health and cultural services, and green spaces.

3.6.6 Land design for sustainable urban development

This performance issue tries to answer the significant GHG emissions attributable to the universities campuses displacements. Chapter 2 largely discussed the importance of the integration between the university and the city, as we identified displacement as an important topic that increases the carbon footprint of universities.

As we already took conscious that many university campuses in France were built far from urban city centers, what boosted the extension of the public transportation, but also the increase in the use of cars. Many universities are aware of this situation and put their efforts in providing some bicycle facilities and green vehicles parking and facilities for charging. Four our case of study, both options are feasible. Also, the promotion of public transport system as the bus and the metro is an essential strategy of sustainable mobility.

In the sustainable building campus approach, the local community is a major actor acting in the development of the public and the commercial amenities to ensure a campus life. On the other hand, the local community benefits from the university that will implement the sustainability locally and will improve the infrastructure conditions (i.e., access to quality transit, green vehicles, and bicycle facilities).

3.6.7 Promotion of a feeling of community/home

'Promotion of a feeling of community/home' is a performance issue for investigating the capacity of the building project in preserving cultural heritage, promoting a sense of place, and sharing the space with the local community.

The university campus should be attractive and functional regarding the city needs. For this purpose, the university campus' equipment should be open to people from outside the university, increasing the connection between the university and the city (CPU, 2014). Furthermore, this promotion of university's structure use will help to avoid that university buildings remain empty during the scholar vacations and the weekends.

Based on our experiences and the literature reviews, we considered that the local cultural is indispensable for the educational institutions building design. In the sense, project must reflect the cultural values of the existing land and community (Bosch et al., 2013).

3.6.8 Social justice

A sustainable university building must, besides providing comfort, to promote the principle of the equitable use to ensure that the design is useful and marketable to people with diverse abilities. Buildings should provide the same means for all users and prevent the segregation or stigmatization of any users (Center for Excellence in Universal Design, 1997).

The Decree n° 2006-555 of 17 May 2006 previews that all the public building should provide facilities to enhance the accessibility of the people with disabilities, whatever their disability. The obligation of the accessibility concerns the external and internal parts of the building and affects the circulation, part of the car parking places, lifts, and their equipment (MLHD, 2006).

The buildings accessible to people with disabilities are considered as being "*all the buildings that, under normal conditions of operation, allow persons with disabilities, with the greatest possible autonomy, to move around, access premises and equipment, use equipment, identify, communicate and benefit from the services for which this facility or facility was designed*" (MLHD, 2006, Article 111-19-2).

Moreover, the ‘Social justice’ encompasses also the social equity and the GSR strategies from the companies that are suppliers of the university building, for the construction process, but also for the building maintenance.

3.7 Performance issues of the category « Planet »

The category 'Planet' has an environmental approach and make mention to the conservation of the natural resources (i.e., energy and water consumption, raw materials use) and the protection of the natural environment (i.e., protection of biodiversity, GHG emissions). We considered the environmental concerns from all the life cycle building stages: design, construction, occupation, maintenance, and destruction, or end of life.

3.7.1 Energy

The major of the environmental construction site problems involves the energy the consumption, biodiversity preservation, the potable water use, the water and the soil pollution prevention, the air pollution emissions, and the waste reduction. For the C4U, equipment features, as the energy consumption labeling scheme determines an important parameter to improve the energy consumption in the construction site. The EU Directive 92/75/EC (Council of the EU, 1992) established an energy label to measure the energy efficiency from 'A' to 'G'. The rate 'A' classifies the most energy efficient, and the 'G' the least efficient.

With regards to the university building, it is possible to affirm that the primary concerns related to the natural resources consumption are the energy use. Energy efficiency aligns the reduction in the energy consumption for heating, cooling, and hot water provision; with the efficient insulation, the economic lighting system, the low energy equipment choices, and the renewable energy production (USGBC, 2014 and RT, 2012). The renewable energy production helps the sustainable buildings to reduce their environmental effects of fossil fuel energy (USGBC, 2014).

The project design concept decides the strategies to improve the building energy efficiency. Furthermore, these strategies need to be controlled and enhanced in the operational phase. Improving the energy efficiency is an important strategy to reduce the carbon dioxide emissions.

For our case study, the renovation project had as a primary goal the reduction of the energy consumption. Passive techniques were employed to improve the isolation and to reduce the losses and heat gains. Even if the '*Aile Sud'* building is not exploring options for the renewable energy, the site has a potential for this, and some options can be explored in the future.

3.7.2 Biodiversity

Before the installation of the building site, the building team should perform a construction site assessment. The construction site assessment is a global evaluation of all the physical conditions of the site. According to the USGBC (2014), a complete site assessment is composed by:

- Topography assessment: Contour mapping, unique topographic features, slope stability risks;
- Hydrology assessment: Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities;
- Climate assessment: Solar exposure, heat island effect potential, seasonal sun angles, prevailing winds, monthly precipitation and temperature ranges;
- Vegetation assessment: Primary vegetation types, greenfield area, significant tree mapping, threatened or endangered species, unique habitat, invasive plant species;
- Moreover, soils assessment.

The care in preserving the biodiversity also has a significant impact on the construction site environmental impacts reduction, especially when the building site is located in an environmental protection area, as is the case of the Rambouillet National Forest.

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The Rambouillet National Forest – one of the most major forests of Île-de-France. In the Rambouillet National forest, the main three species is oak (68% in 2005), represented by three varieties: pedunculate oak, sessile oak and finally red oak introduced in the 1970s for an ornamental purpose. The conifers (Scots pine and pine laricio), which represent 25% of the plantations, were introduced in the late 19th century and after the Second World War on the poorest soils. The main big mammals that can be found there are the deer, the boar, and the roe.

The smallest mammals which are most frequent in the forest are the hare, the rabbit, the European badger, the fox, the weasel, the marten, the marten, the skunk, the Lerot, the dormouse, the mullet Silvester, Shrew, taupe, squirrel, and hedgehog. Many species of birds benefit from the various biotopes offered by the forest massif, including several species protected at European levels such as the Black Peak, the Red-backed Shrike, the Marsh Peak, the Dwarf Blongios, Europe and the Honey Buzzard apivore (DDEAY, 2007).

The idea is to establish a study of the natural site before to install the building site. Normally the environmental impact assessment is provided by an inventory of the fauna and flora with the existent species, and a description of the local soil and climate (Certivèa, 2011).

3.7.3 Soil

This performance issue involves two important strategies: the soil pollution prevention; and the vegetation of the surface, to limit soil sealing of the building project for promoting a maximum percolation of rainwater into the ground. The main goal here is to keep as much as possible the natural water cycle and avoid the pollution.

3.7.4 Water

The potable water consumption should be reduced for gardening and cleaning, and for the toilettes use. A rainwater recovery system can ensure almost all the water needed for gardening and cleaning. Some devices can be implemented to reduce the water volume demand, for instance: the dual flush toilets, and the flow limiters with the presence detection (Certivèa, 2011). Similarly, to energy consumption, some strategies to reduce water use should be formulated in the building design process and demands a control in the operational phase where user's behavior plays an important role.

In addition to the reduction of the potable water consumption, the building's construction should respect and ensure the proper functioning of the natural water cycle. Buildings projects should give priority to vegetation surfaces for limiting the soil sealing and promoting a maximum percolation of

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the rainwater into the ground. The building projects should keep as much as possible the natural water cycle (*Ibid.,* 2011).

3.7.5 Pollutants emissions into the atmosphere

With this performance issue, we aim to reduce the pollutants emissions into the atmosphere. We encompass inside this performance issue the main factor of pollutants emissions in the construction site, and in the occupational building phase.

It is important to reduce, inside the construction site, the air pollution emissions from the transport. The building site layout must establish areas of materials discharge close to the site entrance to avoid unnecessary truck displacement. Furthermore, when discharging, employees must turn off the vehicles. Choosing local suppliers helps to reduce the air pollution emissions of large travel displacement.

In the operational phase, particular attention should be given to the energy use. While the renovation project results in the reduction of the energy consumption, it contributes to the CO2 emissions reduction. Adding ‘environmentally friendly’ habitats, which depend on a change of behavior, could contribute further to the energy efficiency and the cut of the carbon dioxide emissions.

3.7.6 Climate system

The resilience to the climate system is maybe the most important performance issues related to the urban space toward a new 2030 Agenda. The main goal is to reduce vulnerability in the cities to prevent a decrease in the quality of life in the towns.

The climate resilient design is related to the capacity of the project to considers the climate adaptation as a way to contribute to the neighborhoods resilience. As an example we can mention the increase in the green spaces areas. The green spaces areas might act to control the microclimate through their thermoregulation properties. They can also help to control the humidity and the solar radiation. Besides that, the installation of green spaces helps to avoid the phenomenon of soil waterproofing

Climate resilient design buildings are more related to the measures that implemented to adapt the building envelope and to prevent the high indoor temperatures, such as the extra insulation, the extra thermal mass, the southward orientation, the green roof, and the natural ventilation (Bosh et al., 2013).

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3.7.7 Waste

The reduction in the construction and demolition waste (C&DW) is also a priority for the new agenda, considering that France is the country of the European Union (EU) with the highest C&DW generation rate, and the mitigations actions in the French construction sector are required (Doussoulin and Bittencourt, 2015).

The adoption of the sustainable construction patterns is an occasion to attend the requirements of the EU Waste Framework Directive 2008/98/CE (European Parliament, 2008) and the French National Program for Waste Prevention. Both established, respectively, that the waste valorization must growth a minimum of 70% in Europe by 2020. These policies also determined that the France must implement a circular economy model through a C&DW management, prioritizing recycle and reuse systems and minimizing the land filling.

Figure 66 represents the strategy of C&DW management for the French construction scenario applied by the government to attend the 70% of the reduction proposed by the EU Waste Framework Directive. The recovery and the recycling process ensure the C&DW valorization. Otherwise, when the waste is not valorized, it is incinerated, with or without energy recovery), or is provisioned in a storage center (IFEN, 2007).

Firstly, the C&DW management system assesses the possibility to proceed with a waste separation inside the construction site. If it is not possible, the building team should establish a place for this purpose. Distinct bins separate the waste, depending on the material's nature. Each bean has a distinct destination. These bins could be identified by different colors or through a signpost. Reinforcing the bins identification assist in preventing mixing the various waste types.

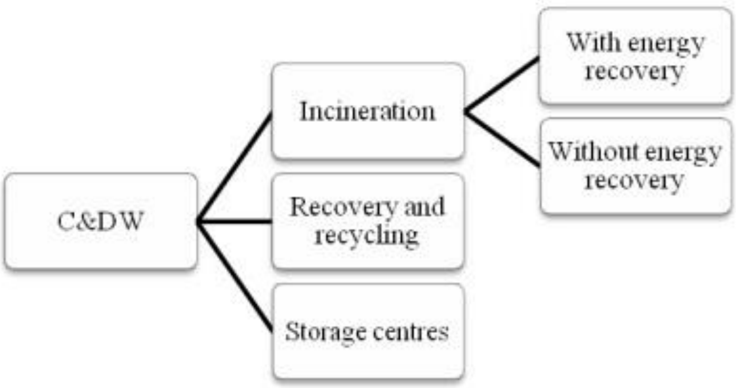

Figure 66. C&DW management for the French construction sector.
Source: Adapted from IPHEN (2007).

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Thereon, depending on the waste type different options for reuse or recycling might be approached. When there is no possibility to reuse or recycle the waste should be disposed of in a responsible way (Doussoulin and Bittencourt, 2015). In France, the C&DW are classified in (Certivèa, 2011):

- Hazardous waste: it includes waste containing asbestos and hazardous industrial waste (e.g., paints, solvents, glues, varnishes and sealants containing organic solvents, oils, and batteries);
- Inert waste: concrete, bricks, tiles and ceramics, land and unpolluted aggregates, mineral insulation, and glass waste;
- Non-hazardous waste that is not packaging waste: glass, plastics, metals, also called industrial waste;
- And packaging waste.

The cut in the C&DW emissions at the source is crucial. It implies identifying and quantifying the C&DW on the construction site by typologies. Furthermore, the C&DW reduction requires more attention in the determination of the construction sites' layouts, the establishment of a building modular construction design, the raise in the actors' awareness about waste prevention, and the emphasize off-site materials manufacture, especially the concrete production off-site.

Ortiz et al. (2010) found many advantages in the C&DW recycling, accentuating the importance of avoiding landfilling. Moreover, according to Blengini (2009), even if sometimes the environmental impacts of the recycling strategies can exceed the environmental benefits, the recycling process still rests as the option more economically feasible and profitable from the energetic and ecological point of view. The waste landfill induces to significant environmental impacts as the water and soil pollution, and the GHG production, like CO2 and methane, due to the waste anaerobic degradation (Lu et al., 2013).

3.7.8 Materials and resources

The construction materials demand will increase as the world population is currently expanding. Besides that, the developing nations are becoming wealthier, with higher expectations for life style and affluence. Limiting the material and the resources consumption without providing a solution for furnishing the alternatives of human capital is a strategy condemned to fail.

Considering this context, the goal of this performance issue is to encourage the use of renewable materials, as for instance, wood, hay, bamboo and flaxen; and to promote the recycling.

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Gao et al. (2001, pg.554) defined recycled building material as "material, which can be remade and reused as a building material after the building disassembled." Recovery or reused materials are materials that did not pass through any chemical transformation. Those elements conserved their internal structure and its physical state. However, they do not need to have the same function as they had in the previous life cycle. The advantage of the reuse process is that it requires less energy to make the materials' components suitable for their new function.

3.8 Performance issues of the category « Profit »

The performance issues of the category 'Profit' refers to the value creation to the local[170] community, and the project performance (Bosh et al., 2013). The university campus as an urban project must contribute somehow to the local economy and its various stakeholders.

3.8.1 Creating local value

An important goal for the construction sector but also for the university is creating the local value. Universities campuses can bring value through the construction site activities but also in the operational phase.

A building site is a space that is passing through mutation, and it has several activities taking place mutually. The construction site is a sort of a 'provisory space' characterized by having an intense flow of materials and people.

The construction site workers are the persons that are directly involved with the site activities. In the sense of the construction of the sustainable university buildings, it is desirable to contribute to local employment (Bosh et al., 2013). Beyond that, the building team should also stimulate the local economy, when hiring a local supplier or buying the construction materials.

3.8.2 Creating value for the sector

The primary goal of this performance issue is the reduction of the costs because of the lower energy and water use.

[170] The term 'local' is defined as from the city or region (Bosh et al., 2013).

3.8.3 Time optimization

The time optimizaton in the construction site can be reached with increasing the workers' productivity, and by the implementation of the construction management strategies.

The productivity of the construction site is also an important concern of the project's performance. Many factors might influence the productivity. We can mention for example the management factors, the effective communication between the workers, the materials suppliers, and the site manager; the employees' motivation; and the professional experience and training (Naoum and Hackman, 1996).

Hosseini et al. (2014) presented a verification study of the lean construction benefits in a case study. They stated that the main argument of the lean construction concept *"is that processes need to be analyzed not only as transformations but also as flows and value generation"* (*Ibid., 2014*, pg.1249). They affirmed that the lean highlights the examination of flows and value generation in designing construction process to obtain a lean process.

The essential ideas of lean concerned to processes in the construction phase can be grouped into three categories: (a) Flow production, (2) Value generation), and (3) Just-in-time delivery in construction processes (*Ibid*., 2014).

The Flow production concept in the construction processes enables the construction managers to enhance their activities by the identification and the reduction of many types of waste. The term 'waste' can be connected with the waste of materials, but also when there are activities, there are not adding any value, as delays, transportation of materials or waiting time (Ibid., 2014; Senaratne and Wijesiri, 2008).

In this sense, we can connect the productivity with the reduction in the waste of activities in the construction process. Hence, the productivity assessment in the construction process can be made by analyzing the delay in delivering the building site.

However, an evaluation of the building management strategies from the planning and design until the project delivery is also necessary. Through a comparison between the planning and design strategies, with the project delivered, it is possible to affirm if the construction management was satisfactory or not. A successful construction management results in a high productivity construction site with less delay. In the long run, construction management can act in the reduction of the GHG emissions (Tang et. al., 2013).

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3.8.4 Costs

In general, low-carbon urban development project, as for instance, a sustainable campus aims to reduce the amount of CO_2 emitted through the adoption of new concepts, practices or low-carbon approaches. All these solutions need to be economically attractive to be convenient for upscaling (*Ibid*., 2013).

Investing in low-carbon urban development projects has environmental and costs impacts. The payback period; which is the time required for owners/operators to receive a return on their investment, based upon their original investment and the annual savings achieved because of the investment; can assist in the calculation of these expenses impacts. Calculation of the payback period is also used for estimation of capital risk as *"high initial investment costs combined with a long payback period reduce the opportunities for upscaling"* (*Ibid*., 2013, pg.43).

In the case of universities, results of the calculation of payback can be useful to take simple decisions between the various actors for the construction of new buildings, renovation or implementation of urban infrastructure.

3.8.5 Adaptability and flexibility

Focusing on the interior design strategies, architects and engineering's should interrogate themselves about the building's lifetime according to its destination, implantation, urban context. Besides that, they might determine if the building will enroll in the short, medium or the long term.

The construction choices in the design phase will depend on the activities that the building will host. The design project preferences might also the adaptability of the building's design in a long-term. For the universities buildings case, the design, architects, engineering, and urban planners must study and consider the possibilities to expand the building in case the number of the students' increase (CPU, 2014).

Furthermore, the building team should incorporate the principle of flexibility in the design of the interior spaces. In the sense that pedagogical and didactic activities are continuously changing, and the spaces could also be transformed to adapt to distinct activities during the day (OECD, 2005a). A flexible space that host several activities reduces the built surface and, consequently, the global building construction and maintenance costs. Incorporating the principle of flexibility in the design of interior spaces is part of the French energy transition objectives previewed in the Law n° 2015-992 from 17 August 2015 (CPU, 2014; *Republique Francaise*, 2017b).

As mentioned before, universities buildings must adapt their existing spaces or projects to the digital innovation. In the place of having large and traditional classrooms, the new trend promotes the flexible classrooms were the tables, and seat can be changed according to the activities needs, promoting an environment for knowledge exchange. The calm spaces of libraries must allocate the spaces for conviviality and collective work (Campus Responsables, 2013).

3.8.6 Constructive choice for the accessibility during maintenance works

The maintenance of the propositions and the solutions of the design project by the project building team is also a significant cost issue. Construction choices must improve the accessibility during the repair works providing adequate conditions of access. On the other hand, the solutions proposed (i.e., products, services or processes) must be easy to maintain, limiting the costs of maintenance (Certivèa, 2011).

3.9 Performance issues of the category « Process »

The performance issues of the category 'Process' have a management approach. The quality of the development process that determines the long-term results of the projects. The environmental, social and economic aspects of a university campus should be projected longstanding. This category aims to cover those aspects of the project that have contributed to a successful process of implementation (Bosh et al., 2013).

3.9.1 Governance model

A governance[171] model transition to an SD society has crucial aspects like the leadership and the democracy. The governance should provide all the information and open access to provide stakeholders dialogue and participation in the deliberation process (ECFESD, 2000). University relies on this governance aspect to drive to democratic decisions and to reinforce its universality approach. The sustainable strategy plan, the formulation of action plans, research and teaching programs, building design plan, architectural project and urban project - all this requires a participative decision-making process toward a sustainable campus.

Successful governance models in higher education allow for a flexible, committed, transparent, accountable and goal-oriented leadership (MacGregor, 2016). The leadership plays an essential role in

[171] \`Governance' describes *"the patterns that emerge from the governing activities of social, political and administrative actors"* (Kooiman, 1993, pg.2).

the implementation of the new ideas and climate-change responses in the low-carbon development projects (UN-Habitat, 2011). For Bosch et al., 2013, a leader should have the ability to convince and inspire the others, engage the stakeholders and create enthusiasm. These are the key factors of success for a project. We will consider here three types of leadership: bridging, lobbying, and persistence.

Leadership bridging is the ability to bring together the right people at the appropriate time to participate in the planning process of a project. Bridging aims to connect various interests to form a supportive group of stakeholders (Bosh et al., 2013). Successful governance systems in higher education institutions encourage new partnership, and network among the state, institutions of higher learning and the private sector.

The C4U tool determines that leadership lobbying is the capacity to create political support for the project through the development of the right connection. The project leader must create the right connections to government officials and creates extensive governmental support for the project (Bosh et al., 2013). The project manager should also show firm determination and manages to keep the project going. Persistence is paramount for university building projects due to the challenge of bringing together public and private actor for the decision-making process with the university. Therefore, leadership persistence is the ability to persevere in adverse times.

As mentioned before, the governance model transition to an SD society employs a participatory form of governing. A participative way of governing implies in the involvement of the public, local community, and professional stakeholders in the process of decision making.

3.9.2 Strategy

The sustainable strategy can be presented as a fundamental approach that contributes to the transition of the green to a sustainable campus. A transparent sustainable strategy drives a sustainable campus. This strategy should consider the development of an action plan that covers the three aspects of the SD and the SR. In the case of the new buildings, this action plan will present the points that the university wants to prioritize aiming a continuous improvement. The action plan can also show the sustainable strategy that the university desires to implement for the new buildings and regarding the new and existing buildings (FONDaTERRA, 2011a).

3.9.3 Maturity of the process

After the establishment of the leadership strategies, the identification of stakeholder's involvements, and the sustainable strategies definition, it is opportune an analysis about the process maturity. The maturity of the process indicates how close the process is to be complete. Some elements can play a decisive role, for instance (Bosch et al., 2013):

- Prior experience with the solution: it means having a background of the project team with the technologies, practices, and principles applied;
- Degree of testing: in other words, the level of experimentation and research of a product or innovation before the implementation;
- Users training: it consists in giving information about the proper use of new technology;
- Continued monitoring and reporting: the evaluation of the extent to which users have been informed about the appropriate use of new technologies or principles in their living environment.

3.9.4 Sustainable sites

Sustainable sites require a proper governance that should succeed with the sustainable strategies implementation inside the construction site. For this finality, governance should set up a construction management plan. Positive results regarding sustainable construction sites are due to the degree of the effectiveness of this construction management plan, associated with the training of the workforce.

Training the workforce is important in the sense that new processes, technologies, approaches or practices require adjustments in the regular way of doing things. To correctly implement sustainable strategies in the construction site, for example, it is important to strengthen the workforce regarding skills and knowledge when necessary. Additional training of the workforce is the key to ensure successful implementation (Ibid., 2013).

3.9.5 Water and energy management

Inside the construction site, continued monitoring and reporting can also be involved water and energy management, and interior air quality control. The water and energy management identify the opportunities for additional water and energy savings by tracking water and energy consumption.

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3.9.6 Interior air quality and temperature control

The interior air quality control evaluates the strategies to control the winter interior temperature and to ensure an efficient ventilation. A proper interior air quality conditions can be reached through a Building Management Systems (BMS) to manage buildings parameters automatically and is particularly important for classrooms and workspaces (Certivèa, 2011).

3.9.7 Sustainable teaching and research

A significant process toward a sustainable campus is carrying out the sustainable teaching and research activities, the sustainable management system, and the improvement of student life. In the scale of the sustainable building, the university can use its infrastructure and operations for multidisciplinary student learning and applied research. It contributes to the understanding of the campus sustainability challenges and in advancing sustainability on the campus. In the context of the campus engagement, the institutional education must set up a sustainable management system covering the natural environment. The university should designate the physical spaces that it will allocate programs and initiatives focused on the sustainability (AASHE, 2016).

3.9.8 Public engagement

The performance issue public engagement highlights the importance of the local community in being involved in the project as actors that must outline their needs, to make action plans, to manage the project and evaluate the results. Participation of the local community is powerful because they can provide additional knowledge when solving problems, help to lead to better decisions and solutions, and can be precious for understanding the complexities of many issues (Bosch et al., 2013).

3.9.9 Campus engagement

The universities campuses should be actively engaged in the promotion of the student life concerning the SD goals. They should mobilize universities' programs and initiatives for this purpose, for instance: active student groups, gardens, farms, cultural art events, conferences, co-curricular sustainability programs and initiatives, and others. Physical spaces inside the university campus designated to these activities are necessary.

Inside this context, the institution might implement an experimental sustainable management system covering the natural environment. Priority should be given, inside the universities' strategic plans, to raise the awareness and the participation of all the stakeholder's groups. This will foster sustainable practices at a local level, as stated by Rene Dubos in the "think globally, act locally” idea. Besides that, raise awareness is a fundamental element for changing behaviors in the built environment.

3.10 Performance issues of the category « Propagation »

This category aims to contribute to accelerating the spread of innovations. Sub-goals and indicator for this group are focused on the determination of the potential for innovations diffusion as a support for the transition toward a low-carbon society (Bosch et al., 2013). We selected the performance issues for evaluating the innovations spread inside the university campus, like the innovation complexity, the potential for dissemination, the level of mimetic process, the advantage for users and stakeholders, the ability to bring about change, trialability, the market demand for the solution, and the innovation's compatibility.

3.10.1 Complexity

Complexity is an important innovation characteristic related to the project's actors. The end-users and the professional stakeholders are the project's actors analyzed. The end-users are those individuals who will be using or working with the innovation, for instance, the university buildings' occupants (e.g., students, researchers, professors, staff). Some innovations are perceived as difficult to understand and use while others are more clear and accessible to the adopters.

In the case of the end users, complexity is related to the technology understand and adoption by the customer. On the other hand, concerning the professional stakeholders, complexity can indicate the complexity for professionals that participate in the value chain, those who are responsible for its supply, the installation, and the maintenance. Professional stakeholders can be the local project managers, the construction companies, the suppliers, and the politicians (*Ibid.*, 2013).

3.10.2 Relative advantage

A relative advantage for end-users and stakeholders can increase the social compatibility. Communication has a significant role here and a Green Plan built democratically is essential to reach a social compatibility inside the university campus.

3.10.3 Dissemination

The dissemination potential has as the primary goal to provide information about how the regional and international networks of actors act alongside. It might help to influence behaviors and share sustainable performance to build a responsible corporate body (FONDaTERRA, 2011b).

A high potential of dissemination means the determination of an SD and GSR's charter of commitment and correct practices. It also indicates the effectiveness of the approach and continuous improvement. Communication has a vital role for the dissemination potential of a project innovation. All these approaches have a significant impact in the transition toward a sustainable campus.

3.10.4 Standards evolution

Some innovators projects might lead to a public discussion and promote standards evolution concerning the public procurement, or in the rules and regulations, influencing and inspiring other administrations.

3.10.5 Mimetic processes

The level of mimetic process aims to evaluate the extent to which a project innovation (e.g., technology, new product) has been copied in other places or by other actors. Copying the innovation in its country of origin, and internationally can determine a high-level diffusion to other locations.

Besides that, an excellent diffusion to other actors encompasses that innovation is copied and has become the new guideline for commercial parties. Extensive copies of the innovation can mean that the innovation can provide some relative advantage. The end-users and the stakeholders can profit of these benefits when the applied technologies have a direct and an extremely positive effect on the actors (Bosch et al., 2013).

3.10.6 Ability to bring about change

The ability to bring about change is *"the potential of a low-carbon urban projects to change the institutions in which the projects are embedded"* (*Ibid*., 2013, page. 82). In the case of the construction sector, the construction sites that achieve remarkable sustainable performance should diffuse their technologies, principles, and practices of other construction sites in distinct scales and places.

> *"The exchange of information among different countries is a key element to promote a wider diffusion of practices for sustainable development in the fields of architecture and urban*

planning, contributing to the improvement of new skills and economic and production activities, while also reducing the environmental impact of construction on the territory" (Giachetta et al., 2013, page 46).

3.10.7 Innovation characteristics

The potential of diffusion of an innovation depends on also on the market demand for the solution. Our model aims to measure the rate of adoption of innovation considering that the innovation should meet the needs of its potential adopters. It is possible that innovation might have a unique connection to general problems in European cities, but that the demand for a solution is relatively low (Bosch et al., 2013). It is desirable always to work and develop innovations where there is a widespread market demand for the offered solution.

Market demand for the solution is critical when diffusing an innovation. However, the technical compatibility should not be neglected. Technical compatibility means the extent to which the innovation fits with existent practices, administrative and existing technological standards or infrastructures (Bosch et al., 2013). It takes into account that transition to an SD society needs to take place promptly and that we should give priority to the innovations that we can immediately implement.

Another element that assists in the diffusion of innovations is the trialability. The trialability is "t*he degree to which an innovation may be experimented with on a limited basis"* (Rogers, Diffusion of Innovations 1995, pg.16). In other words, trialability is the rate of testing locally to avoid major risks of a global scale. Universities campus should test innovations locally to stimulate a learning process between students and researchers.

3.11 Structuring the performance issues

However, since after defining the sustainable performance issues of a renovation process for university building we still needed to justify the structuration of our approach. We assessed the performance issues proposed, pragmatically, using as reference the 17 Sustainable Development Goals of the United Nations (see Table 21 and Table 22).

After analyzing the Table 21 and the Table 22, we can affirm that all the 31 performance issues identified in our model are all integrated within the '17 SDG's to Transform the World' until 2030.

Using this ambitious and reliable framework for structuring our performance issues allowed us to justify and validate our choices.

Table 21. Justification of our approach according to the 17 SDGs of UN.

TOP-GOALS / SDG UN	PEOPLE (P1)	PLANET (P2)	PROFIT (P3)	PROCESS (P4)	PROPAGATION (P5)
SDG1 - NO POVERTY					
SDG2 - ZERO HUNGER					
SDG3 - GOOD HEALTH AND WELL-BEING	Health and security, Indoor environmental quality, Interior air quality and temperature control, Comfort				
SDG4 - QUALITY EDUCATION				Sustainable teaching and research	
SDG5 - GENDER EQUALITY					
SDG6 - CLEAN WATER AND SANITATION		Water		Water and energy management	
SDG7 - AFFORDABLE AND CLEAN ENERGY		Energy	Total cost saving for the end users, Costs	Water and energy management	
SDG8 - DECENT WORK AND ECONOMIC GROWTH	Work conditions				
SDG9 - INDUSTRY, INNOVATION, AND INFRASTRUCTURE			Creating local value		Innovation characteristics, Complexity, Relative advantage
SDG10 - REDUCED INEQUALITIES	Social justice				

Table 22. Justification of our approach according to the 17 SDGs of UN (Continuation)

TOP-GOALS / SDG UN	PEOPLE (P1)	PLANET (P2)	PROFIT (P3)	PROCESS (P4)	PROPAGATION (P5)
SDG11 - SUSTAINABLE CITIES AND COMMUNITIES	Land design for sustainable urban development, Ensuring a livable area, Promotion of a feeling of community/home , Pollutants emissions into the atmosphere			Ability to bring about change	Sustainable sites, Campus engagement, Mimetic processes
SDG12 - RESPONSIBLE CONSUMPTION AND PRODUCTION		Waste, Materials, and Resources	Adaptability and flexibility, Constructive choice for the accessibility during maintenance works, Time optimization		Maturity of the process
SDG13 - CLIMATE ACTION	Climate system, Pollutants emissions into the atmosphere				
SDG14 - LIFE BELOW WATER					
SDG15 - LIFE ON LAND		Biodiversity, Soil			
SDG16 - PEACE, JUSTICE, AND STRONG INSTITUTIONS					
SDG17 - PARTNERSHIPS FOR THE GOALS				Governance model, Strategy, Public engagement	Dissemination, Standards evolution

4 STEP 3: REPRESENTING THE SYSTEM

Goal: The goal of this step is to identify and mobilize the indicators from the various sources to represent the system. In other words, it consists of informing about the problem of the renovation process performance of the 'Aile Sud' building through a catalog of indicators that represent the performance issues defined previously, and the discussion with the actors. This step corresponds to the third step of the INTEGRAAL framework as is presented in Figure 67.

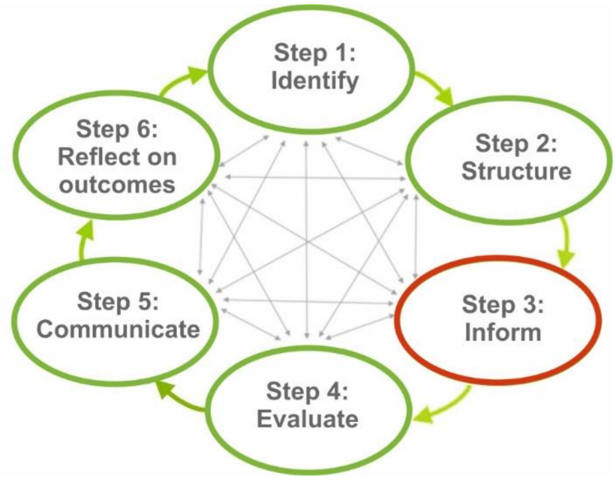

Figure 67. Step 3 of the INTEGRAAL framework

4.1 Making an inventory of tools and data available to represent the system

One of the goals of the literature review conducted during the Step 2 should be to make a list of the tools available to represent the system. There is no particular methodology for this inventory, but a classification may be necessary by category of activity, spatial scale, or field of study.

From the research problem, we defined the performance issues (i.e., the main goals or aspects) that are relevant to the decision-making process. We used the key performance indicators (KPI) to measure this performance issues. The KPI are *"performance measurement that evaluates the success of a particular activity"* (Cabeza et al., 2015, pg. 820). The success can be defined as the achievement of an operational goal or the progress toward the strategic goals.

Initially, we created a list of indicators related to the university assessment, building assessment, and urban innovations assessment. Then, we analyzed the indicators from the existing tools and methods

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(i.e., HQE, LEED, STARS, EVVADES, B4U, and BREEAM[172]) presented in Chapter 3 considering their definition, measure unit, and type. According to the type, the KPI can be quantitative or qualitative. Quantitative in the sense that it can be measured by giving a value, or qualitative, by giving an adjective without scale (Cabeza et al., 2015).

After this, we analyzed further documentation, as the scientific papers, norms, technical reports, and regulations, as the ADEME, OECD, UN, CPU, Eurofound, European Commission, UNESCO reports, AFNOR norms, and RT 2012.

As we already described in Chapter 3, we used the EPLANETe Blue platform to perform the Step 3 and 4 of the INTEGRAAL framework. Firstly, we created in the 'Gallery of Theories, Tools, and Terrains' a profile of each method of the KPI found in the literature review. All the KPIs that were not grouped in a method or tool were placed together in a group called 'literature review'. Each profile of method or tool is composed of a 'Tool or Method' name, acronym, description, category of tools, detailed description, and scale and scope. Each method or tool has a crosslink with an indicator from the KIKs gallery.

Thereon, we worked inside the KIKs (Kerbabel™ Indicators Kiosks) Gallery where is presented a collection of Indicators in various contexts of interest to 'User Communities' in ePLANETe. We added a list of indicators that we found in the literature (Raharinirina and O'Connor, 2010). The KIK is a system which allows the cataloging of quantitative and qualitative indicators, containing a maximum of information about the indicators. To insert the indicators in the KIK Gallery of the 'Sustainable Campus', which is the name of the community and the KIK that we have been working for the 'Aile Sud' building evaluation, it was necessary to fill some general information about the concept of the indicator, the scientific profile, the scope and interpretation, and the nformation source (see Table 23).

A complete inventory of the indicators is available for building assessment, university evaluation, and innovations assessment, from existing methods but also from the literature review, is presented in Annex 10. This relation between both galleries of the 'Doorway CAMELOT' was explained in Figure 68.

[172] See the list of indicators for each method in the Annex 2, 3, 4, 5, 6 and 7.

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Table 23. KPI's data inside the KIK Gallery of the ePLANETe Blue

KNOWLEDGE PERFORMANCE INDICATORS INSIDE A KIK COMMUNITY

- **CONCEPT OF THE INDICATOR:** The KIK to which the indicator belongs, Community, Name, an intuitive and convenient Acronym and a Non-Technical Explanation of the object or attribute.
- **SCIENTIFIC PROFILE:** Specification about the Character of the Information (e.g., qualitative or quantitative), Unit of Measure, Qualitative Convention (e.g., high/medium/low, Red/Green, Present/Absent), and Data Set Charter (e.g., a unique object/value or a data set.
- **SCOPE AND INTERPRETATION:** The Scope states the coverage of the information (e.g., the geographical or systems range, or the population covered of the information); and the Interpretation explains the relevant range of measurement (and limits to scope) and/or the meaning attached to qualitative descriptive conventions.
- **INFORMATION SOURCE AND STATUS:** Institutional Sources, Scientific Sources, Reference Terrains, and Other Sources Types.
- **INDEPENDENT USE OF PRE-EXISTING INFORMATION:** The Source Analytical Conventions, which specifies the pre-existing situation(s) in which the indicator appears as an input or output of analytical systems (e.g., data sets, variables in algorithms and models) in analysis and representation; the Exploitation for Evaluations Operations, that determines the pre-existing situation(s) in which the indicator is mobilized as a component in a normative evaluation procedure (multi-criteria or other); and the Existing Visualization, that specifies the way(s) that the indicator is portrayed in a graph, on a map, or within a 2D or 3D virtual reality of a pre-existing representation.
- **KNOWLEDGE QUALITY ASSESSMENT:** K Status, that determines whether the information is primarily empirical or conceptual in character; KQA issues, that specifies in general terms the knowledge quality (KQA) issues associated with the indicator; and the NUSAP Profile, which is provided to characterize the knowledge quality issues associated with the indicator.
- **SCALE OF THE DESCRIPTION:** Observation Scale, that specifies the organizational scale at which the object or attribute is described; Component Levels, that should signal relevant 'inferior' organizational levels allowing a multi-scale interpretation; and Higher Levels (e.g Social, Governance, Economic and Environment).

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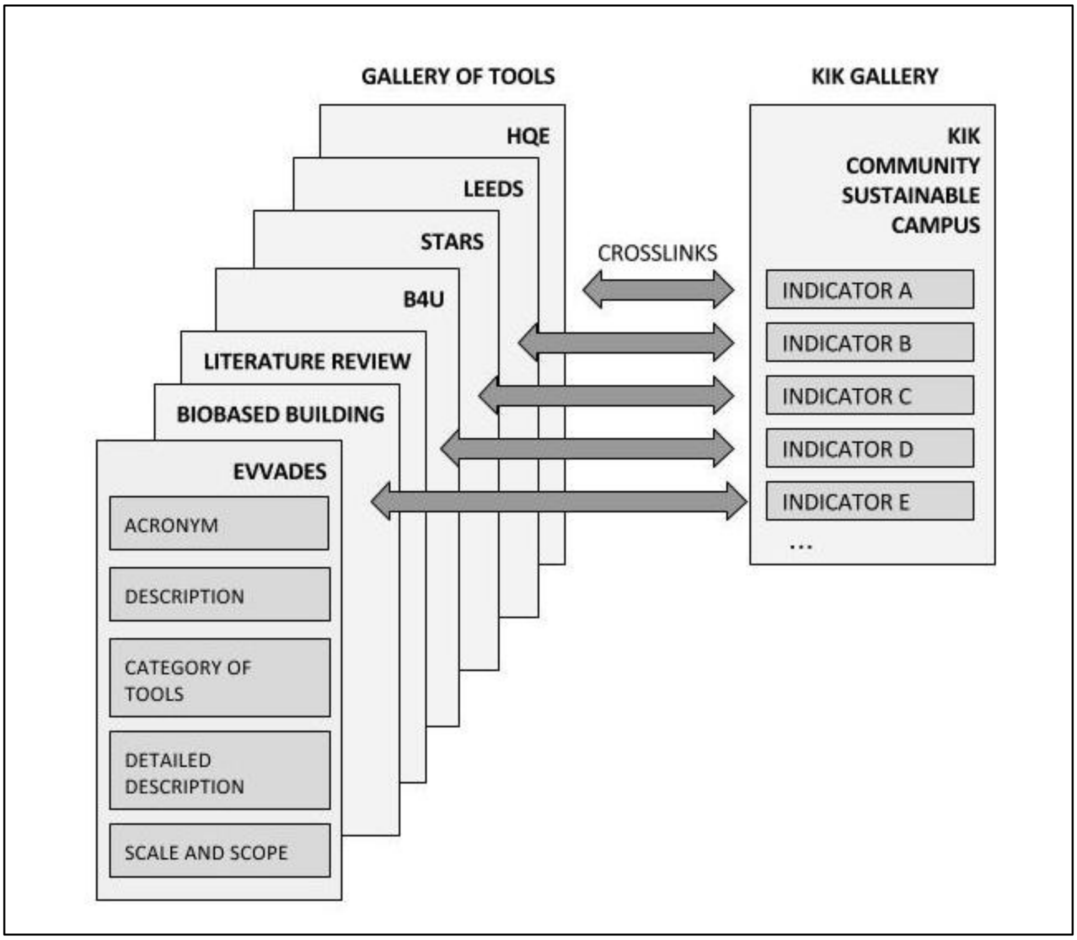

Figure 68. Elements of each ePLANETe's Gallery and the 'crosslink' between indicator of a KIK community and methods and tools

4.2 Building a base of relevant indicators for the problem studied

After finishing our exhaustive indicator's inventory, we used the Kerbabel Representation Rack (KRR) to select the indicators that are pertinent to our case study. The KRR l allowed us to structure the diversity of existing representations of the sustainable university building. The KRR is situated in the ePLANETe platform, inside the 'Gallery of Deliberation Support Tools' (DST), and inside the 'Doorway CAMELOT'.

The aim of the KRR is to mobilize the various forms of knowledge associated with distinct actors (i.e., scientists, experts, associations, environmental justice organizations). This knowledge comes from distinct conceptual approaches (i.e., scientific, vernacular or other), tools (i.e., analysis, modeling) or theories. The method offers the actors, who are 'knowledge carriers', the opportunity to situate and manifest the relevance of their knowledge about the context.

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Specifically, the Representation Rack proposes a process, combining objective and subjective dimensions, to identify and to crop the knowledge associated with a concern such as sustainable university building. Moreover, it provides an opportunity for the 'knowledge carriers' to situate their knowledge, evaluating its relevance, in relation to the way in which the representation of the problematic studied is constructed (Gassama, 2016).

The KRR consists of four axes:

- The first axis is constituted by the 'knowledge carriers' or any individual or category of person or organization that carries a set of knowledge about the sustainable university building. For our case study, we were the 'knowledge carrier' and any external actor participate directly of this KRR part;
- The second axis, which is that of the conceptual approaches/Tools/Theories, makes possible to identify, through the analysis of academic works and expert reports, but also, through links with the field actors; all forms of knowledge production mobilized to represent the sustainable university building. We selected six methods to represent the assessment for our case study (i.e., EVVADES, HQE, LEED, B4U, STARS, Bio-based building; and the C4U literature review[173]);
- The third axis identifies the situations to be compared according to the scenarios. In our case study, we have just one scenario which is the renovation process of the *'Aile Sud'* building;
- The fourth axis defines the criteria for comparison, in other words, the sub-goals selected to evaluate the main objectives of our case study.

Finally, the KRR proposes to evaluate the relevance of the knowledge according to the four axes retained. In our case, the' knowledge carriers' participated in the relevance evaluation of each indicator for each cross-tabulation of values on the four proposed axes.

The KRR allow us to visualize all the indicators for each method selected, and to select the indicators of the C4U tool through a pertinence analysis. This relevance analysis was performed in the exhaustive list of the indicators selected at the beginning of our study, and produces what we denominate of 'indicators candidates'.

The indicators can be weighted according to their pertinence as 0, for no pertinence; 1, for low pertinence; or 4, for strong pertinence. We performed this analysis as experts, taking as a reference our discussions with the actors. All the indicators that received a 4 in the pertinence analysis were

[173] We denominated 'C4U literature review' a fictitious tool were we grouped all the indicators found in the literature review.

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added to the list of 'indicators candidate.' The complete list of 'indicators candidate' for the worksite of *the 'Aile Sud'* building is presented in Table 24.

Table 24. List of the indicators candidate for the '*Aile Sud'* building worksite

PERFORMANCE ISSUES	INDICATOR NAME	REFERENCE
COMFORT	Thermal comfort	LEED
	Considering the potential site climate	HQE
	Ensuring a minimum thermal comfort level and windows protection from the sun	HQE
	Ensuring adequate ventilation	HQE
	Acoustic comfort inside the building	C4U Literature review
	Limiting noise pollution at the construction site	HQE
	Daylight access	HQE
	Controlling of the visual atmosphere by users	HQE
	Adequate minimum lighting	LEED
INDOOR ENVIRONMENTAL QUALITY	Low-emitting materials	LEED
	Bio-based use in the building materials	Bio-based building
	Air quality management plan of the construction site	LEED
HEALTH AND SECURITY	Life expectancy of construction site workers	C4U Literature review
	Security of construction site workers	C4U Literature review
	Choosing building products to limit the health impacts	HQE
	Optimize cleanliness of the construction site	HQE
WORK CONDITIONS	Work satisfaction inside the construction site	C4U Literature review
ENSURING A LIVABLE AREA	Availability of public amenities	B4U
	Availability of commercial amenities	B4U
LAND DESIGN FOR SUSTAINABLE URBAN DEVELOPMENT	Access to quality transit	LEED
	Bicycle facilities	LEED
	Green vehicles	LEED
PROMOTION OF A FEELING OF COMMUNITY/HOME	Connection to the existing cultural heritage	B4U
	Openness to the city	C4U Literature review
	Design for a sense of place	B4U
SOCIAL JUSTICE	Buildings accessible to people with disabilities	C4U Literature review
	Social equity with the supply chain	C4U Literature review
ENERGY	Annual primary energy consumption of buildings	B4U
	Annual final energy consumption of buildings	B4U
	Renewable energy production	LEED

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	Reducing construction site energy consumption	HQE
	Optimizing energy performance	LEED
BIODIVERSITY	Preserving biodiversity during construction site	HQE
	Construction site assessment	LEED
SOIL	Vegetation of surfaces /soil impermeabilization	HQE
	Water and soil pollution prevention from the construction site	HQE
WATER	Limiting the water use for gardening and cleaning	HQE
	Limiting water needs in toilets	HQE
	Potable water use reduction inside the construction site	C4U Literature review
POLLUTANTS EMISSIONS INTO THE ATMOSPHERE	Air pollution emissions in the construction site	B4U
	Carbon dioxide emissions	B4U
CLIMATE SYSTEM	Climate resilient design neighborhood	B4U
	Climate resilient design building	B4U
WASTE	Identify and quantify the construction waste by typologies	HQE
	Reducing construction waste at the source	HQE
	Reduction of materials used	B4U
	Optimize the treatment and reduction of W.E.E.E. (Waste Electrical and Electronic Equipment)	EVVADES
MATERIALS AND RESOURCES	Share of renewable materials	B4U
	Share of materials recyclable	B4U
CREATING LOCAL VALUE	Use of local workforce in the construction site	B4U
	Use of local suppliers of products and materials	C4U Literature review
CREATING VALUE FOR THE SECTOR	Total cost saving for the end users	B4U
TIME OPTIMIZATION	Productivity in the construction site	C4U Literature review
	Construction management strategies	C4U Literature review
COSTS	Payback period of the building	B4U
	CO2 emissions reduction cost efficiency	B4U
ADAPTABILITY AND FLEXIBILITY	Adapting the construction choices to the building lifetime	HQE
	Adapting building interior spaces to digital innovation	C4U Literature review
	Incorporating the principle of flexibility in the design of interior spaces	C4U Literature review
CONSTRUCTIVE CHOICE FOR THE ACCESSIBILITY DURING MAINTENANCE WORKS	Ensuring accessibility for building maintenance	HQE
	Products, systems and construction processes	HQE

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GOVERNANCE MODEL	Leadership 'bridging'	B4U
	Leadership 'lobbying'	B4U
	Leadership 'persistency'	B4U
	Involvement of public stakeholders	B4U
	Involvement of professional stakeholders	B4U
STRATEGY	Define a sustainable strategy	EVVADES
MATURITY OF THE PROCESS	Prior experience with the solution	B4U
	Degree of testing	B4U
	User training	B4U
	Continued monitoring/reporting	B4U
SUSTAINABLE SITES	Sustainable sites management implementation	Literature review
	Training of the workforce	B4U
WATER AND ENERGY MANAGEMENT	Water metering	LEED
	Building-level energy metering	LEED
INTERIOR AIR QUALITY AND TEMPERATURE CONTROL	Controlling of the winter interior temperature	HQE
	Management device to ensure effective ventilation	HQE
SUSTAINABLE TEACHING AND RESEARCH	Campus as a living laboratory	STARS
PUBLIC ENGAGEMENT	Local community involvement	B4U
CAMPUS ENGAGEMENT	Student's life	STARS
	Sustainable management system	EVVADES
	Raise awareness	EVVADES
COMPLEXITY	Complexity for end-users	B4U
	Complexity for professional stakeholders	B4U
RELATIVE ADVANTAGE	Advantage for end-users	B4U
	Advantage for stakeholders	B4U
DISSEMINATION	Act alongside regional and international networks of actors	EVVADES
STANDARDS EVOLUTION	Change in public procurement	B4U
	Changing rules & regulations	B4U
MIMETIC PROCESSES	Diffusion to other locations	B4U
	Diffusion to other actors	B4U
ABILITY TO BRING ABOUT CHANGE	Diffusion of sustainable construction site	Literature review
INNOVATION CHARACTERISTICS	Trialability	B4U
	Current market demand for the solution	B4U
	Technical compatibility of Innovation	B4U

5 CONCLUSION

The main goal of this chapter was, through the reflection of the research problem, find tools to build a structure that allowed us to represent a model assessment for the performance strategy of the renovation process of the *'Aile Sud'* building, that we denominated C4U.

Performing the Step 1 of the INTEGRAAL framework we delimitated as our field of study the universities buildings in France. We justified this choice by presenting the major environmental problems of these buildings, as the high energy consumption and the CO2 emissions. Furthermore, some social aspects appoint the lack of the integration of the urban space and the absence of the displacement options for the campuses' users. We took a case study to help us to build our model that once completed and validated it can be applied to others university buildings.

The 'Aile Sud' building was chosen as our case study due to its recent renovation building process; interested context between university being implemented in a cultural site; its recognized energy efficiency ability, and its project inspirations in the BBC, HQE certifications. Besides that, the building is considered as being an urban innovation.

Furthermore, we justified the scale studied as not being 'building-centric' due to the importance that the building has for the urban matrix; and our choice for elaborating the C4U tool even when another tool already exists. The participative aspect of our assessment might add legitimacy and acceptability to our model.

In Step 2, we presented our methodology for proceeding a literature review, and we introduced the context description of the *'Aile Sud'* building. The special context of our case study is found in the quantity of the various group of stakeholders and actors that worked together in the planning, implementation and renovation project.

The literature review was essential for the performance issues identification. With the determination of the performance issues, we tried to answer, « What are the sustainable performance issues of a renovation process of a university building? » After analyzing the literature review results and the discussion with the actors results about the B4U we concluded that it is required 31 performance issues to characterize a renovation process of a university building.

Even if the sources investigate (e.g., literature review and existing methods) are reliable and can offer interesting results, we still believe that a structuration of the performance issues with a proper approach has a positive impact on this study. Because of this, we built a framework for structuring

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analysis of the C4U's performance issues. The 17 SDG's of the United Nations were used to judge our performance issues. We concluded that all the 31 performance issues identified in our model are integrated within the '17 SDG's, justifying and validating our choices.

Finally, we performed the Step 3 of the INTEGRAAL framework to identify and mobilize indicators. From an exhaustive list of building, university and urban innovations indicators we determined - with the assistance of the ePLANETe platform and its Representation Rack, KIK and Gallery of Tools – 95 'indicators candidate' for our C4U tool.

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THIRD PART

HOW CAN A NEW TOOL CONTRIBUTE TO THE DECISION MAKING OF A UNIVERSITY BUILDING RENOVATION PROCESS?

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Chapter V. Practical experience and validation of C4U tool

1 INTRODUCTION

After finishing to structure the system of the C4U tool in the previous chapter, we will proceed with the evaluation of the '*Aile Sud'* building using the indicators selected in Step 3.

In Step 4 of the INTEGRAAL framework, we will evaluate the case study giving values to the qualitative and the quantitative indicators in an expert system, but also in a deliberation section with the actors.

Then, results will be analyzed by categories (i.e., People, Planet, Profit, Process, and Propagation) and by sub-goals what will assist us in the identification of drivers and barriers of the renovation project of the *'Aile Sud'* building. Finally, we will determine the main outcomes of the assessment regarding our case study and the C4U tool.

2 STEP 4: EVALUATING AND DELIBERATING

Goal: The goal of this step is to evaluate the alternatives in a multi-criteria participatory approach. In the context of our study, this step is consisted by two stages: an evaluation section and a deliberation section. This step corresponds to the fourth step of the INTEGRAAL framework as is presented in Figure 69.

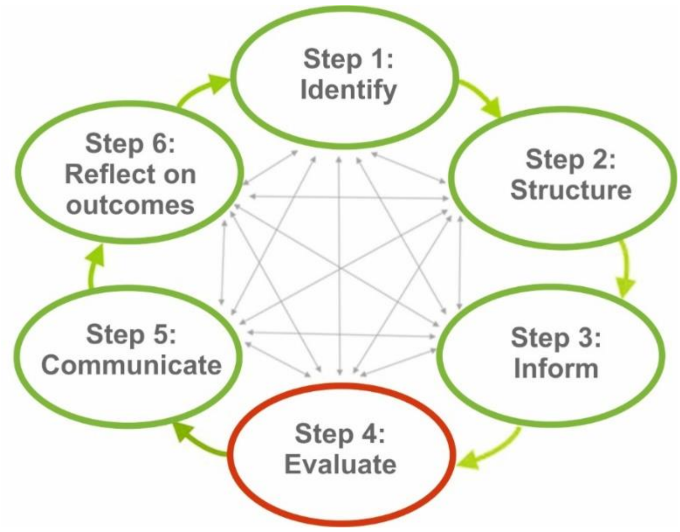

Figure 69. Step 4 of the INTEGRAAL framework

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2.1 Evaluation section

For this Step 4 of the INTEGRAAL framework, we worked building a K4U in the Deliberation Support Tools Gallery (v5) inside the CAMELOT Doorway in the ePLANETe platform (Annex 8).

Performing a K4U means to build an assessment for a case study, which in our situation is the '*Aile Sud'* building. We provided values for each 'indicator candidate' selected during the Step 3. A specific algorithm converts and aggregates each indicator value (from 1 to 10) to draw a final spider diagram.

This first analysis was performed inside an expert system. In other words, it means, that we gave our value's proposition taking as knowledge base the dialogues that we had with the actors (i.e., with the project leader, the UVSQ's responsible for projects maintenance and development, user's and REEDS representative). In this sense, it is possible to say that we represented their view and interests. These dialogues were conducted especially during the assessment of the worksite with the B4U method.

The outcome of the previous steps of the INTEGRAAL approach was a concern about the sustainable renovation strategy of university buildings represented by 31 performance issues and 96 indicators.

We determined an evaluation system composed of quantitative and qualitative indicators. All the general information for the C4U's indicators can be found in the KIK Sustainable Community. For the quantitative indicators, we proposed to measure the indicator according to the unit proposed, however, situating the value between a Likert scale, starting from 1 to 5, according to its performance. Therefore, a normalization is needed to transfer this values in a common scale to all the candidate indicators. Every indicator is provided by normalization guidelines when it is necessary.

We present here as an example of the indicator Access to quality transit, which is part of the 'Land design for sustainable urban development' performance issue, inside the 'People' category. Access to quality transit is a quantitative indicator that wants to assess «how far is the building, in a walking distance, from a bus or metro stop?» A possible answer to this question will be in 430 meters, which according to our assessment guidelines for this indicator will corresponds to the value 4, which in our normalization norm will corresponds to the value 7 (see Table 25).

Likert scale, from 1 to 5, was adopted for the qualitative indicators. According to McLeod (2008), the Likert Scale is a five (or seven) point scale that is used to allow individuals to express how much they agree or disagree with an affirmation. We will take as an example the indicator 'Connection to the existing cultural heritage' which is a qualitative indicator that aims to assess link to the distinctive physical and cultural values of the existing land and community in the project design. In this sense, actors should answer « To what extent the design of the project made a connection to the existing cultural heritage?

Table 25. Guidelines of the indicator 'Access to quality transit'

QUANTITATIVE INDICATOR: ACCESS TO QUALITY TRANSIT	
DESCRIPTION	This indicator wants to encourage the reduction of vehicle use and promotion of other public transport systems as bus and metro. The goal is to reduce greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.
NATURE	Quantitative
SOURCE	USGBC (2014)
UNITY	Meters (m)
NORMALISATION	1 to 10 according to the Linkert scale (1 → 0; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
GUIDELINES	The indicator 'Access to quality transit' provides a quantitative measure and is rated on a five-point Linkert scale: How much far is the building, in a walking distance, from a bus or metro stop? Guidelines for 'Access to quality transit': 1 → More than 1200m of walking distance of existing bus or metro stops 2 → Between 1000m and 1200m of walking distance of existing bus or metro stops 3 → Between 800m and 1000m of walking distance of existing bus or metro stops 4 → Between 400m and 800m of walking distance of existing bus or metro stops 5 → Less than 400m of walking distance of existing bus or metro stops

As it is presented in Table 26, five distinct answers are possible on the Likert scale, «Not at all», «Little», «Average», «Much», and «Very much»; depending on the strength/intensity of experience that is always linear in a Likert scale. If we agree that the design of the project is much connected to the existing cultural heritage, a value 4 will be given to this indicator. However, according to the normalization norm of all qualitative indicators, 4 is equal to a 7, so the real final value of our indicator is 7.

All the guidelines are available in the KIK Gallery. However, we created a 'C4U Tutorial Guide' where all the information about all the indicators can be found (see Annex 11). Table 27 presents the values that we gave to all the indicators candidate in the expert system. Once we gave values to all the indicators, we inserted in the section 'Build your assessment' in the K4U tool, in the ePLANETe platform to show all the K4U results but also to furnish a spider diagram of the results of the renovation strategies performance assessment of the '*Aile Sud'* building.

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Table 26. Guidelines of the indicator 'Connection to the existing cultural heritage'

QUALITATIVE INDICATOR CONNECTION TO THE EXISTING CULTURAL HERITAGE	
DESCRIPTION	This indicator is defined as "*the extent to which the design of the project reflects the distinctive physical and cultural values of the existing land and community*" (Bosch et al., 2013). When designing a project, the architects should consider that heritage places are an important link between the past and the future generations. Keeping the location's unique identity could bring economic as well as other benefits to the area.
NATURE	Qualitative
SOURCE	Bosch et al. (2013)
UNITY	Linkert scale
NORMALISATION	1 to 10 according to the Likert scale (1 → 0; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
GUIDELINES	The indicator 'Connection to the existing cultural heritage' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the design of the project made a connection to the existing cultural heritage? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Connection to the existing cultural heritage' 1. Not at all: No attention has been paid to existing cultural heritage 2. Little: Heritage places have received some attention in the project, but not as an essential element. 3. Average: Somme attention has been given to the conservation of heritage places. 4. Much: Heritage places are reflected in the project design. 5. Very much: Heritage places are included in the project as clear and recognizable landmarks.

Figure 70 presents the spider diagram of the '*Aile Sud'* building assessment within the expert system. The figure shows the total score of 6.37 (from 10) to the category People, 4.68 to the category Planet, 7.25 to the category Profit, 5.38 to the category Process, and 5.85 to the category Propagation.

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Table 27. Values for all the indicators candidate

TOP-GOAL: PEOPLE				
PERFORMANCE ISSUES	**INDICATOR NAME**	**TYPE**	**VALUE**	**NORM. VALUE**
COMFORT	Thermal comfort	Qualitative	2	**3**
	Considering the potential site climate	Qualitative	3	**5**
	Ensuring a minimum thermal comfort level and windows protection from the sun	Qualitative	4	**7**
	Ensuring adequate ventilation	Qualitative	5	**10**
	Acoustic comfort inside the building	Qualitative	3	**5**
	Limiting noise pollution at the construction site	Qualitative	2	**3**
	Daylight access	Quantitative	9	**9**
	Controlling of the visual atmosphere by users	Qualitative	5	**10**
	Adequate minimum lighting	Qualitative	5	**10**
INDOOR ENVIRONMENTAL QUALITY	Low-emitting materials	Quantitative	3	**5**
	Bio-based use in the building materials	Quantitative	3	**5**
	Air quality management plan of the construction site	Qualitative	4	**7**
HEALTH AND SECURITY	Life expectancy of construction site workers	Quantitative	5	**10**
	Security of construction site workers	Qualitative	4	**7**
	Choosing building products to limit the health impacts	Qualitative	3	**5**
	Optimize cleanliness of the construction site	Qualitative	4	**7**
WORK CONDITIONS	Work satisfaction inside the construction site	Qualitative	3	**5**
ENSURING A LIVABLE AREA	Availability of public amenities	Qualitative	5	**10**
	Availability of commercial amenities	Qualitative	2	**3**
LAND DESIGN FOR SUSTAINABLE URBAN DEVELOPMENT	Access to quality transit	Quantitative	4	**7**
	Bicycle facilities	Qualitative	2	**3**
	Green vehicles	Qualitative	1	**1**
PROMOTION OF A FEELING OF COMMUNITY/ HOME	Connection to the existing cultural heritage	Qualitative	5	**10**
	Openness to the city	Qualitative	2	**3**
	Design for a sense of place	Qualitative	5	**10**
SOCIAL JUSTICE	Buildings accessible to people with disabilities	Qualitative	4	**7**
	Social equity with the supply chain	Qualitative	3	**5**

TOP-GOAL: PLANET				
PERFORMANCE ISSUES	INDICATOR NAME	TYPE	VALUE	NORM. VALUE
ENERGY	Annual primary energy consumption of buildings	Quantitative	1	**1**
	Annual final energy consumption of buildings	Quantitative	6	**6**
	Renewable energy production	Quantitative	1	**1**
	Reducing construction site energy consumption	Qualitative	3	**5**
	Optimizing energy performance	Qualitative	5	**10**
BIODIVERSITY	Preserving biodiversity during construction site	Qualitative	2	**3**
	Construction site assessment	Qualitative	2	**3**
SOIL	Vegetation of surfaces /soil impermeabilization	Quantitative	5	**10**
	Water and soil pollution prevention from the construction site	Qualitative	3	**5**
WATER	Limiting the water use for gardening and cleaning	Quantitative	1	**1**
	Limiting water needs in toilets	Quantitative	4	**7**
	Potable water use reduction inside the construction site	Qualitative	2	**3**
POLLUTANTS EMISSIONS INTO THE ATMOSPHERE	Air pollution emissions in the construction site	Qualitative	2	**3**
	Carbon dioxide emissions	Quantitative	4	**7**
CLIMATE SYSTEM	Climate resilient design neighborhood	Qualitative	3	**5**
	Climate resilient design building	Qualitative	5	**10**
WASTE	Identify and quantify the construction waste by typologies	Qualitative	3	**5**
	Reducing construction waste at the source	Qualitative	2	**3**
	Reduction of materials used	Quantitative	2	**2**
	Optimize the treatment and reduction of W.E.E.E. (Waste Electrical and Electronic Equipment)	Qualitative	2	**3**
MATERIALS AND RESOURCES	Share of renewable materials	Quantitative	5	**5**
	Share of materials recyclable	Quantitative	9	**9**

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TOP-GOAL: PROFIT				
PERFORMANCE ISSUES	**INDICATOR NAME**	**TYPE**	**VALUE**	**NORM. VALUE**
CREATING LOCAL VALUE	Use of local workforce in the construction site	Quantitative	6	**6**
	Use of local suppliers of products and materials	Quantitative	8	**8**
CREATING VALUE FOR THE SECTOR	Total cost saving for the end users	Quantitative	10	**10**
TIME OPTIMIZATION	Productivity in the construction site	Qualitative	3	**5**
	Construction management strategies	Qualitative	3	**5**
COSTS	Payback period of the building	Quantitative	4	**4**
	CO2 emissions reduction cost efficiency	Quantitative	7	**7**
ADAPTABILITY AND FLEXIBILITY	Adapting the construction choices to the building lifetime	Qualitative	5	**10**
	Adapting interior building spaces to digital innovation	Qualitative	5	**10**
	Incorporating the principle of flexibility in the design of interior spaces	Qualitative	4	**7**
CONSTRUCTIVE CHOICE FOR THE ACCESSIBILITY DURING MAINTENANCE WORKS	Ensuring accessibility for building maintenance	Qualitative	5	**10**
	Products, systems and construction processes	Qualitative	3	**5**
TOP-GOAL: PROCESS				
PERFORMANCE ISSUES	**INDICATOR NAME**	**TYPE**	**VALUE**	**NORM. VALUE**
GOVERNANCE MODEL	Leadership 'bridging'	Qualitative	4	**7**
	Leadership 'lobbying'	Qualitative	3	**5**
	Leadership 'persistency'	Qualitative	4	**7**
	Involvement of public stakeholders	Qualitative	4	**7**
	Involvement of professional stakeholders	Qualitative	2	**3**
STRATEGY	Define a sustainable strategy	Qualitative	3	**5**
MATURITY OF THE PROCESS	Prior experience with the solution	Qualitative	3	**5**
	Degree of testing	Qualitative	1	**1**
	User training	Qualitative	3	**5**
	Continued monitoring/reporting	Qualitative	4	**7**

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SUSTAINABLE SITES	Sustainable sites management implementation	Qualitative	3	**5**
	Training of the workforce	Qualitative	2	**3**
WATER AND ENERGY MANAGEMENT	Water metering	Qualitative	2	**3**
	Building-level energy metering	Qualitative	5	**10**
INTERIOR AIR QUALITY AND TEMPERATURE CONTROL	Controlling of the winter interior temperature	Qualitative	2	**3**
	Management device to ensure effective ventilation	Qualitative	3	**5**
SUSTAINABLE TEACHING AND RESEARCH	Campus as a living laboratory	Qualitative	5	**10**
PUBLIC ENGAGEMENT	Local community involvement	Qualitative	3	**5**
CAMPUS ENGAGEMENT	Student's life	Quantitative	4	**7**
	Sustainable management system	Qualitative	3	**5**
	Raise awareness	Qualitative	3	**5**
TOP-GOAL: PROPAGATION				
PERFORMANCE ISSUES	**INDICATOR NAME**	**TYPE**	**VALUE**	**NORM. VALUE**
COMPLEXITY	Complexity for end-users	Qualitative	3	**5**
	Complexity for professional stakeholders	Qualitative	3	**5**
RELATIVE ADVANTAGE	Advantage for end-users	Qualitative	4	**7**
	Advantage for stakeholders	Qualitative	4	**7**
DISSEMINATION	Act alongside regional and international networks of actors	Qualitative	5	**10**
STANDARDS EVOLUTION	Change in public procurement	Qualitative	2	**3**
	Changing rules & regulations	Qualitative	1	**1**
MIMETIC PROCESSES	Diffusion to other locations	Qualitative	5	**10**
	Diffusion to other actors	Qualitative	3	**5**
ABILITY TO BRING ABOUT CHANGE	Diffusion of sustainable construction site	Qualitative	3	**5**
INNOVATION CHARACTERISTICS	Trialability	Qualitative	3	**5**
	Current market demand for the solution	Qualitative	5	**10**
	Technical compatibility of Innovation	Qualitative	2	**3**

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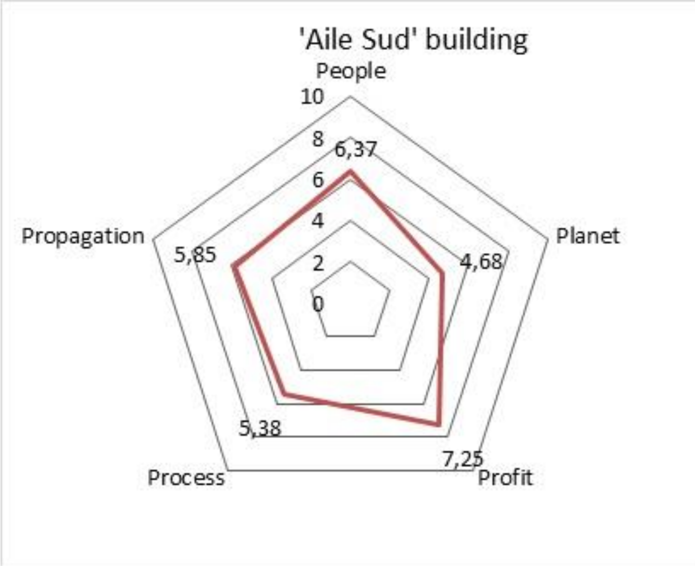

Figure 70. Spider diagram of the 'Aile-Sud' building within an expert system

2.2 Deliberation section

After proposing an assessment of the performance strategy of the *'Aile Sud'* building inside an expert system, we invited the project leader and the director of property assets of the UVSQ for a deliberation section. The section took place on 24 February 2017, it lasted two hours, and it was held in the Alembert building at the UVSQ inside the Guyancourt site.

The main primary of this deliberation section was to present the performance strategy of the renovation of the *'Aile Sud'* building assessment inside the expert system to validate the C4U tool but also to discuss and deliberate about the evaluation. The purpose is to answer if the C4U tool is understandable in the opinion of the actors invited to the section. Furthermore, we wanted to know their judgment about the performance strategy of the renovation of *'Aile Sud'* building assessment.

2.2.1 Actors selection for the deliberation section

We selected for this section the actor that occupied the position of project leader, and the actor that held the position of the property assets director of the UVSQ during the implementation of the UVSQ in the BN.

As already specified before, the project leader was the person responsible for coordinating the project and integrating the UVSQ interests with the local authorities. The director of property assets of the UVSQ was the responsible for assisting the construction companies, for the conclusion of the contracts

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with the contractors, and direction of the execution works inside the building site. Both works played a crucial role in the successful development of the implementation project of the UVSQ inside the BN site.

2.2.2 Deliberation aspects of this section

This section involved the fours aspects of the deliberation presented by Dryzek and List (2003). In a first moment, we introduced the performance issues and indicators selected to assess the work site. After that, we provided the values given by each indicator in the context of the renovation of *'Aile Sud'* building assessment, and we presented the results of the expert system (Informational aspect).

After informing the actors, we demand about their judgments according to a selection of 31 indicators. The criteria for the selection of indicators for the meeting was: just qualitative indicators and indicators that are drivers of the dialogue between the actors. The objective was to mobilize the actors but also their knowledge. In this sense, the actors gave values to the indicators selected according to their judgments and arguments (Argumentative aspect).

Actors provided their judgments from their reflections about their preferences (Reflective aspect). Each actor had the opportunity to express his judgments for each indicator. In many moments, the actors agreed with their judgments, and sometimes they disagreed and provided their reflections creating a structure of knowledge discovery and social interaction (Social aspect).

After reflecting and discussing the question of each qualitative indicator selected, the actors needed to decide about the answer to be given. The possible answers, or values for each indicator, varied from 1 to 5. In some moments, the answers corresponded to a "Not at all" until "Very much", to a "Not taken into consideration" until "Very much considered" or to a "Not at all satisfactory" until "Very satisfactory".

2.2.3 Discussions of the values given to the indicators

Table 28 presents the 31 indicators analyzed and the values for each indicator for the expert analysis and the deliberation section with the actors. We highlighted in green all the indicators that had the same value for the expert system analysis and in the participants' deliberation section; and in blue, all the indicator that received distinct values due to distinguished judgments.

Table 28. List of the indicators discussed by the project manager and leader

TOP-GOALS	SUB-GOALS	INDICATORS	VALUE EXPERT	VALUE ACTORS
PEOPLE	Comfort	Considering the potential site climate	3	3
		Limiting noise pollution at the construction site	2	4
	Indoor environmental quality	Air quality management plan of the construction site	4	5
	Health and security	Security of construction site workers	4	5
	Work conditions	Work satisfaction inside the construction site	3	4
	Promotion of a feeling of community	Openness to the city	2	4
	Social justice	Social equity with the supply chain	3	3
PLANET	Biodiversity	Preserving biodiversity during construction site	2	2
		Construction site assessment	2	4
	Soil	Water and soil pollution prevention from the construction site	3	3
	Water	Potable water use reduction inside the construction site	2	2
	Pollutants emissions into the atmosphere	Air pollution emissions in the construction site	2	3
	Climate systems	Climate resilient design neighborhood	3	3
		Climate resilient design building	5	3
	Waste	Reducing construction waste at the source	2	3
PROFIT	Time optimization	Productivity in the construction site	3	3
		Construction management strategies	3	3
	Adaptability and flexibility	Adapting the construction choices to the building lifetime	5	3
		Adapting interior building spaces to digital innovation	5	5
		Incorporating the principle of flexibility in the design of interior spaces	4	4
PROCESS	Governance model	Leadership 'bridging'	4	3
		Leadership 'lobbying'	3	5

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		Leadership 'persistency'	**4**	**5**
	Strategy	Define a sustainable strategy	**3**	**3**
	Maturity of the process	User training	**3**	**3**
		Continued monitoring/reporting	**4**	**3**
	Sustainable sites	Sustainable sites management implementation	**3**	**2**
		Training of the workforce	**2**	**1**
	Public engagement	Local community involvement	**3**	**4**
	Campus engagement	Sustainable management system	**3**	**3**
		Raise awareness	**3**	**3**
PROPAGATION	Ability to bring about change	Diffusion of sustainable construction site	**3**	**2**
	Innovation characteristics	Trialability	**3**	**3**

Some indicators required more discussion to arrive in a consensus decision-making, and some indicators received arguments. In the category 'People,' inside the sub-goal 'Promotion of a feeling of community,' the indicator 'Openness to the city' received a value of 4 in the deliberation section and a value of 2 in the expert system analysis. They explained about the integration between the UVSQ and the BN.

> *"We did know that the integration between the UVSQ/BN site and the city was necessary. Otherwise, it would be hard for students to access the site. We asked for the Rambouillet's major to create a special bus line to connect the Rambouillet train station to the Bergerie Nationale site"* (Project leader and the Director of property assets statements).

In the category 'Profit,' in the sub-goal 'Adaptability and flexibility,' the indicator 'Adapting the construction choices to the building lifetime' received a value of 5 in the expert evaluation. However, the actors agreed to give a score of 3 from 1 to 5. They mentioned that *"even if the construction material used in the improvement of building walls isolation was modern, the material did not have an excellent durability."*

The indicator 'Adapting building interior spaces to digital innovation' received a value of 5 in the expert evaluation. The actors agreed with the value 5, and the project leader made some comments:

> *"The adaptation to suit to digital innovation was an important issue for the design of interior spaces. Furthermore, the university provided a broadband network access for the Aile Sud*

building with the extension to the Royal network[174] *until the BN. The connection of the BN to the Royal grid was indispensable for the installation of IACA group in the 'Aile Sud' building. At this moment, we had to deal with the difficult to coordinate the different actors of this network extension"* (Project leader and the Director of property assets statements).

Still in the sub-goal 'Adaptability and flexibility,' the expert evaluation resulted giving a 4 for the indicator 'Incorporating the principle of flexibility in the design of interior spaces'. The participants agreed to give the same value and mentioned that:

> *"Many discussions during the design concept of the renovation activities of the 'Aile Sud' building took place to find the best use of interior spaces. However, some decisions were taken by the head of the architectural project and were not informed by the project leader, bringing disagreement, and because of this, we prefer to give a 4 and not a 5 as a score"* (Project leader and the Director of property assets statements).

In the category 'Process,' in the sub-goal 'Governance model', the indicator 'Leadership bridging' received a value of 4 in the expert evaluation. In a first moment, the project leader affirmed that he would prefer to give a score 4 for this indicator, but after some discussion, the participants agreed to give a rating of 3 from 1 to 5.

> *"For the development of the project, I could give a 4, however for the implementation of the project I would give a 3 because of the significant failures regarding the project decision making. In the context of the project team, I was excluded from the process of the project decision making in some moments, and as the project leader, I supposed to be part of this kind of process every time. Another problem in the project decision making was due to the lack of the local authority's connection in the critical decisions*" (Project leader statement).

Still in the sub-goal 'Governance model,' the actors agreed to give a 5 as a value for the indicator 'Leadership lobbing'. The project leader succeeds in creating the right connections to government officials and creates extensive governmental support for the project. "*We succeed to obtain the agreements of the Yvelines Department for all the project needs."*

[174] The Royal grid is a broadband network for teaching and research in the Yvelines Department. Currently, it interconnects 16 sites, especially the five founding institutions (UVSQ, INRIA, INRA, Rectorate of the Academy of Versailles, the IUFM of the Versailles Academy) (UVSQ, 2008).

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In the sub-goal 'Maturity of the process' the indicator 'User training' received a value of 3 in the expert system evaluation. The actors give also a value 3. They justify the score affirming that:

> *"Our intentions in the project implementation deserve a score 5, however, any building's occupants received training because there was no training available at that moment. This happened because of the Head of the architectural project, that judged this was not relevant to the project. Despite the lack of interested of the Head of the architectural project, we succeed to have at least a security training for the building users"* (Project leader and director of property assets statements).

For the indicator 'Continued monitoring/reporting,' they choose to give a score 3 from 1 to 5 because *"even if there was continued supervision in the project development to verify if the project was following the ambitions, rules, and regulations, there was not any report of this".*

In the sub-goal 'Campus engagement' the indicator 'Sustainable management system' received a value of 3 in the expert evaluation. The actors confirmed the value 3 from 1 to 5. *"We would like to give a 5 because of the leadership features however due to the lack of actions control we will give a score 3 for this indicator"*.

The final evaluation resulted in a score of 6.89 for the category 'People'; a score of 4.82, for the category 'Planet'; 6.50, to the category 'Profit'; 5.48 for the category 'Process'; and 5.69 for the category 'Propagation.'

Figure 71 presents the results of the participants' deliberation assessment regarding each category, or Top-goal. In blue, it is possible to find the diagram of the deliberation results between the actors. In red, it is represented the primary results of the expert system analysis. The graphic shows some contrast of opinions expressed by the expert system and the actors' assessment.

The participation of the actors in the evaluation was crucial to provide some legitimacy to the evaluation of the case study. Regarding the practical validation of our C4U tool, we can affirm that both actors did not have difficulty when judging the measure of the indicators performances, proving that, in a general way we can affirm that the C4U is an intuitive tool and easy to understand.

However, we identified a phenomenon for few indicators which have been shown to be ambiguous. In this case, when an ambiguous indicator confronted the actors they found themselves in an empirical situation where they had difficulty to choose just one answer.

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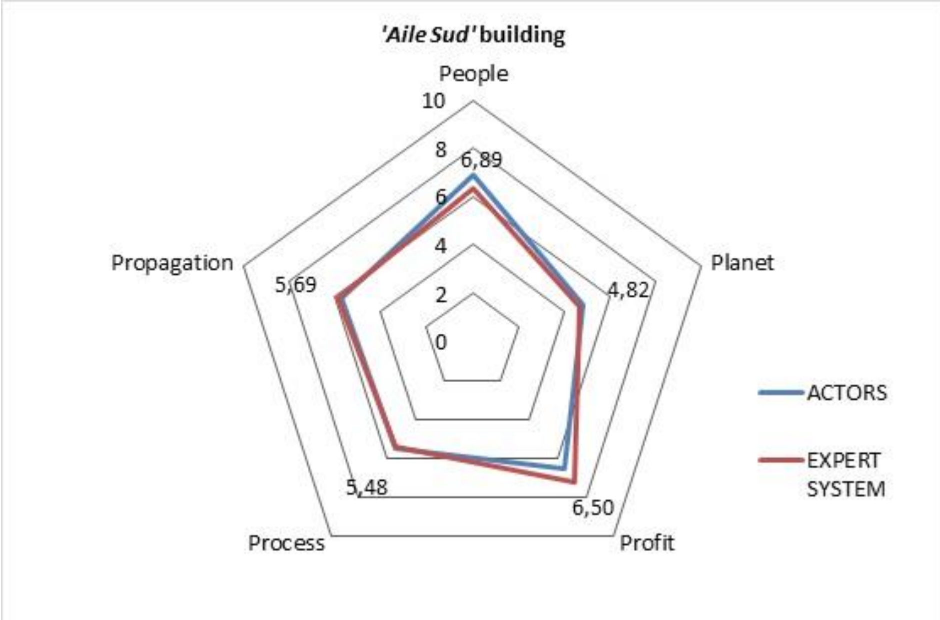

Figure 71. Spider diagram of the 'Aile Sud' building assessment

3 STEP 5: ANALYZING AND TO COMMUNICATING

Goal: The goal of this step is to analyze the results of the deliberation and communicate this results to the actors. We started to analyze this results in Step 4 with the spider diagram. Notwithstanding, in Step 5, we will analyze the results of each category (i.e., People, Planet, Profit, Process, and Propagation) and of each performance issue that corresponds to the strategy performance assessment of the '*Aile Sud'* building renovation.

The analysis of each C4U's performance issue allows us to perform an interpretation of the results to understand what can be learned from the C4U's evaluation results. This step corresponds to the fifth step of the INTEGRAAL framework as is presented in Figure 72.

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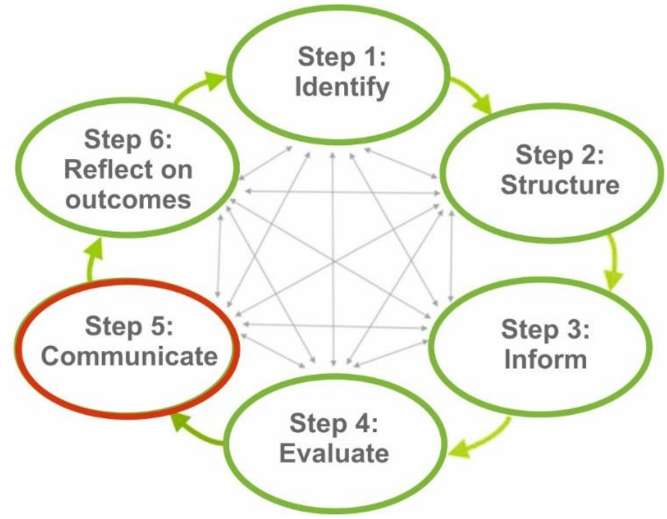

Figure 72. Step 5 of the INTEGRAAL framework

3.1 Performance issues analysis of the category 'People'

As already presented in section 2.2, the category People received a final score of 6.89 within the deliberation section with the actors. The performance issues 'Promotion of a feeling of community/home', 'Work conditions,' 'Health and Security,' and 'Comfort' had a final score above the average. 'Social justice,' 'Land design for sustainable urban development,' 'Ensuring a livable area,' and 'Indoor Environmental quality' had final scores below the average (Figure 73).

'Promotion of a feeling of community/home,' received the higher score for the category 'People'. The higher score can be explained by the design of the *'Aile Sud'* building renovation project, that very much considered the existing cultural heritage. The renovation project retained the building historical façade in the act of the place's history recognition. The design project of the *'Aile Sud'* building succeeds in creating a 'sense of place' in which safety, interior design project, and visual identity contribute to it.

Furthermore, much attention has been paid to open the university campus to the city. 'Land design for sustainable urban development' received the lowest score for the category 'People'. Despite of the accessibility to the public transport system (e.g., bus from the Rambouillet's train station and the train from Paris), little infrastructure was provided to bicycles (i.e., storage and shower rooms), and any green vehicles facilities was detected (i.e., preference in the parking space and installation of electrical vehicle supply equipment).

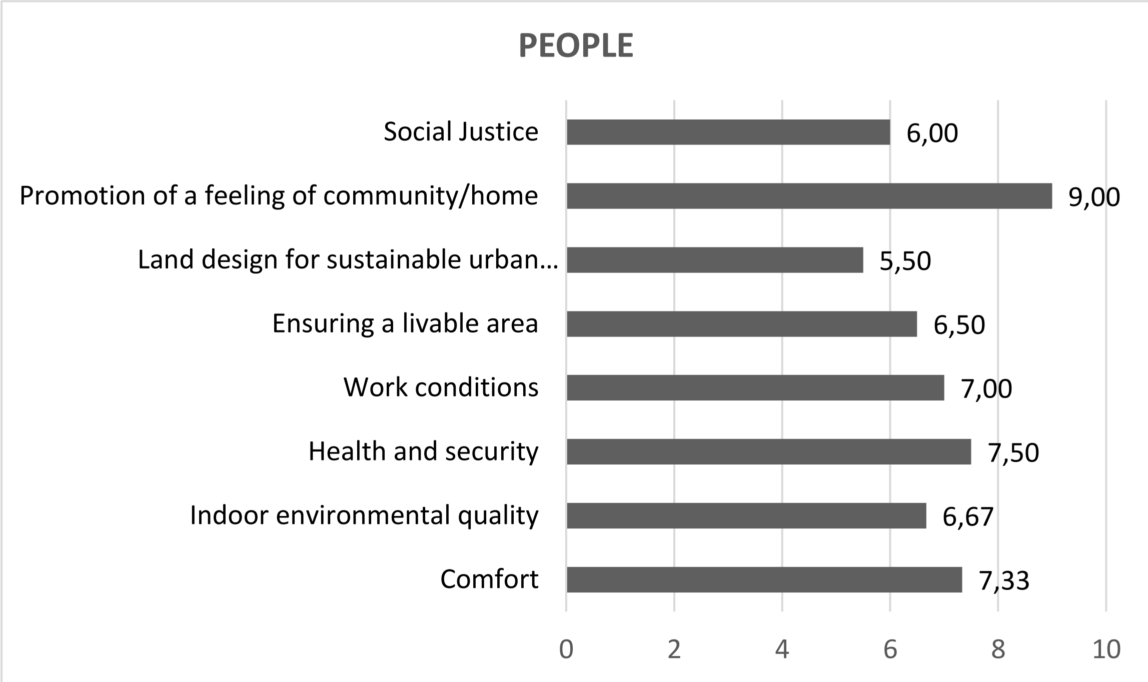

Figure 73. Results of the performance issues analysis of the category 'People'

3.2 Performance issues analysis of the category 'Planet'

According to the section 2.2, the category 'Planet' received a final score of 4.82 within the deliberation section with the actors. Figure 74 shows that the performance issues, or sub-goals, 'Materials and Resources', 'Pollutants emissions into the atmosphere', 'Soil', and 'Biodiversity' had a final score above the average, however 'Waste', 'Water' and 'Energy' had final scores below the average.

The sub-goal 'Soil' succeed in achieving the higher score for the category 'Planet', due to the concerns on limiting soil sealing in the *'Aile Sud'* building renovation project when designing parking lots and outdoor recreation areas, and to the prevention of water and soil pollution during the construction site activities.

The sub-goal 'Water' was the performance issue with the lowest score. Despite of the efforts in reducing the water needs in toilets of the *'Aile Sud'* building, almost any measure was put in place to reduce water for gardening and cleaning, and inside the construction site.

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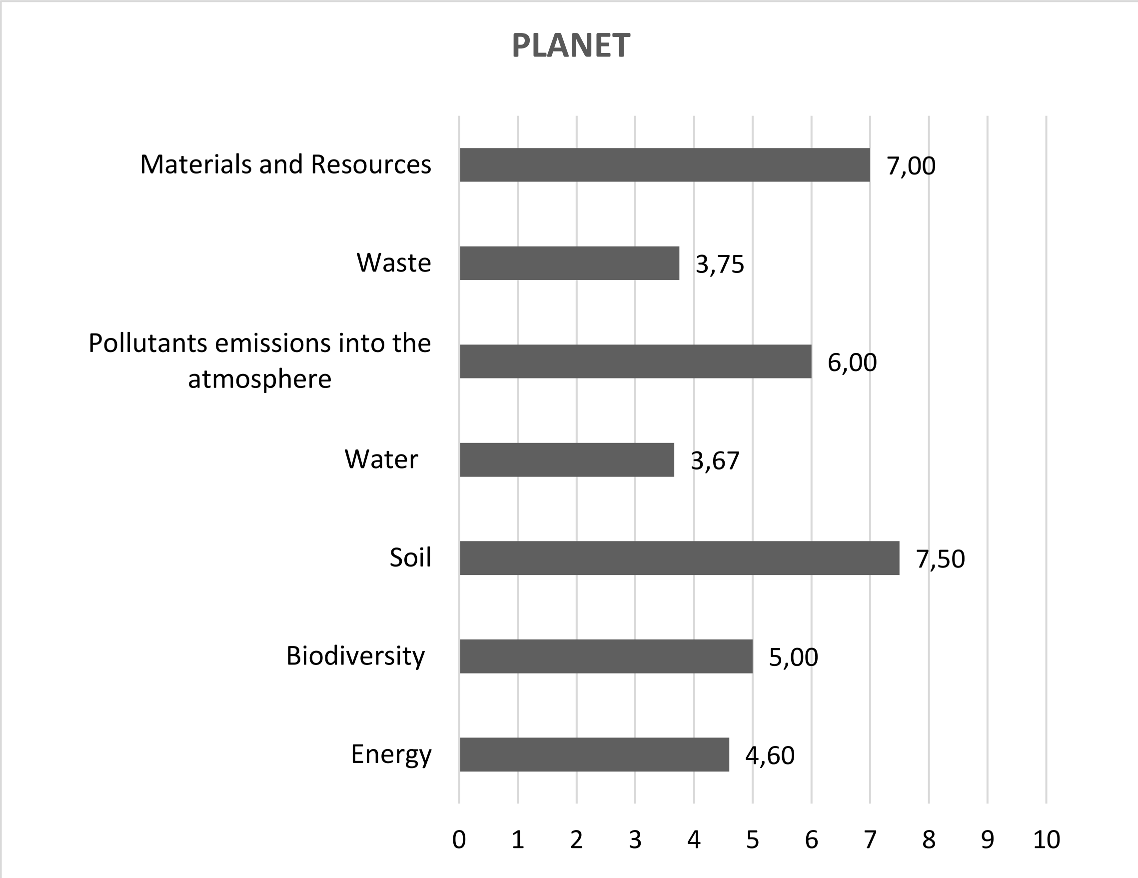

Figure 74. Results of the performance issues analysis of the category 'Planet'

3.3 Performance issues analysis of the category 'Profit'

The section 2.2 presented a final score of 6.5 within the deliberation section with the actors for the category 'Profit'. Figure 75 presents the 'Constructive choice for the accessibility during maintenance works', 'Adaptability and flexibility', and 'Creating value for the sector' as performance issues that had a final score above the average, however the performance issues 'Costs', 'Time optimization', and 'Creating local value' had final scores below the average.

The sub-goal 'Creating value for the sector' achieve the higher score in the 'Profit' category due to the significant reduction of annual costs savings because of the energy and water reduction. In the case of the *'Aile Sud'* building, energy reduction was the main reasons for the annual costs savings.

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‘Creating local value’ and ‘Time optimization’ were the lowest scores in the ‘Profit’ category. This can be explained due to the low rate of local employment during the project's execution, despite the significant use of local products and materials suppliers during the construction site activities. Moreover, regarding the productivity, the construction site had a normal performance and delay to accomplish the construction activities was on average, as a reflect of a normal construction management plan.

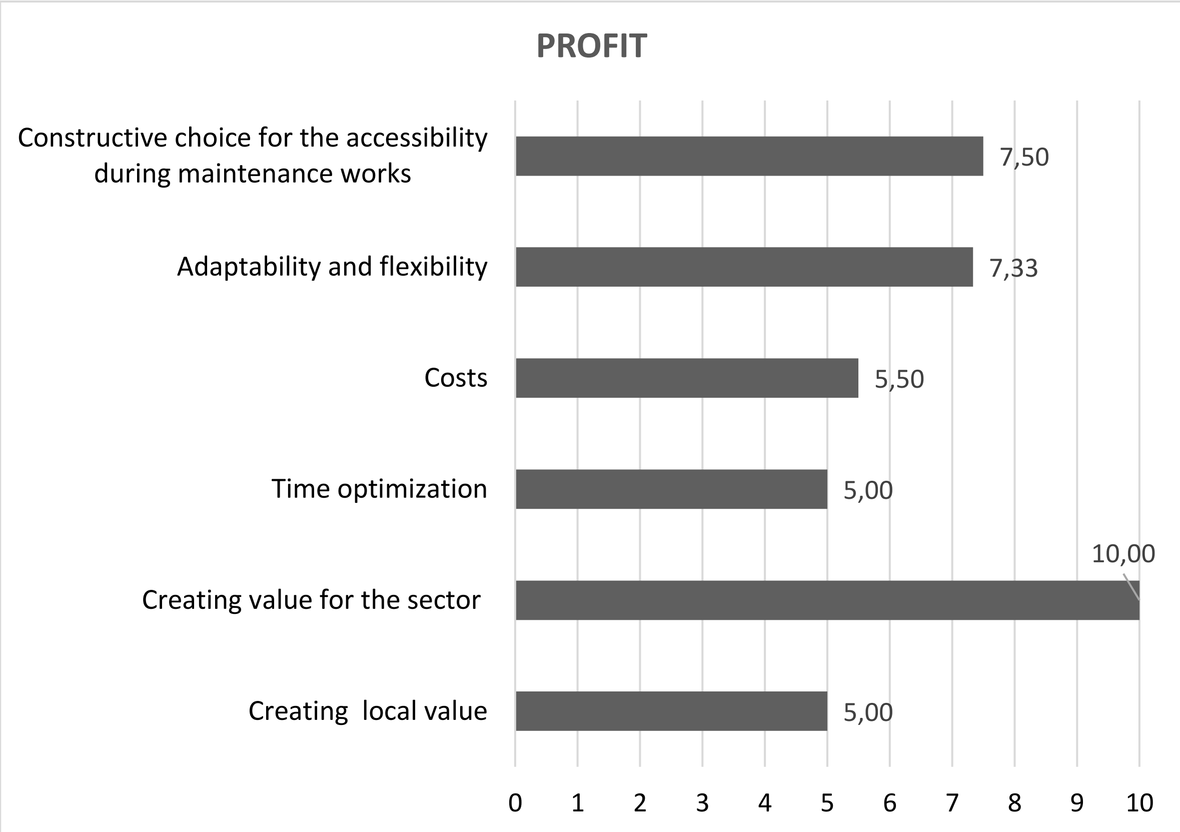

Figure 75. Results of the performance issues analysis of the category ‘Profit’

3.4 Performance issues analysis of the category ‘Process’

The section 2.2 presented a final score of 5.48 within the deliberation section with the actors for the category ‘Process’. As is presented in Figure 76, the ‘Campus engagement’, ‘Sustainable teaching and research’, ‘Water and energy management’, and ‘Governance model’ received a final score above the average. ‘Public engagement’, ‘Interior air quality and temperature control’, Sustainable sites’, ‘Maturity of process’, and ‘Strategy’ had a final score below the average.

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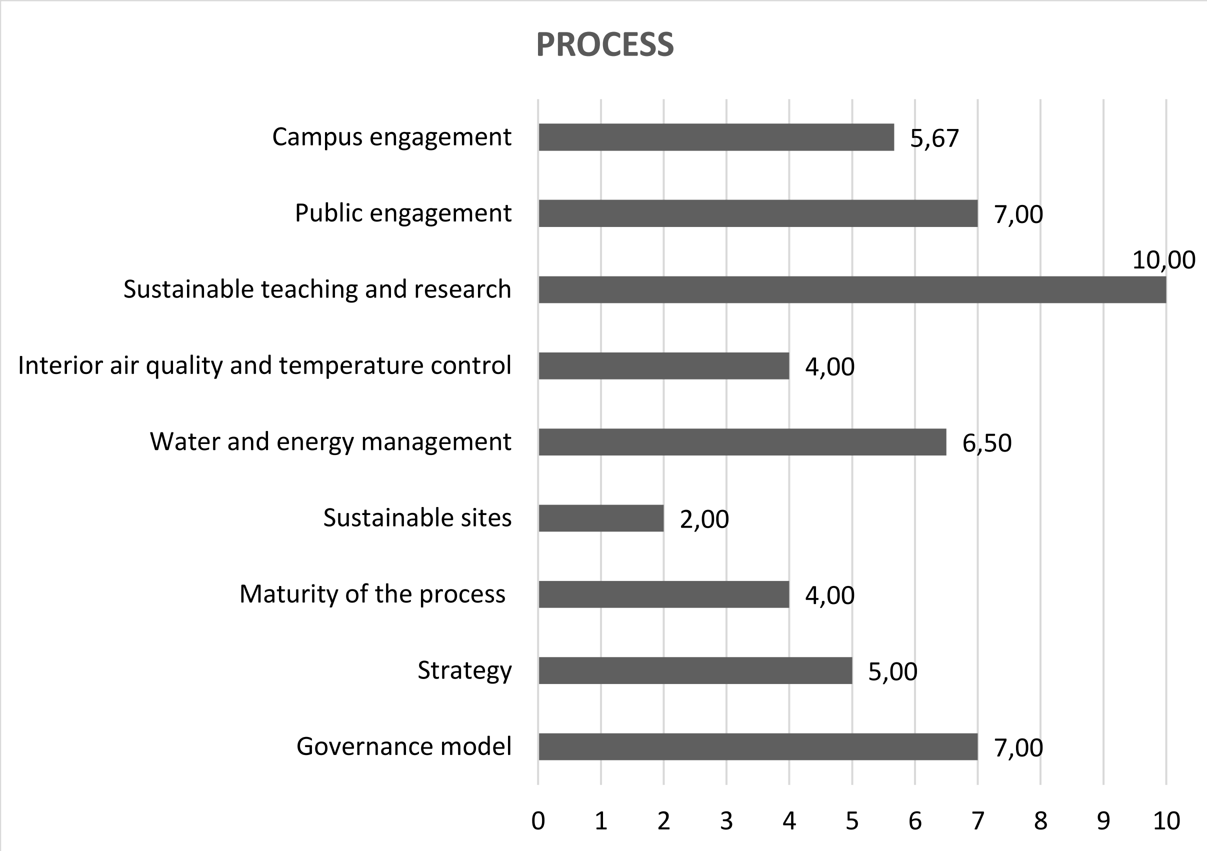

Figure 76. Results of the performance issues analysis of the category 'Process'

The results revealed that the 'Sustainable teaching and research' had a higher score of the 'Process' category because of the remarkable ability of the Center REEDS in promoting multidisciplinary student learning and applied research in relation to sustainability. The 'Sustainable sites' has the lowest score of the Process' category. The score can be a consequence of a low effective sustainable site management plan and a lack of training of the workforce.

3.5 Performance issues analysis of the category 'Propagation'

As already mentioned in the section 2.2, the category 'Propagation' received a final score of 5.69 within the deliberation section with the actors. The performance issues 'Innovation characteristics', 'Mimetic processes', 'Dissemination', and 'Relative advantage' had final scores above the average, as shows Figure 77, specially the 'Dissemination' that had a final score of 10 because of the leadership features of the Center REEDS in implementing a SD and GSR charter of commitment and good practices.

The 'Ability to bring about change', 'Standards evolution', and 'Complexity' had a final score below the average. The 'Standards evolution' received the lowest score of the category. Even if the renovation

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project of the '*Aile Sud'* building used a new public procurement procedure, the project did not attract public and professional attention because of this. Besides that, the project has not, at any level, inspired changes in rules and regulations.

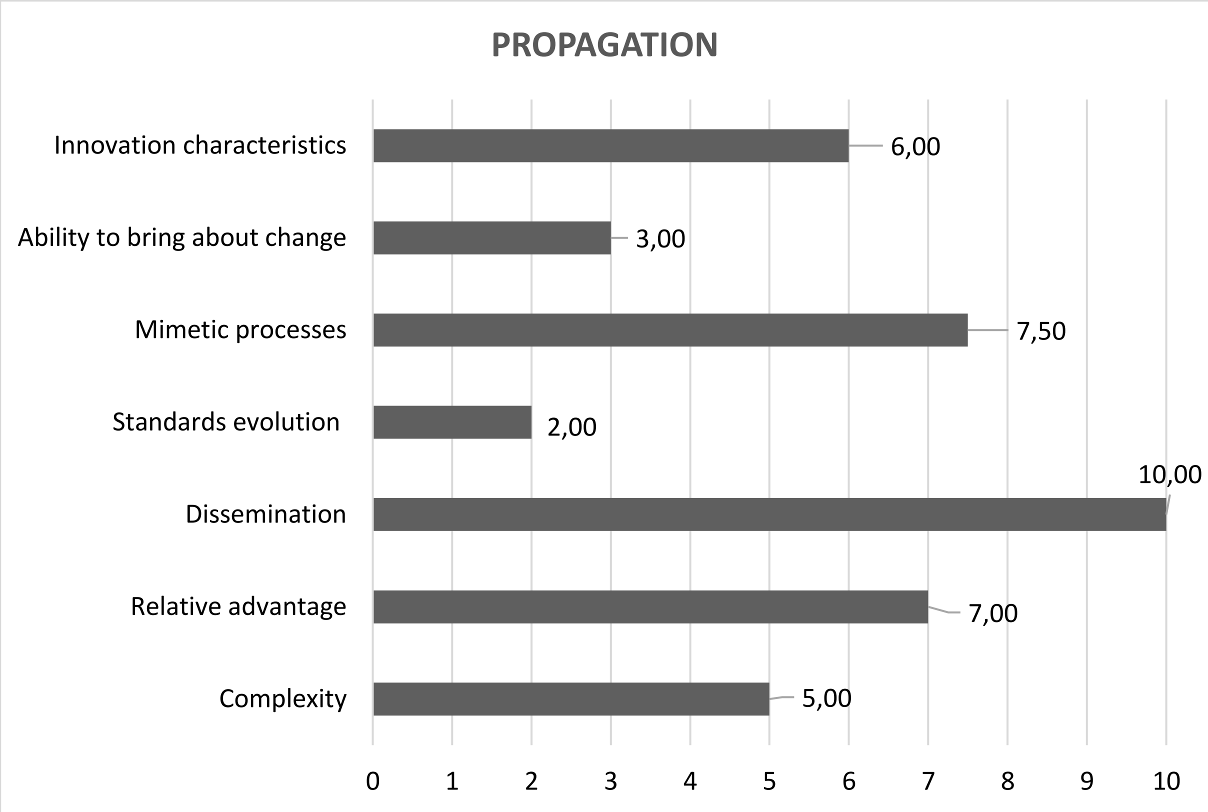

Figure 77. Results of the performance issues analysis of the category 'Process'

3.6 Communication to the actors

A document with the final spider diagram, and list of indicators and the performance issues was sent to the actors to communicate them about the results of the assessment of the renovation project strategies of the '*Aile Sud'* building.

4 STEP 6: REFLECTING ON OUTCOMES

<u>Goal:</u> The goal of this step of the INTEGRAAL approach is to think about the whole evaluation process. In a first moment, we will present a discussion about the '*Aile Sud'* building assessment, and then we will discuss the validation of the C4U tool. This step corresponds to the last step of the INTEGRAAL framework as is presented in Figure 78.

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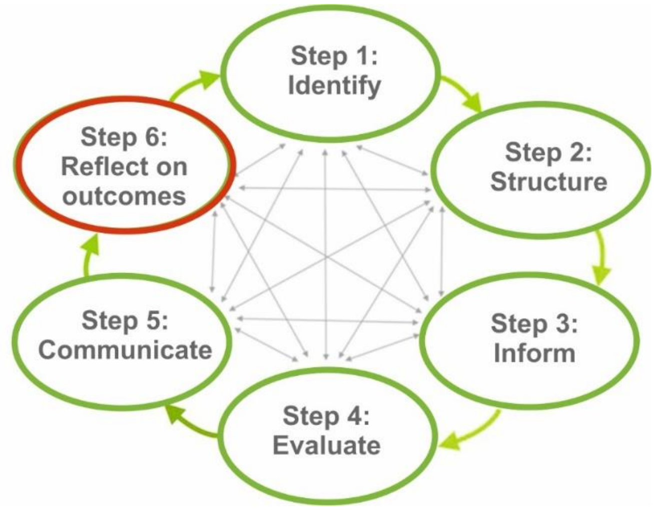

Figure 78. Step 6 of the INTEGRAAL framework

4.1 Discussion about the '*Aile Sud*' building assessment

The INTEGRAAL approach assisted us in the mobilization of indicators and performance tools of the '*Aile Sud*' building to create a tool that we denominated C4U that had as main goal provide an assessment of the renovation strategies performance of the '*Aile Sud*' building. The main objective was to answer if the '*Aile Sud*' building renovation process succeed. Taking into consideration the complexity of the sustainability, it is impossible to provide 'yes' or 'no' as an answer.

As we mentioned in Chapter 4, we analyzed the real situation, which is the '*Aile Sud*' building after the renovation, to measure where this building is inside its goals to achieve a sustainable performance building. We can say that the overall score for our worksite is the average between the total scores of the five categories what will give us a 5.88 score on a scale from 0 to 10, where 0 would be 'not sustainable at all' and 10 could be 'sustainable university building.'

The renovation strategies of the '*Aile Sud*' building and the implementation of the Center REEDS of the UVSQ in the BN, contribute to the achievement of the overall score 5.88, which is still far from the ideal situation. Beyond that, the assessment results showed that the renovation strategies succeed on achieving a score above the average for the performances issues in the category 'People' and 'Profit'. However, for the performance issues 'Planet', 'Process', and 'Propagation', the renovation strategies resulted in scores that are below the average.

All this outlook provides to us some valuable feedbacks that might contribute to the improvement of the '*Aile Sud*' building performance, but also could be a significant tool for actor's learning process. In the dynamic context of the INTEGRAAL framework, if improvement actions will be employed[175], the actors could return to the first step to evaluate again the new strategies many times they will judge necessary in a continuous improvement approach.

However, how does the *'Aile Sud'* building contribute to the sustainable development goals? For answering this question, we will get back to the section 3.11 in Chapter 4 where we crossed the five top-goals of the C4U with the 17 sustainable development goals (SDGs) of the United Nations (Table 21 and Table 22). We use this framework to analyze how its performance issue has been contributing to each SDGs indicated previously.

4.1.1 SDG 3 – Ensure healthy lives and promote well-being for all ages

The Goal 3 aims to ensure health and wellness for all, at every stage of life (UN-Habitat, 2016). In this sense, we can affirm that the principal contributions of the renovation strategies of *'Aile Sud'* building to the Goal 3 are:

- User's thermal comfort and well-being during the summer by windows protection from the sun and adequate and natural ventilation;
- All workspaces and classrooms have daylight access and users can control the natural light with roller shades systems, curtains, and portable outdoor shading devices;
- Limiting noise pollution at the construction site to avoid nuisance in the immediate neighborhood;
- Important air quality control during the construction site management to preserve worker's health, security, and well-being;
- The absence of accidents involving employees in the construction site due to the respect to the safety measures and risk prevention actions.

The main possibility of improvements identified are:

- Enhance the thermal comfort of the interior spaces of the building to improve user's well-being during the winter by providing interior dispositive that allows users to control the heating system and the respective training for this purpose;

[175] We consider here that improvement actions are stragies that can be employed to improve the institution operation, user behavior, monitoring and control of energy and water consumption, in other words, everything related to the building operation, use and maintenance. The procedure employed in the construction site, or in the design and planning phase cannot be change. However, if a new construction site and a new project will need to take place, the construction site and concept design strategies could be improved.

- For future renovation works, the building team could consider using more low-emitting materials, and bio based materials, making health impacts a parameter when choosing building products.

4.1.2 SDG 4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

The goal 4 seeks to ensure inclusive and equitable quality education for all, and at the same time to promote lifelong learning opportunities to everyone (UN-Habitat, 2016).

The renovation strategies of the '*Aile Sud'* building contributed with the goal 4 because it furnishes to the UVSQ a place for the research activities of the Center REEDS but also a training and learning activities center in the context of SD and GSR. Furthermore, the '*Aile Sud'* building was a subject of some research works that have as the main goal the understanding of the campus sustainability challenges. Center REEDS ensured equal access for all women and men and multi-cultural students and researchers.

4.1.3 SDG 6 - Ensure availability and sustainable management of water and sanitation for all

The goal 6 has as the main purpose to ensure water and sanitation for everyone. As a core of SD, water should be preserved, and its quality must be guaranteed (UN-Habitat, 2016). Despite the reduction in the potable water needs in toilets of the '*Aile Sud'* building, it is still recommended to reduce the potable water consumption for gardening and for cleaning by the introduction of a rainwater recovery system. It is also proposed the implementation of a water metering system to identify opportunities for additional water savings. Moreover, it is recommended for future renovation works in the '*Aile Sud'* building potable water use reduction inside the construction site.

4.1.4 SDG 7 - Ensure access to affordable, reliable, sustainable and modern energy for all

For the UN-Habitat (2016), energy is crucial for achieving a significant part of the other SDGs due to its role in the eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change.

The main contributions of the renovation strategies of '*Aile Sud'* building to the Goal 7 are:

- After renovation, the '*Aile Sud'* building achieved final energy savings, comparing to the initial project, of 79.24%;

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- Substantial investments in the energy efficiency were implemented as the renovation of the existing electricity installations providing energy economy, energy-saving lighting, installation of occupancy sensors in the rooms and corridors that turn on the light with the user's presence, increase in the use of natural lighting, and the implementation of passive houses' techniques for the reduction of energy need for heating and cooling (e.g., insulation system[176], and thermal reinforced insulation system[177] to reduce heat loss by windows);
- A Building Management System (BMS) monitored the building's mechanical and electrical equipment such as ventilation, lighting system, power systems, fire systems, and security system. The BMS allowed to track energy consumption daily and could be a key to identify further opportunities for additional energy savings;
- All these energy efficiency measures helped the '*Aile Sud*' building to have a significant total of costs saving, but also a CO2 emissions reduction cost efficiency.

The main recommendations for the '*Aile Sud'* building regarding the energy use are:

- Renewable energy share in the total final energy consumption;
- Provide user's training and promote awareness to reduce more the energy consumption.

4.1.5 SDG 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

The main target of the goal 8 is to promote sustained, inclusive and sustainable economic growth as a key to achieving the SD. Furthermore, it is aimed full employment, decent work for all and social protection (UN-Habitat, 2016).

The main contributions of the renovation strategies of '*Aile Sud'* building to the Goal 8 were providing job quality, security, and satisfaction inside the construction site. Even if construction site is a transitory site that, depends on the size, lasts from 1 to 24 months in average; they could have important impacts in the worker's health when safety measures are not respected (e.g., adequate safety equipment for each activity, as custom hard hats, safety glasses, safety vests, work gloves and fall protection).

[176] For the thermal envelope improvement, walls, thermal bridges and glasses were studied separated to maximize the passive solar heating. (1) Walls: For the thermal envelope improvement, walls, thermal bridges and glasses were studied separated to maximize the passive solar heating; (2) Thermal bridges: Four types of thermal bridges were analyzed; (3) Glazing: A study of the existed glass system was carried on and a glass modern system was installed without compromising the historical façade.

[177] It is composed by a double-glazing technology and inert gas to fill the cavity within a low-emissivity.

4.1.6 SDG 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

The goal 9 involves three important aspects of the SD: infrastructure, industrialization, and innovation. Infrastructure supplies the basic physical systems and structures essential to the operation of a society or enterprise. Industrialization conducts economic growth, creates job opportunities and thereby reduces income poverty. Innovation accelerates the technological capabilities of industrial sectors and prompts the development of new skills (UN-Habitat, 2016).

The '*Aile Sud'* building contributes to the goal 9 in a few aspects:

- The '*Aile Sud'* building is an urban innovation in the sense that it incorporates eco-innovations, as the passive house techniques, that contribute to a low-carbon and climate resilient development society;
- Passive houses techniques employed had significant eco-innovations features and a possibility to widespread locally, in other buildings of the Bergerie Nationale, but also in other European cities[178];
- The renovation works of the '*Aile Sud'* building contributed to the improve access to information and communication technology because of the extension to the Royal network until the BN;
- The renovation works of the '*Aile Sud'* building cooperate integrating local suppliers of products and equipment into the construction site.

The main recommendation regarding this goal 9 is related to the user's training. For reducing the complexity of the eco-innovations for the '*Aile Sud'* building's end-users, some training could be provided, as is the case of the BMS. Training has as the main goal to provide to users the information needed about some innovations applied in the building to get accustomed to working with these innovations.

[178] Even if this variety of renovation technique requires high initial investment and this rests an important barrier, some important French dispositives, as mentioned in the section 5.5 (e.g., CITE, 'L'éco-prêt à taux zéro', and the 'Habiter Mieux') are strategic financial supports dedicated to the insulation refurbishment and technologies implementation, notably the renewable energies.

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4.1.7 SDG 10 - Reduce inequality within and among countries

The goal 10 aims to reduce all sort of inequalities, as based on age, sex, disabilities, race, ethnicity, origin, religion and economic (UN-Habitat, 2016).

Social justice is an important element of SD and is an essential subject in sustainable constructions, as stated before. For the construction site activities, the building team recruited local products and equipment suppliers, promoting the local economy and reducing.

In the design phase, social justice was incorporated to ensure that the design will be useful and marketable to people with disabilities. An extension reflection about the accessibility of the project design of the '*Aile Sud'* buildings was made. The corridors and doors are properly large to allow the wheelchair users passage and the rooms and toilets allow the wheelchair manipulation. An elevator ensures wheelchair users access from the basement until the third floor. Besides that, the main building entrance has ramps to ensures the wheelchair users access to the building. The building is equipped with tactile paving close to the stairs to warn and conduct visually handicapped.

4.1.8 SDG 11 - Make cities and human settlements inclusive, safe, resilient and sustainable

The goal 11 is related to make cities and human settlements inclusive, safe, resilient and sustainable to prepare society for the new urban population of 2030, where six on each ten people will be living in urban dwellers. The increase in the population of the cities could be interpreted as a driver for SD (UN-Habitat, 2016).

The main contributions of the '*Aile Sud'* building with the goal 11 are:

- Access to quality public transport is available for the students, researchers and professors that came from Paris, but also from the Rambouillet center;
- Preservation, protection, and conservation of all cultural and natural heritage, during the construction site but also respecting the architectural façade of the '*Aile Sud'* building when designing the renovation project;
- Contribution to the local economy as the '*Aile Sud'* building is located close to the community center;
- Contribution to the reduction of the adverse per capita environmental impact of cities due to the adaptation measures in the building design and reduction in the carbon dioxide emissions;

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- Access to safe, inclusive and accessible, green and public spaces for students and physical space for the development of programs and initiatives from university focused on sustainability;
- Contribution to enhance sustainable construction and cities, in the sense that passive houses techniques employed and tested in the '*Aile Sud'* building, can be diffuse to other locations.

Some suggestions to better achieve the goal 11 can be provided:

- As goal 11 has a secondary target on "providing access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport", we could suggest an improvement in the existing transport system, but also more infrastructure for bicycles and green vehicles facilities;
- The local community was included as an important factor to be considered in the project. However there was a lack of the participation of local community when taking decisions about the renovation strategies of the 'Aile Sud' building. For further projects of the 'Aile Sud' building it is recommended a direct participation of the community;
- For further renovation works in the 'Aile Sud' building, it is suggested a more efficient sustainable site management plan with a training of the workforce.

4.1.9 SDG 12 - Ensure sustainable consumption and production patterns

The goal 12 wants to guarantee a sustainable consumption and production patterns that improve the quality of life, minimize natural resources and toxic materials used, and the waste and pollutants generated (UN-Habitat, 2016).

The main contributions identified for the goal 12, are:

- Contribution to the efficient use of natural resources due to the significant amount of materials used in the '*Aile Sud'* building renovation project that can be recycled;
- Contribution of reduction of waste generation in the sense that the interior spaces of the building are adapted to the digital innovation and other activities, incorporating the principle of 'flexibility' in the design of interior spaces, and are accessible to maintenance works;
- The prior experience with the solution between the project team helped to reduce mistakes and waste in the construction site.

The main possibilities for improvement are:

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- The identification and quantification of waste in the construction site of the renovation works of the '*Aile Sud'* building followed the current regulations, however did not explore possibilities of waste valorization. We recommend that, for future works in the '*Aile Sud'* building, an implementation of a waste management system focalized in the circular economy. This might help the '*Aile Sud'* building to contribute to a reduction of the waste generation;
- For future renovations, a more effective prevention waste system in the construction site through the reduction of materials used would be a great opportunity to contribute as well to the reduction of the waste generation;
- The implementation of a waste water recovery would be also an important strategy to reduce potable water in toilets.

4.1.10 SDG 13 - Take urgent action to combat climate change and its impacts

The goal 13 calls an urgent action to combat climate change and minimize its disruptions (UN-Habitat, 2016). The main contributions identified of the '*Aile Sud'* building for the goal 13, are:

- Strengthen resilience and adaptive capacity to climate due to the inclusion of climate adaptation measures in the building design;
- Reduction of air pollution emissions in the construction site;
- Reduction of reduction carbon dioxide emissions in the occupancy phase due to the reduction of energy use.

4.1.11 SDG 15 - Protect, restore and promote sustainable use of terrestrial ecosystems

The goal 15 has as main objective the sustainable management of forests, restoring degraded lands and successfully combating desertification, reducing degraded natural habitats and ending biodiversity loss (UN-Habitat, 2016).

The main contribution identified of the '*Aile Sud'* building for the goal 15 is the combat to desertification and the limit of soil sealing of the building project by the implementation of porous surfaces, to promote maximum percolation of rainwater into the ground and keep as much as possible the natural water cycle.

The recommendation to better reach the goal 15 in future renovation works of the '*Aile Sud'* building, is to develop an accurate ecologic diagnostic in the construction site to conserve and restore the biodiversity.

4.1.12 SDG 17 - Strengthen the means of implementation and revitalize the global partnership for sustainable development

The goal 17 wants to reinforce the means of implementation and revitalize the global partnership for sustainable development. The main contribution identified of the '*Aile Sud*' building for the goal 17 are:

- Strong leadership during the '*Aile Sud*' building project implementation that contributed to encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies for partnerships;
- The public procurement procedure used in the '*Aile Sud*' building renovation project mobilized the various actors and strategies of partnerships;
- Promotion of a sustainable strategy (i.e., in conformity to Green Plan scheme targets) of the Center REEDS closely aligned with the challenges and general advantages of SD&SR and establishment of a SD&SR charter of commitment and desirable practices to enhance policy coherence for sustainable development.

4.2 Possibly scenario for performance improvement

After analyzing all the main contributions of the '*Aile Sud*' building renovation strategies[179] to the achievement of the SDGs, we made some recommendations for actions to improve the performance of the '*Aile Sud*' building. We created a hypothetical scenario from the main actions recommended. This scenario includes a new renovation work in the '*Aile Sud*' building. Table 29 presents the recommendations related to the building and the construction site.

For helping decision making, we returned to the Step 4 of the INTEGRAAL framework for evaluating this new scenario. Figure 79 presents a spider diagram representing both scenarios. Scenario 1, in red, presents the actual situation of the '*Aile Sud*' building, and scenario 2, in blue, shows the hypothetical situation of a new renovation work in the '*Aile Sud*' building with the application of the recommended actions, presented in Table 29. The overall score of the can improve from the 5.87 (real situation) to 7.12 (with the improvements).

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[179] A strategy is a way forward to make happen a desired future, in our case the achievement of sustainable development and its objectives for the university building (Hugé et al., 2011).

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Table 29. Recommended actions for the *'Aile Sud'* building

RECOMMENDATIONS RELATED TO THE BUILDING	RECOMMENDATIONS FOR THE CONSTRUCTION SITE
Improvement of thermal comfort during the winter more low-emitting materials and bio based materials	Potable water use reduction
Reduction of potable water consumption for gardening and for cleaning	Including participation of local community
Introduction of a rainwater recovery system	More effective sustainable site management plan
Implementation of a water metering system	Enhance training of the workforce
Implementation of a training for user's regarding energy and water control	Enhance the identification and quantification of waste in the construction site
Explore possibilities to implement renewable energy	Implementation of a waste management system
Raise user's awareness	Implementation of an effective prevention waste system
Reduce innovations' complexity for end-users by training	Accurate ecologic diagnostic in the construction site
Enhance the infrastructure for bicycles and green vehicles facilities	
Implementation of a waste water recovery to reduce potable water use in toilets	

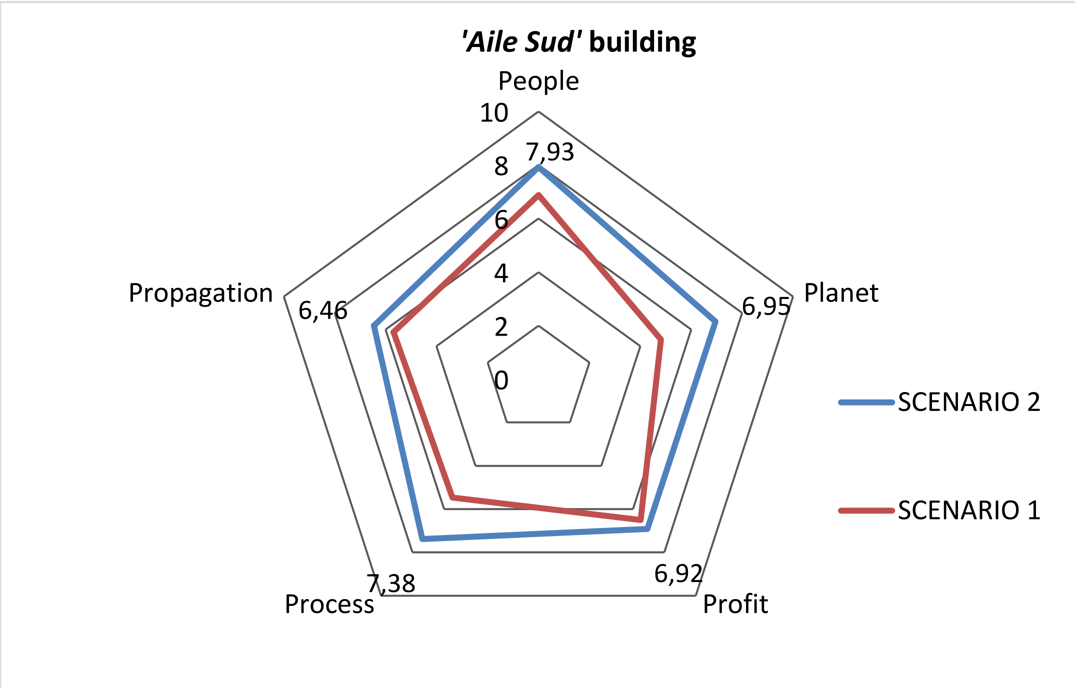

Figure 79. Spider diagram with both scenarios

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4.3 Discussion about the validation of the C4U tool

After the conclusion of the case study evaluation and the respective reflections about the possibilities for the performance improvement of the case study, it is still necessary to answer if the C4U tool meet our expectations. To answer this question, we will first discuss the practical experience with the '*Aile Sud'* building. Secondly, we will provide a theoretical validation of the C4U tool regarding the principles for the SD assessment.

4.3.1 Practical experience

The practical experience of the C4U tool application in the '*Aile Sud'* building case study demonstrated that the performance issues considered to assess the performance of the renovation strategy correspond to the potential targets of the SDGs. Beyond that, the C4U experience with the '*Aile Sud'* building showed that goal related to the distinct stage of a building life cycle (e.g., construction site activities, design planning, occupation, others) and distinct scales of sustainability (e.g., relations between the building and the city) were integrated with success in the tool.

The 'tree structure' of the C4U allow us to understand the main contributions of the renovation strategies of the '*Aile Sud*' building to the SDG's. The spider diagram provides a general graphical representation about the results of the five Top-goals (i.e., People, Planet, Profit, Process and Propagation) which is valuable to visually understand the results but also to compare results within distinct scenarios. The 'tree structure' contributed to once we needed to clarify some issue to go through the performance issues results and indicators scores.

Moreover, the C4U tool provided a diversity of judgement, since it is a multi-actor method that drives social learning, especially due to the support of the EPLANETe platform. For Fernandez-Gimenez et al. (2008), social learning is "*an intentional process of collective self-reflection through interaction and dialogue among diverse participants (stakeholders)".* Pahl-Wostl et al. (2008) define social learning as *"developing new relational capacities, both between social agents, in the form of learning how to collaborate and understand others' roles and capacities differently".*

During the Step 4 of the INTEGRAAL framework, where actors were invited to give values to the indicators candidates, they passed through this *"collective self-reflection"* mentioned by Fernandez-Gimenez et al. (2008) where actors shared their knowledge, experiences and judgements through interaction and dialogue.

Giving continuity to the Step 6 of the INTEGRAAL, we presented a list of recommendations for the '*Aile Sud'* building for adapting the building management, control and monitoring activities, uses and behaviors of the '*Aile Sud'* building to the goals that could be established in a strategic plan of SD&SR toward a sustainable university building. The monitor and control of this strategic plan can promote social learning in the sense that actors might learn how to collaborate with the plan.

4.3.2 Theoretical validation

To proceed with the analytical validation of the C4U tool, we will use as a reference the ten Bellagio Principles for Assessment Toward Sustainable Development presented previously in the 8.1 (Hardi and Zdan, 1997).

4.3.2.1 Principle 1: Guiding Vision and Goals

We can affirm that the C4U tool guides the actors to a clear understanding of the SD in the buildings and this vision, it is highlighted the connection between the buildings and the urban space. This vision of SD in the buildings, conduct us, through the literature to define the main goals, that are represented in the C4U as performances issues.

4.3.2.2 Principle 2: Holistic perspective

The C4U guide users to a holistic view in the sense that is a tool to assist the sustainability assessment and is structured in the four pillars of the sustainability (i.e., social, economic, environmental and political). The observation can illustrate this holism needs that the university's building sustainable performance is not limited to reducing its environmental externalities and should consider the positive and negative consequences of human activity.

4.3.2.3 Principle 3: Essential Elements

The C4U assessment tool considers the key elements to progress toward sustainable development as:

- Equity and disparity within the current population and between present and future generations, dealing with such concerns as resource use concerning energy, water and materials; and building accessible to all;
- The ecological conditions on which life depends by preserving biodiversity, the water cycle, and avoiding water and soil pollution;

- Economic development and other, non-market activities that contribute to human/social well-being.

4.3.2.4 Principle 4: Adequate Scope

The tool has an adequate scope in the sense that:

- It adopts a time horizon long enough to capture both human and ecosystem time scales thus responding to needs of future generations as well as those current to short term decision-making. As, the C4U have goals that are related to the reduction of natural resources consumption that in a short-time can provide reduction of environmental impacts and costs; and in a long-term will ensure the quota of natural capital for the future generations;
- It defines the space of study large enough to include not only local but also long-distance impacts on people and ecosystems. As stated before, the C4U was designed to be a tool to assess building inside its system but also its relationship with the urban and natural system.

4.3.2.5 Principle 5: Practical Focus

The C4U tool is based on five main categories that organizes the performance issues and quantitative and qualitative indicators. Despite a vast number of key issues for analysis regarding the university building, we selected pertinent performance issues and the indicators with the aid of the INTEGRAAL approach.

4.3.2.6 Principle 6: Openness

SA should make the methods and data that are used accessible to all, and make explicit all judgments, assumptions, and uncertainties in data and interpretations. We used the EPLANETe platform for the C4U tool construction. All the methods used as a reference and all the list of indicators candidate of the KIK Sustainable Campus are accessible in this platform to everyone. In this context, if another actor wants to build a new tool to evaluate for instance the performance of the constructions sites, he could access in the EPLANETe galleries the methods and indicators available.

The EPLANETe system also makes accessible to all the judgments (i.e., expert system and actor's deliberation) used for the performance assessment of the renovation strategies of the '*Aile Sud'* building. All the information related to the worksite assessment with the C4U tool is open and available.

4.3.2.7 Principle 7: Effective Communication

Assessment of progress toward SD should be designed to address the needs of the audience and set of users. Regarding the universities, our literature review showed that there is a demand for renovating the university buildings for the energy consumption and CO2 emissions reduction. In the context of the buildings, we identified in the Chapter 1 some existing barriers for implementing green buildings. Issa et al. (2010) stated that practitioners are uncertain about green buildings, and Häkkinen and Belloni (2011) highlighted a lack of previous experience and information. The C4U as a tool to help decision making can assist universities in renovations processes and can reduce the uncertainties regarding the green buildings.

An assessment of progress toward SD must also draw from indicators and other tools that are stimulating and serve to engage decision-makers aim, from the outset, for simplicity in structure and use of clear and plain language. The C4U tool provides to its users exactly this, as we demonstrated in Step 6 of the INTEGRAAL framework. The spider diagram rests a simple and clean language that makes comparative scenarios studies easier

4.3.2.8 Principle 8: Broad Participation

The C4U ensures a broad participation due to its participative approach that provides legitimacy to the results. Furthermore, the tool ensures the involvement of the decision-makers to secure link to adopted policies and resulting action. We demonstrated in Step 6 of the INTEGRAAL framework that the 'Aile Sud' building assessment might lead to recommendations that can constitute a hypothetical scenario that might make possible the comparison between both scenarios to aid decision-making. There is still an option here for dividing each recommendation in strategy actions and connecting each action to a stakeholder group.

4.3.2.9 Principle 9: Ongoing Assessment

The C4U tool has this feature of promoting an ongoing assessment. Real situations of university buildings can be assessed for identifying opportunities of performance improvement inside the INTEGRAAL framework context toward SD. Current goals and values on the indicators can be adjusted, in an interactive, adaptive, and responsive to change system. The tool promotes development of collective learning and feedback to decision-making.

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4.3.2.10 Principle 10: Institutional Capacity

The C4U tool provides continuity of assessing progress toward SD by clearly assigning responsibility and providing ongoing support in the decision-making process, and providing institutional capacity for data collection, maintenance, and documentation.

Table 30 presents an assessment framework for comparing the C4U tool and the other existing methods according to the ten Bellagio Principles. It is possible to conclude that the C4U is the only tool, from the seven tools, presented, that meet all the Bellagio Principles. This represents for us a theoretical validation of the tool.

Table 30. Assessment framework of the C4U and the existing methods according to the Bellagio Principles

METHODS / PRINCIPLES	C4U	B4U	LEED	BREEAM	HQE	STARS	EVVADES
PRINCIPLE 1: GUIDING VISION AND GOALS	X				X		
PRINCIPLE 2: HOLISTIC PERSPECTIVE	X	X				X	X
PRINCIPLE 3: ESSENTIAL ELEMENTS	X	X				X	X
PRINCIPLE 4: ADEQUATE SCOPE	X	X			X		
PRINCIPLE 5: PRACTICAL FOCUS	X	X	X	X	X	X	X
PRINCIPLE 6: OPENNESS	X	X				X	
PRINCIPLE 7: EFFECTIVE COMMUNICATION	X	X	X	X	X	X	X
PRINCIPLE 8: BROAD PARTICIPATION	X					X	X
PRINCIPLE 9: ONGOING ASSESSMENT	X		X	X		X	X
PRINCIPLE 10: INSTITUTIONAL CAPACITY	X						

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As a tool for helping the decision-making process, the C4U assessment might need to be followed by a sustainability campus report were universities will describe all their possible targets and actions to meet the SDGs, including the renovation of their existing buildings. This report should be updated with some frequency to communicate to the actors the university improvements, but also its new goals.

5 CONCLUSION

From the Chapter 5, regarding the Step 4 of the INTEGRAAL framework, it is possible to conclude that the expert system provided an assessment of the '*Aile Sud'* building with the approximate categories' results compared to the deliberation section results. The deliberation between actors provided legitimacy for the assessment, but also valuable comments regarding the values given to the performance indicators for the renovation strategy assessment of the '*Aile Sud'* building.

The deliberation section provided results that were born from a discussion, reflection and a knowledge exchange between actors. The assessment of the *'Aile Sud'* building renovation resulted in a score of 6.89 for the category 'People'; a score of 4.82, for the category 'Planet'; 6.50, to the category 'Profit'; 5.48 for the category 'Process'; and 5.69 for the category 'Propagation'.

This section helped us to validate the C4U regarding the practical experience, in the sense that actors did not have difficulty when judging the measure of the indicators performances, proving that, in a general way we can affirm that the C4U is an understandable tool. During the deliberation section, the actors experienced the phenomenon of the ambiguity that was partly positive because it contributed for some reflection about the judgments of each actor.

An analysis by category showed that the category 'People', the sub-goals 'Promotion of a feeling of community/home', 'Work conditions', 'Health and security', and 'Comfort' had a final score above the average. On the contrary, the 'Social justice', 'Land design for sustainable urban development', 'Ensuring a livable area', and 'Indoor Environmental quality' had final scores below the average.

For the category 'Planet', the results showed that the performance issues, or sub-goals, 'Materials and Resources', 'Pollutants emissions into the atmosphere', 'Soil', and 'Biodiversity' had a final score above the average. However, the 'Waste', 'Water' and 'Energy' had final scores below the average.

For the category 'Profit', the results presented the 'Constructive choice for the accessibility during maintenance works', 'Adaptability and flexibility', and 'Creating value for the sector' as performance issues that had a final score above the average. Nonetheless, the performance issues 'Costs', 'Time optimization', and 'Creating local value' had final scores below the average.

For the category ‘Process’, the results showed that the ‘Campus engagement’, ‘Sustainable teaching and research’, ‘Water and energy management’, and ‘Governance model’ received a final score above the average. ‘Public engagement’, ‘Interior air quality and temperature control’, Sustainable sites’, ‘Maturity of process’, and ‘Strategy’ had a final score below the average.

For the category ‘Propagation’, the performance issues ‘Innovation characteristics’, ‘Mimetic processes’, ‘Dissemination’, and ‘Relative advantage’ had final scores above the average. Though,the ‘Ability to bring about change’, ‘Standards evolution’, and ‘Complexity’ had a final score below the average.

The results of the ‘*Aile Sud’* building was analyzed for a better interpretation of the outcomes. A discussion of the performance issues results provided a reflection about the contributions of the ‘*Aile Sud’* to the SDGs. This debate on the main contributions indicated some improvement possibilities of the ‘*Aile Sud’* to the SDGs and a hypothetical scenario including these enhancements. A diagram showed that the hypothetical scenario enhanced the overall performance of the building, proving that the C4U aligned with the INTEGRAAL framework are potential tools for the decision-making process.

Finally, we concluded the chapter providing a theoretical validation of the C4U tool with the Bellagio Principles. The assessment framework for comparing the C4U tool and the other existing methods according to the ten Bellagio Principles showed that the C4U is the only tool, from the seven tools presented that meet all the Bellagio Principles.

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GENERAL CONCLUSION

This thesis aimed to develop an approach to assist the decision-making process in the university building renovation process toward the sustainable development. The INTEGRAAL methodology was adopted in this work to help us with the problem of issue identification, but also in the utilization of standardized indicators to evaluate our case study, the '*Aile Sud'* building. The ePLANETe platform was used to support us in the construction of our new model, named C4U.

The deliberation section with the actors showed some contrast of opinions expressed by the expert system and the actors' assessment, confirming that the actors' participation in the evaluation was crucial to provide some legitimacy to the case study assessment. This section provided some valuable comments regarding the values given to the performance indicators for the renovation strategy assessment of the '*Aile Sud'* building. We can affirm that the section respects the fours deliberation aspects (Informational, Argumentative, Reflective, and Social) presented by Dryzek and List (2003).

The results of the *'Aile Sud'* building renovation assessment showed a score of 6.89 for the category 'People'; a score of 4.82, for the category 'Planet'; a score of 6.50, for the category 'Profit'; a score of 5.48 for the category 'Process'; and a score of 5.69 for the category 'Propagation'. We determined that the overall rating for our worksite was the average between the total scores of the five categories what gave us a 5.88 score on a scale from 0 to 10, where 0 would be 'not sustainable at all' and 10 could be a 'sustainable university building.'

The case study results analysis demonstrated that some categories achieved a score above the average, as for instance 'People' and 'Profit'; and some categories achieved a score below the average, as, 'Planet', 'Process', and 'Propagation'.

An analysis by category was held to provide more detailed explanation regarding the performance issues results:

- Inside the category 'People', the sub-goals 'Promotion of a feeling of community/home', 'Work conditions', 'Health and Security', and 'Comfort' had a final score above the average. 'Social justice', 'Land design for sustainable urban development', However, the sub-goals 'Ensuring a livable area', and 'Indoor Environmental quality' had final scores below the average;
- Within the category 'Planet', the results showed that the sub-goals, 'Materials and Resources', 'Pollutants emissions into the atmosphere', 'Soil', and 'Biodiversity' had a final score above the average. Nonetheless, 'Waste', 'Water' and 'Energy' had final scores below the average;

- In the category 'Profit', the results presented the 'Constructive choice for the accessibility during maintenance works', 'Adaptability and flexibility', and 'Creating value for the sector' as performance issues that had a final score above the average. Indeed, the performance issues 'Costs', 'Time optimization', and 'Creating local value' had final scores below the average;
- In the category 'Process', the results showed that 'Campus engagement', 'Sustainable teaching and research', 'Water and energy management', and 'Governance model' had a final score above the average. 'Public engagement', 'Interior air quality and temperature control', 'Sustainable Sites', 'Maturity of process', and 'Strategy' had a final score below the average.;
- Inside the category 'Propagation', the performance issues 'Innovation characteristics', 'Mimetic processes', 'Dissemination', and 'Relative advantage' had final scores above the average. 'Ability to bring about change', 'Standards evolution', and 'Complexity' had a final score below the average.

A discussion of the performance issues of the '*Aile Sud'* building reflected the contributions of the case study to the SDGs and provided a better interpretation of the outcomes. We can conclude that the 'Aile Sud' building is partly responsible for the SDG achievement, precisely, the goals 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, and 17. Beyond that, some improvement possibilities were detected to better achieve the SD goals 3, 6, 7, 9, 11, 12 and 15.

A hypothetical scenario, including these enhancements, was created to analyze how these recommendations could improve the sustainable building performance. The results showed that the improvement recommendations enhanced the overall performance of the building, from 5.88 to 7.12, proving that the C4U aligned with the INTEGRAAL framework are legitimate tools for the decision-making process, and for the buildings continuous improvement.

From the practical experience with the C4U, we can conclude that:

- The C4U is an intuitive, user friendly tool, in the sense that, the actors did not have difficulty when giving values to the performance indicators. A further study with various deliberation section could be considered to exclude all kind of ambiguity between the indicators;
- All the sub-goals selected to assess the renovation strategy performance correspond to the potential targets of the SDGs, providing a validation regarding the SDG goals that will transfer to the real world;
- Besides that, the C4U application with the '*Aile Sud'* building showed that, indicators related to the diverse stages of a building life cycle (e.g., construction site activities, design planning,

occupation, others), and the various scales of sustainability (e.g., relations between the building and the city) were successfully integrated in the tool;

- The 'tree structure' of the C4U allowed us to understand the main contributions of the renovation strategies of the '*Aile Sud'* building to the SDG's;
- The spider diagram provided a general graphical representation of the five Top-goals results, which was valuable to understand the results visually, but also to compare results within distinct scenarios;
- The C4U tool provided judgment diversity since it is a multi-actor method that drives social learning.

Despite the valuable contribution of the practical experience with the C4U, a theoretical validation approach was considered necessary. An analysis was performed using an assessment framework of the existing methods according to the ten Bellagio Principles for Assessment Toward Sustainable Development. The results of the analysis showed that the C4U tool was the only tool, from the seven tools, presented, that meet all the Bellagio Principles, confirming the theoretical validation of our tool.

We would like to give further guidance about the performance improvement of the university buildings. The C4U is a tool to support the decision-making process, what is, in other words, a method to provide information to the decision makers akin to management information. The continuous improvement of university campuses requires a participative strategic sustainability plan where universities will describe all their possible targets and actions to meet the SDGs. This report could be updated with frequency to communicate to the actors the results of universities improvements and also their new goals.

Also, this research allows us to answer several questions that we posed at the beginning of the thesis as essential to the understanding of sustainable university building.

Why does the issue of sustainable development arise nowadays?

Many theories about social development emerged from experiences of the Industrial Revolution and after the Second World War, leading to the emergence of different movements, including; the Environmental movement, the Conservation movement, and the Neo-Malthusian theories brought attention to the natural capital preservation. A second wave emerged, the support for a sustainable development paradigm of society developing an alliance between 'development' and 'environment'.

The Brundtland Report (UN, 1987) defined the three pillars of SD as being economic growth, environmental protection, and social equality. However, the report developed a limited definition about SD without giving further information about how the various industry sectors could meet the SD in a practical approach. Thus, the 1992's Earth Summit had a major role because it established a common goal for humanity through the Rio Declaration, but also published the main humanity challenges in the Agenda 21. The Agenda 21 had a substantial impact in mobilizing nations and industrial sectors toward SD.

There is no consensus on the precise meaning of sustainability, in what determined the development of many models to represent the SD dimensions. Whatever the theoretical approach adopted, the condition of sustainability is that the human capital and natural capital flows should be maintained over time (Faucheux and O'Connor, 2002).

Nowadays, the issue of SD arises to try to keep this equilibrium and seeks to respond to a social demand that is evolving in time and space. We can affirm that we already pass through an awareness phase where definitions, challenges, and scopes were discussed. Currently, society is going through a new direction guided by new policies that demand the development of new strategies to meet its SD and SR in our current age. A coherent example can be found in the 17 SDG's to transform the world, which is a plan of action for the humanity for the next fifteen years.

The SDG's contributes with this idea of "think globally, act locally," in the sense that in a short-term period we could promote many local changes to meet the 17 goals established by the UN. The strategy, for maybe 15, 20 or 30 years, could have significant long-term results in the various industrial sectors.

Universities are important actors in this social transformation. However, universities are also a part of society and need to meet their SD and SR, not only now, but also in the future. To measure their major accomplishments and opportunities for improving they need to establish inside their campuses strategic sustainability plans to inform the actors where the universities are regarding their challenge goals.

How can the sustainable development be applied in the urban planning, in buildings, and the universities campuses?

<u>Urban Planning</u>

In the last decades, the UN's conferences and events have influenced many social sectors, and, especially, the urban planning and the architecture. The Brundtland Report and the Agenda 21, brought attention to environmental (e.g., pollution, waste disposal, energy and water consumption, and others) and social problems (e.g., physical and social division, poverty and others). Environmental and social problems are considered to be significant consequences of the fast growth in the cities combined with an uncontrolled urban sprawl.

The first society signs about how to build a sustainable city appeared with the ‘ecocities’ or ‘green cities’ concepts. Both concepts gave much attention to the environmental impacts of the urban space and relevant social issues, as the social justice promotion and the local economy support. The similarities between the ‘ecocities’ and the ‘sustainable cities’ make it increasingly the difficult to discern between both concepts.

The sustainable city can be determined as an important key for formulating the vision of the future cities. The new urban approach brings attention to the humanity's current lifestyle, and it questions the transport, buildings, resource management, organizations, and urban spaces are going to be adapted to the future populations. It questions how cities will provide prosperity, security, and resilience.

Nowadays, the sustainability can be applied in the urban space at the local, national, and international level. At a local level, we can highlight the implementation of the Goal 11 of the '2030 Agenda for SD' developed by the UN-HABITAT and the Local Agenda 21. It involves local government and civil society. An effective local action for sustainable urbanization needs a supportive and enabling policy at the national level.

Furthermore, it requires decentralization and the empowerment of local authorities. International support consists in the mobilization of the multilateral and bilateral development agencies, regional and international associations of local governments, professional associations, international support networks, and NGOs

Buildings

The construction sector contributes significantly to the global economy and, naturally, to the development of the cities. However, it is also responsible for substantial environmental impacts. At the end of the 90s, boosted by the environmental regulations and societal pressures, the construction sector started to recognize the environmental aspects related to its activities to find solutions to reduce the adverse effects on the environment and society. In this context, the green building practice emerged and was widespread with the U.S. Green Building Council by the LEED rating system.

We considered that ‘green buildings’ and ‘sustainable buildings’ have the same definition and they can provide significant environmental, social and economic benefits:

- Environmental benefits: energy, water and raw materials reduction; decrease in the GHG emissions, reduction in the waste disposal and environmental releases, improve in the of indoor air quality, and others;
- Social benefits: occupants comfort and health promotion, local heritage protection, and others;
- Economic befits: reduction of energy and water use costs, return on the investment, marketing benefits, tax advantages and incentives, and others.

Furthermore, these advantages should extend beyond the physical building boundaries to reach the local community. The building must contribute to the security, health promotion, and the economic development of the community.

SD can be applied to new buildings construction, or by existing buildings renovation processes. The SD strategies should be implemented inside all construction project stages, from the design and costing, right up to occupation.

Energy performance is usually the main target for the European countries when constructing or renovating buildings. Active and passive design techniques can provide valuable results for the Passive Houses, ZEB, BBC, and BEPOS implementation.

Green buildings group several best practices that are dependent upon each situation, climate, and localization. For each case study, a list of strategies and actions planning is required.

The GBR systems (e.g., LEED, HQE, BREEAM) can help as necessary drivers, even if they still present some limitations and are more environmentally oriented. GBR systems can provide information and guidance on GB subject for the construction stakeholders. From a construction company perspective, GBR systems are an essential way to increase their image and market competitiveness. It is crucial to highlight that rating systems should be implemented with a building management and control, to ensure the construction quality and occupants well-being.

The implementation of SD strategies in the existing buildings in France is motivated by the emergence of government tax incentives to drive energy efficiency in building renovation that might help to increase public awareness.

Eco-innovations are important drivers for the improvement of buildings sustainable performance. Eco-innovations are also significant in the achievement of sustainable manufacturing that includes initiatives such as closed-loop production.

University campus

Universities can contribute to the societal transition toward sustainability through:

- The local community: universities can encourage local systems to integrate diverse SD knowledge types to improve the application of social change knowledge to meet the Agenda 21 requirements;
- The society: universities play a major role in society as stable, free and independent institutions;
- The companies: universities are forming new leaders and decision-makers that will join companies, will adhere and foster the SD and SR values;

Furthermore, the sustainable campus can bring social, environmental and economic benefits. A strategic sustainability plan should communicate in detail to all the stakeholders the main actions of the campus of the future, but also must conserve and to reinforce campus attractiveness.

What are the challenges faced by the urbanization, the building sector, and the university campus?

Urban Planning

After our literature review, we can conclude the main challenges for planning the urban environment inside the SD principles are:

- The new way of governance with a democratic participation and collective efforts of local government, municipality, inhabitants; and partnership between public and private sector;
- The complexity of the urban systems involved and significant interrelation in urban and metropolitan area;
- The diversity in the patterns of urbanization since there is a strong connection between urbanization and national levels of economic and human development.

However, further challenges can be noticed for the developing countries, as:

- The overwhelming scale and speed of urban growth;
- The inadequate existing urban infrastructure;
- Rapid and concentrated in the urban center's industrialization;
- Limited managerial, technical and institutional capacities;
- The urban and national economies with low levels of output and weak financial capabilities.

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Buildings

The main challenges found regarding the GB implementation are:

- The high initial costs of adopting and investing in GB aligned with the results uncertainties;
- Low levels of awareness by the buildings' owners;
- The risk of a new technology or material development, and a lack of experience with this new technique or material;
- Time for implementation and training;
- Lack of manufacturer and supplier support in some countries;
- Lack of information to support the decision-making.

The change of attitude and behavior, and the cooperation between project stakeholders, can be understood as a challenge but also as a drive. Extra barriers are identified for developing countries.

University campus

The main challenges of higher education institutions is the transition toward a sustainable campus are related to the building user's awareness, especially regarding the energy use; and the GHG emissions reduction, associated with the students, teachers and researchers' commuting. Another challenge that we could identify was the establishment of an effective communication link between all the stakeholders about the university sustainability strategies.

How can we evaluate the strategy performance of the university building renovation process?

The performance evaluation of the university building renovation strategy and process depends on understanding the reality of the situation and the idealized situation. Taking as an example our case study, we have in a real situation one building that passed through many renovation works to meet some environmental goals. The ideal situation is to have a sustainable university building integrated with its environment. Providing to actors the knowledge about the real situation will assist them to take decisions for the construction improvement.

A Sustainability Assessment might help to improve the decision-making process in the renovation and the development of projects and plans from a sustainability perspective. The most important is that SA assists in the improvement in monitoring results and communication. In this sense, universities can integrate their resources and goals into their strategic sustainability plans.

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As the assessment of sustainability is a complex subject, a multi-criteria decision-making analysis was recommended to support decision makers to learn and to understand the main problems of the several phases of the building lifecycle to guide then to identify actions.

However, no democratic legitimacy in the assessment can be guaranteed if the actor's participation in the SA of the building can incorporate their experiences via the deliberation process.

We conclude that an integrative method involving a multi-criteria and participative assessment is the ideal approach for measuring the performance of the university building renovation process.

What are the contributions and limitations of the existing methods of building and university assessment?

Existing building assessment methods

The main contributions found in the existing methods for building assessment is the possibility to provide an evaluation following a list of indicators that consider the several aspects of water, energy, IAQ, materials, waste management, materials, and others. Over the years, the GBR systems have contributed to the design and construction of buildings, and has improved their environmental sustainability beyond existing regulations and in eco-innovation best practice.

Despite the capacity of providing some change in the construction sector, the GBR systems have many limitations regarding the lack of the actor's participation, in the results visualization, and in the indicators and categories to express the performance issues of all sustainability dimensions. The 'building-centric approach' is indicated as another limitation of the current GBR systems that often considers a building evaluation study as just the built environment.

Existing university assessment methods

From experience with the sustainability tracking and assessment tools for higher education, it is possible to conclude that both tools can be considered necessary to raise awareness through the sustainability evaluation of the higher education institutions.

However, we remarked the lack of indicators relating to user's comfort, indoor environmental quality, accessibility, materials, and sustainability of the site itself. Also, the building life cycle considered in the both methods is limited to the operational phase.

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How can a new tool contribute to the decision making of a university building renovation process?

The new tool can assist in the decision making of a university building renovation by the continuous improvement and by social learning approaches.

The performance strategy assessment of the university building renovation provides reliable information about the real situation of the *'Aile Sud'* building through a broad diversity of judgment by users since the C4U is a multi-actor method. Various scenarios can be created to help with establishing goals for performance improvement or to analyze the main advances achieved.

The C4U tool drives actors to a social learning approach. The tool promotes dialogue and interactions where the actors shared their knowledge, experiences, and judgment. Inside a continuous improvement approach, the monitoring and control of a strategic plan can promote social learning. The actors could learn how to cooperate in their actions.

What are the performance issues of a university building renovation process?

After conducting a literature review and a discussion section with the actors involved in the *'Aile Sud'* building project, we can conclude that the performance issues for the building renovation process are:

- Comfort;
- Indoor Environmental quality;
- Health and security;
- Work conditions;
- Ensuring a livable area;
- Land design for sustainable urban development;
- Promotion of a feeling of community/home;
- Social justice;
- Energy;
- Biodiversity;
- Soil;
- Water;
- Pollutants emissions into the atmosphere;
- Climate system;
- Waste;
- Materials and resources;
- Creating local value;

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- Creating value for the sector;
- Time optimization;
- Costs;
- Adaptability and flexibility;
- Constructive choice for the accessibility during maintenance works;
- Governance model;
- Strategy;
- Maturity of the process;
- Sustainable Sites;
- Water and energy management;
- Interior air quality and temperature control;
- Sustainable teaching and research;
- Public engagement;
- Campus engagement;
- Complexity;
- Relative advantage;
- Dissemination;
- Standards evolution;
- Mimetic processes;
- Ability to bring about change;
- moreover, Innovation characteristics.

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LIST OF ANNEXS

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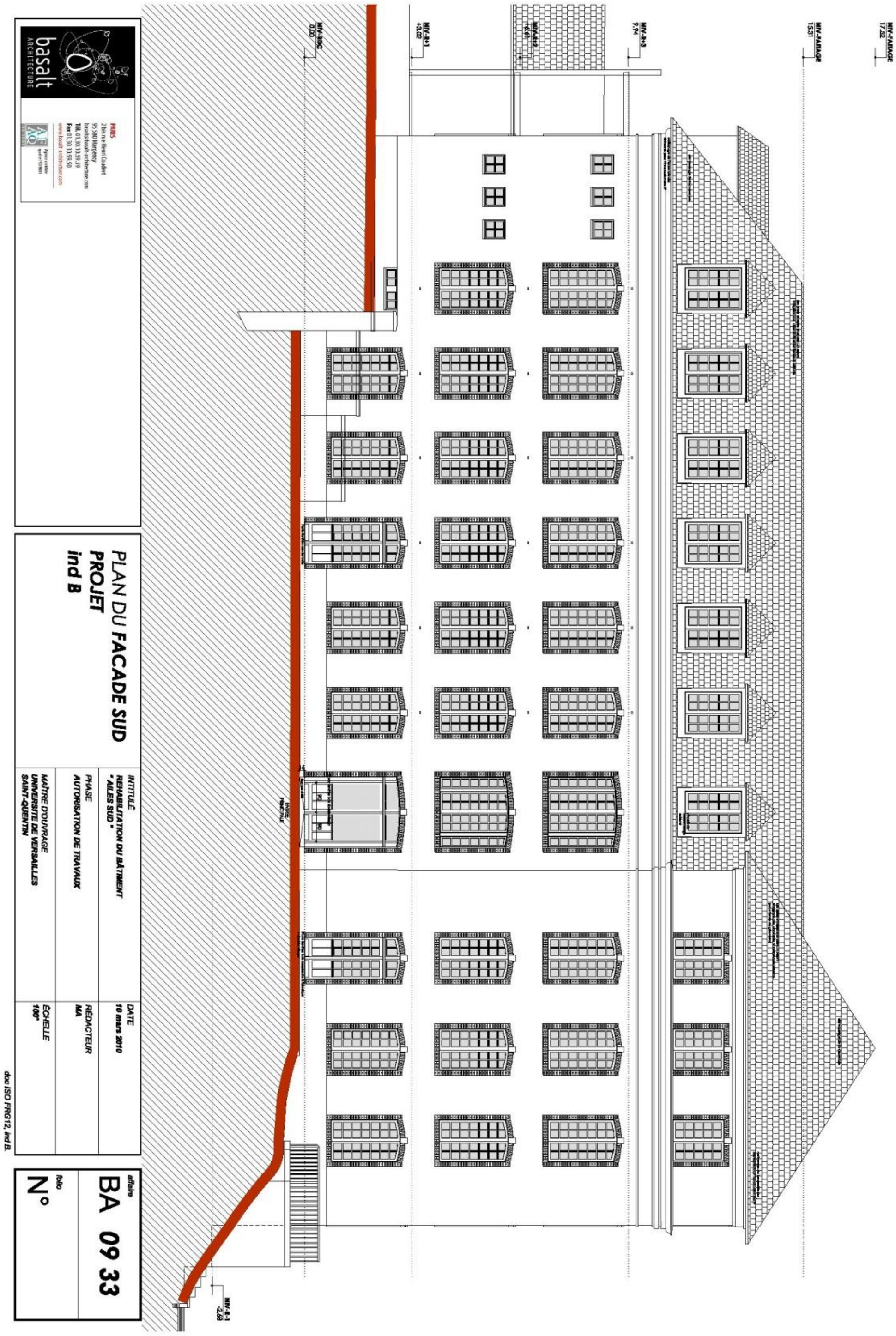
ANNEX 1. THE *'AILE SUD'* BUILDING PROJECT

A1.1 FAÇADE OF THE 'AILE SUD' BUILDING. SOURCE. UVSQ, 2009.



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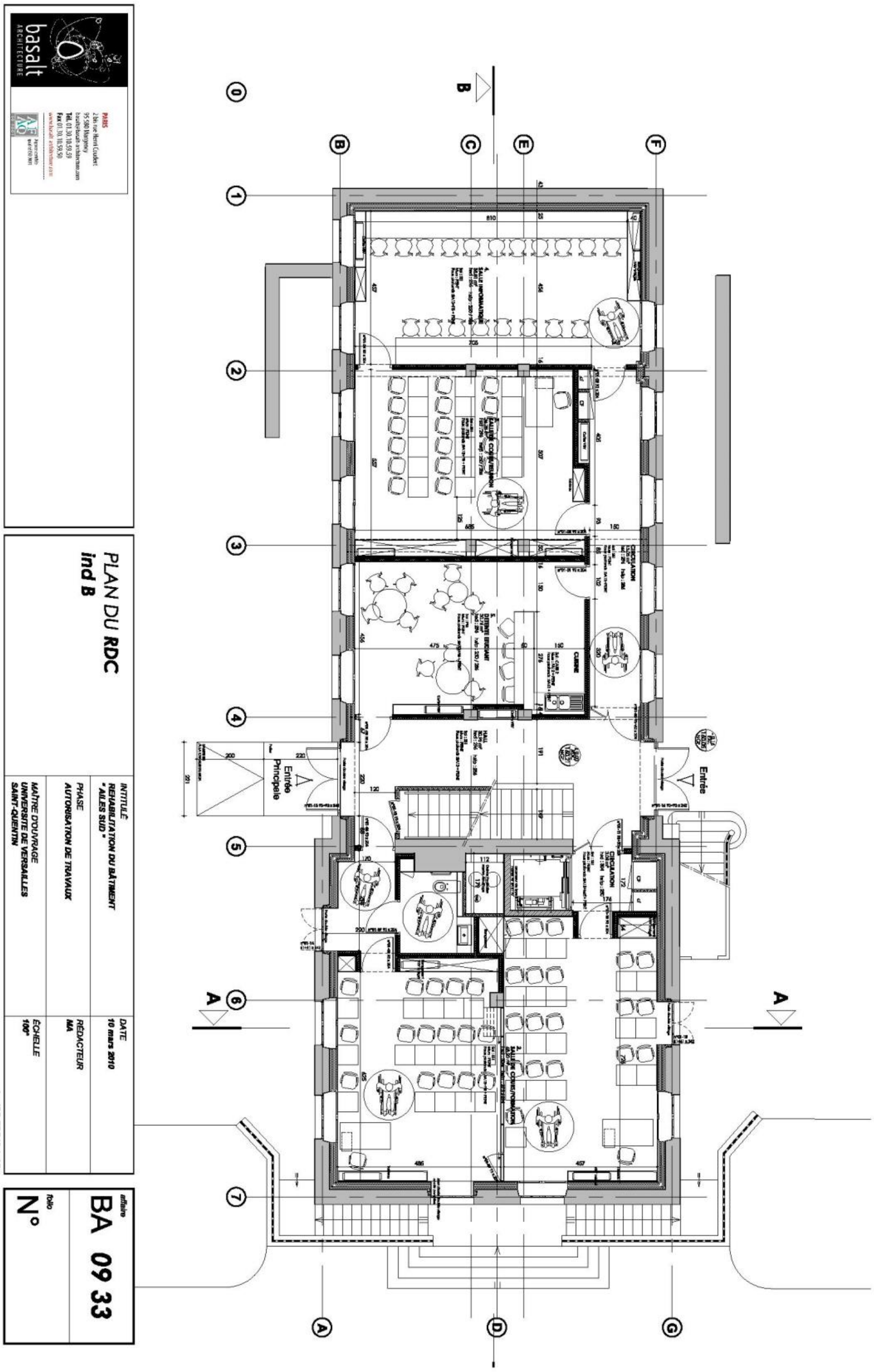
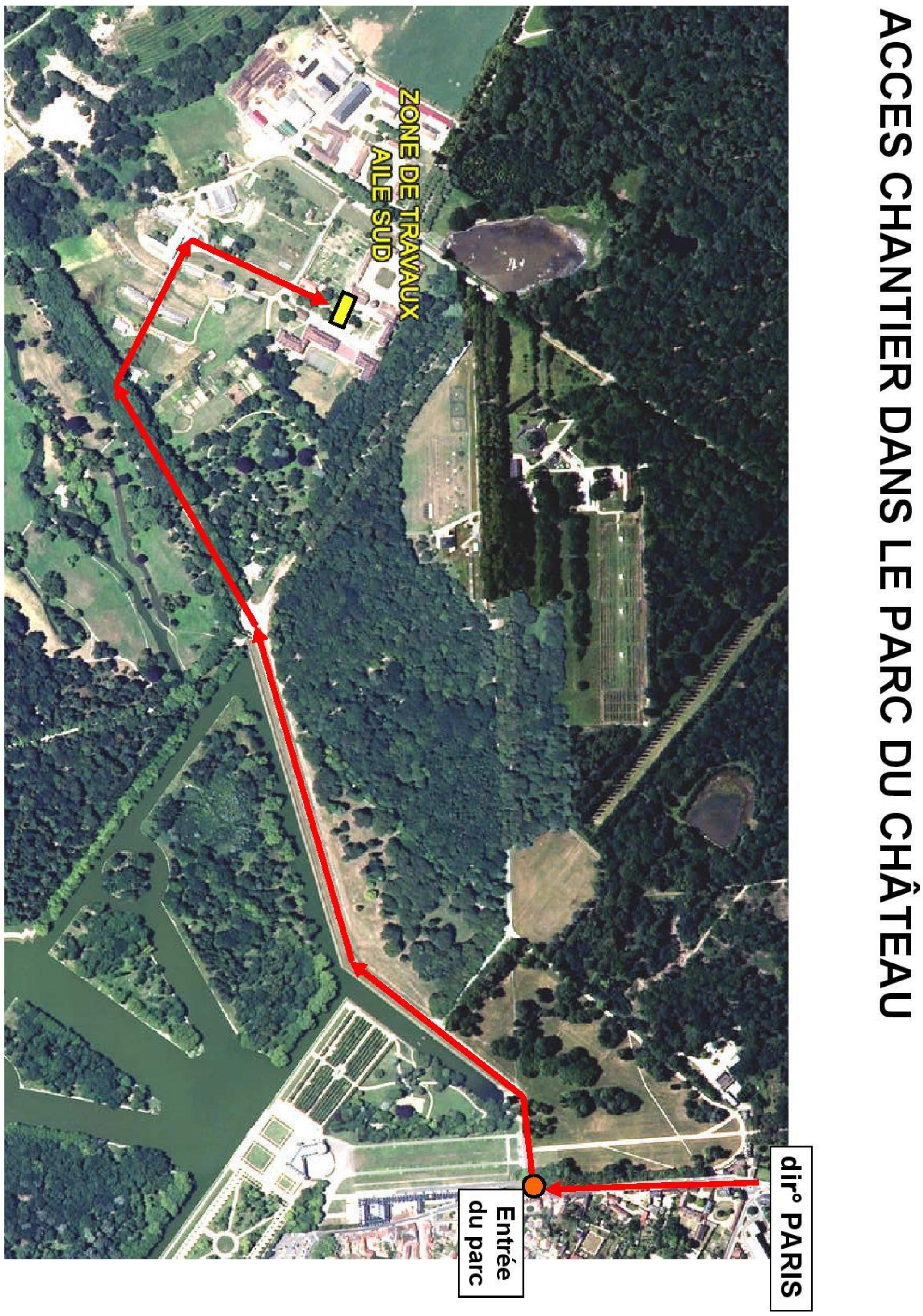
A.1.2 LAYOUT STUDY OF THE GROUND LEVEL OF THE 'AILE SUD' BUILDING.

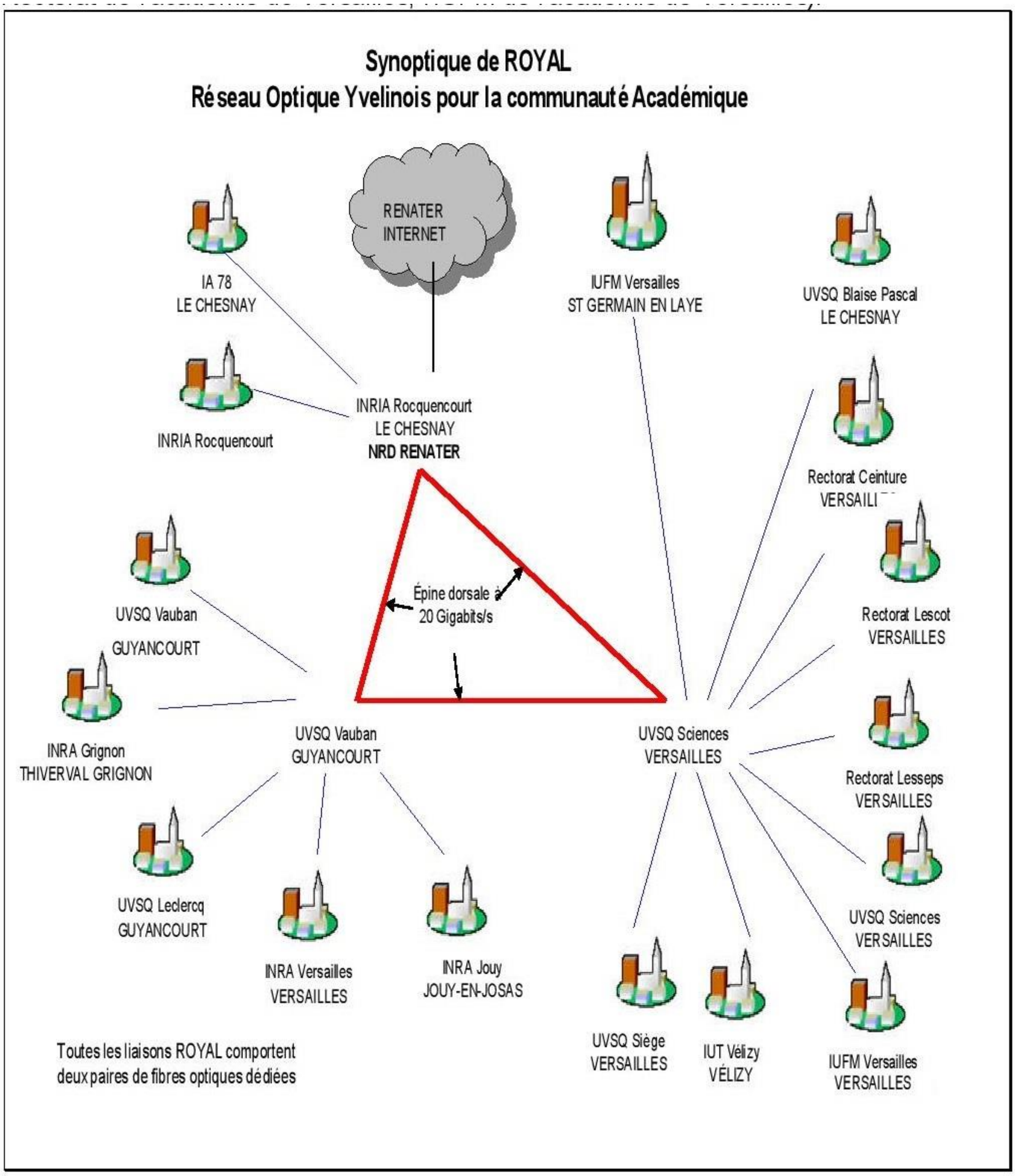
SOURCE. UVSQ, 2009.



A1.3 ACCESS PLAN OF THE BN DURING THE CONSTRUCTION SITE. SOURCE. UVSQ, 2009.



A1.4 REPRESENTATIVE SCHEME OF THE ROYAL NETWORK. SOURCE. UVSQ, 2010.



ANNEX 2. LEED RATING SYSTEM

A.2.1 SCORECARD OF THE LEED FOR NEW CONSTRUCTIONS IN SCHOOLS. SOURCE. USGBC, 2017.

LEED for New Construction in Schools (v4)

		POSSIBLE: 1
Credit	Integrative process	1

LOCATION & TRANSPORTATION		POSSIBLE: 15
Credit	LEED for Neighborhood Development location	15
Credit	Sensitive land protection	1
Credit	High priority site	2
Credit	Surrounding density and diverse uses	5
Credit	Access to quality transit	4
Credit	Bicycle facilities	1
Credit	Reduced parking footprint	1
Credit	Green vehicles	1

SUSTAINABLE SITES		POSSIBLE: 12
Prereq	Construction activity pollution prevention	REQUIRED
Prereq	Environmental site assessment	REQUIRED
Credit	Site assessment	1
Credit	Site development - protect or restore habitat	2
Credit	Open space	1
Credit	Rainwater management	3
Credit	Heat island reduction	2
Credit	Light pollution reduction	1
Credit	Site master plan	1
Credit	Joint use of facilities	1

WATER EFFICIENCY		POSSIBLE: 12
Prereq	Outdoor water use reduction	REQUIRED
Prereq	Indoor water use reduction	REQUIRED
Prereq	Building-level water metering	REQUIRED
Credit	Outdoor water use reduction	2
Credit	Indoor water use reduction	7
Credit	Cooling tower water use	2
Credit	Water metering	1

ENERGY & ATMOSPHERE		POSSIBLE: 31
Prereq	Fundamental commissioning and verification	REQUIRED
Prereq	Minimum energy performance	REQUIRED
Prereq	Building-level energy metering	REQUIRED
Prereq	Fundamental refrigerant management	REQUIRED
Credit	Enhanced commissioning	6
Credit	Optimize energy performance	16
Credit	Advanced energy metering	1
Credit	Demand response	2
Credit	Renewable energy production	3
Credit	Enhanced refrigerant management	1
Credit	Green power and carbon offsets	2

MATERIAL & RESOURCES		POSSIBLE: 13
Prereq	Storage and collection of recyclables	REQUIRED
Prereq	Construction and demolition waste management planning	REQUIRED
Credit	Building life-cycle impact reduction	5
Credit	Building product disclosure and optimization - environmental product declarations	2
Credit	Building product disclosure and optimization - sourcing of raw materials	2
Credit	Building product disclosure and optimization - material ingredients	2
Credit	Construction and demolition waste management	2

INDOOR ENVIRONMENTAL QUALITY		POSSIBLE: 16
Prereq	Minimum IAQ performance	REQUIRED
Prereq	Environmental tobacco smoke control	REQUIRED
Prereq	Minimum acoustic performance	REQUIRED
Credit	Enhanced IAQ strategies	2
Credit	Low emitting materials	3
Credit	Construction IAQ management plan	1
Credit	IAQ assessment	2
Credit	Thermal comfort	1
Credit	Interior lighting	2
Credit	Daylight	3
Credit	Quality views	1
Credit	Acoustic performance	1

INNOVATION		POSSIBLE: 6
Credit	Innovation	5
Credit	LEED Accredited Professional	1

REGIONAL PRIORITY		POSSIBLE: 4
Credit	Regional priority	4

TOTAL	110

40-49 Points	50-59 Points	60-79 Points	80+ Points
CERTIFIED	SILVER	GOLD	PLATINUM

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A.2.2 COMPLETE LIST OF CATEGORIES AND INDICATORS OF THE LEED FOR NEW CONSTRUCTIONS IN SCHOOLS. SOURCE. USGBC, 2017.

CATEGORIES	INDICATORS
LOCATION AND TRANSPORTATION	LEED for neighborhood development location
	Sensitive land protection
	High priority site
	Surrounding density and diverse uses
	Access to quality transit
	Bicycle facilities
	Reduced parking footprint
	Green vehicles
SUSTAINABLE SITES	Construction activity pollution prevention
	Environmental Site Assessment
	Site Assessment
	Site development - protect or restore habitat
	Open space
	Rainwater management
	Heat island reduction
	Light pollution reduction
	Site master plan
	Joint use of facilities
WATER EFFICIENCY	Outdoor water use reduction
	Indoor water use reduction
	Building-level water metering
	Outdoor water use reduction
	Indoor water use reduction
	Cooling tower water use
	Water metering
ENERGY AND ATMOSPHERE	Fundamental commissioning and verification
	Minimum energy performance
	Building-level energy metering
	Fundamental refrigerant management
	Enhanced commissioning
	Optimize energy performance
	Advanced energy metering
	Demand response
	Renewable energy production
	Enhanced refrigerant management
	Green carbon and carbon offsets
MATERIALS AND RESOURCES	Storage and collection of recyclables
	Construction and demolition waste management planning
	Building life-cycle impact reduction

	Building product disclosure and optimization - Environmental product declarations
	Building product disclosure and optimization - Sourcing of raw materials
	Building product disclosure and optimization - Material ingredients
	Construction and demolition waste management
INDOOR ENVIRONMENT QUALITY	Minimum indoor air quality performance
	Environmental tobacco smoke control
	Minimum acoustic performance
	Enhanced indoor air quality strategies
	Low-emitting materials
	Construction indoor air quality management plan
	Indoor air quality assessment
	Thermal comfort
	Interior lighting
	Daylight
	Quality views
	Acoustic performance
INNOVATION	Innovation
	LEED Accredited Professional
REGIONAL PRIORITY	Regional Priority: Specific Credit

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ANNEX 3. THE BREEAM CERTIFICATION

A.3.1 BREEAM'S CATEGORIES AND CREDITS LIST. SOURCE. BRE, 2017.

CATEGORIES	CREDITS OR INDICATORS
MANAGEMENT	• Project brief and design • Life cycle cost and service life planning • Responsible construction practices • Commissioning and handover • Aftercare
ENERGY	• Reduction of energy use and carbon emissions • Energy monitoring • External lighting • Low carbon design • Energy efficient cold storage • Energy efficient transportation systems • Energy efficient laboratory systems • Energy efficient equipment • Drying space
HEALTH & WELLBEING	• Visual comfort • Indoor air quality • Safe containment in laboratories • Thermal comfort • Acoustic performance • Safety and security
TRANSPORT	• Public transport accessibility • Proximity to amenities • Cyclist facilities • Maximum car parking capacity • Travel plan
WATER	• Water consumption • Water monitoring • Water leak detection • Water efficient equipment
MATERIALS	• Life cycle impacts • Hard landscaping and boundary protection • Responsible sourcing of materials • Insulation • Designing for durability and resilience • Material efficiency
WASTE	• Construction waste management • Recycled aggregates • Operational waste • Speculative floor and ceiling finishes • Adaptation to climate change • Functional adaptability
LAND USE AND ECOLOGY	• Site selection • Ecological value of site and protection of ecological features • Minimizing impact on existing site ecology • Enhancing site ecology • Long term impact on biodiversity
POLLUTION	• Impact of refrigerants

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	• NOx emissions • Surface water run-off • Reduction of night time light pollution • Reduction of noise pollution
INNOVATION	• Innovation

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ANNEX 4. THE HQE CERTIFICATION

A.4.1 CATEGORIES AND GOALS OF HQE METHOD. SOURCE. CERTIVÈA, 2015.

CATEGORIES	GOALS
ENVIRONMENT	Target 1: Building relationship with its immediate environment Target 2: Integrated choice of products, systems and construction processes Target 3: Low environmental impact construction site Target 5: Water Management Target 6: Waste management Target 7: Maintenance - Sustainability Environmental Performance
ENERGY	Target 4: Energy Management
COMFORT	Target 8: Hygrothermal comfort Target 9: Acoustic comfort Target 10: Visual Comfort Target 11: Olfactory comfort
HEALTH	Target 12: Health quality of spaces Target 13: Health quality of air Target 14: Health quality of water

A.4.2 HQE'S LIST OF GOALS, SUB GOALS AND INDICATORS. SOURCE. CERTIVÈA, 2015.

TARGET 1: BUILDING RELATIONSHIP WITH ITS IMMEDIATE ENVIRONMENT	
SUB-GOALS	**INDICATORS**
LAND DESIGN FOR SUSTAINABLE URBAN DEVELOPMENT	Ensuring consistency between the urban development and the community politics
	Optimizing access and manage the flows
	Control on modes of transport and favors those who are the least pollutants for optimal functionality
LAND DESIGN AND BIODIVERSITY CONSIDERATION	Vegetation of surfaces
	Maintain and improve biodiversity
	Landscape integration of outdoor facilities
	Preserving biodiversity during construction site
OUTDOOR SPACES QUALITY FOR USERS	Creating a satisfying outdoor climate atmosphere
	Creating a satisfactory outdoor acoustic environment
	Creating a satisfactory visual atmosphere
	Ensuring healthy outdoor spaces
	Ensuring adequate night outdoor lighting
	Avoiding visual pollution
	Ensuring the right to the sun and natural light to local residents

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BUILDING IMPACTS ON LOCAL RESIDENTS	Ensuring the right to peaceful to local residents
	Ensuring the right to the views of local residents
	Ensuring the right to health quality of outdoor spaces for local residents
	Limit night visual pollution
	Selecting a site without disturbance on local residents
TARGET 2: INTEGRATED CHOICE OF PRODUCTS, SYSTEMS AND CONSTRUCTION PROCESSES	
SUB-GOALS	**INDICATORS**
SUSTAINABILITY AND ADAPTABILITY CONSTRUCTIVE CHOICES	Choosing products, systems and processes whose characteristics are verified and compatible to use
	Structure's adaptability in the time according to its lifetime and its uses
	Adapting the constructive choices to the building lifetime
	Disassembly / separability of construction products for an optimal end of life management
CONSTRUCTIVE CHOICE FOR THE ACCESSIBILITY DURING MAINTENANCE WORKS	Ensuring accessibility for building maintenance
	Products, systems and construction processes easy to maintain and limiting the environmental impacts of maintenance
CHOICE OF CONSTRUCTION PRODUCTS TO LIMIT THE STRUCTURE ENVIRONMENTAL IMPACTS	Knowledge about the construction equipment and products environmental impacts
	Choosing building products to limit their contribution to building environmental impacts
	Using materials and products with low CO2 emissions
	Implement a minimum volume of wood
CHOICE OF CONSTRUCTION PRODUCTS TO LIMIT THE HEALTH IMPACTS	Influence in the health impact of construction products to the indoor air quality
	Choosing building products to limit the building health impacts
	Limit the pollution by potential wood treatments
TARGET 3: LOW ENVIRONMENTAL IMPACT CONSTRUCTION SITE	
SUB-GOALS	**INDICATORS**
OPTIMIZING THE CONSTRUCTION WASTE MANAGEMENT	Identify and quantify the construction waste by typologies
	Reducing construction waste at source
	Valorize construction waste in adequacy with the existing local industries and ensure the right destination of waste
	Optimizing the collection, separation and consolidation of waste construction site
LIMITING NUISANCE AND POLLUTION ON THE CONSTRUCTION SITE	Limit noise pollution at the construction site
	Limit visual impact and optimize cleanliness of the construction site
	Limit pollution due to traffic from the construction site
	Water and soil pollution prevention from the construction site
	Avoiding air pollution at the construction site
LIMITATION OF RESOURCE CONSUMPTION ON CONSTRUCTION SITE	Reducing construction site energy consumption
	Reducing water consumption on site
	Easy reuse of excavated soil on the site

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TARGET 4: ENERGY MANAGEMENT	
SUB-GOALS	**INDICATORS**
REDUCING ENERGY DEMAND BY ARCHITECTURAL DESIGN	Improving building's ability to reduce summer and winter energy needs
	Improving the envelope air permeability
	Limit the envelope air permeability
	Improving the envelope's ability to limit losses
REDUCTION IN PRIMARY ENERGY CONSUMPTION	Reducing the primary energy consumption due to heating, cooling, lighting, ECS, ventilation, and other operations activities (depending on the building type)
	Implementing innovative (s) system (s)
	Limiting the consumption of equipments not-included in the thermal regulation
	Use of local renewable energy
	Limiting the artificial lighting included in the thermal regulations
	Improving the data center's energy efficiency
REDUCING POLLUTANTS EMISSIONS INTO THE ATMOSPHERE	CO2 equivalent amounts generated by the energy use
	SO2 equivalent amounts generated by the energy use
	Quantities of radioactive waste generated by the electricity network use
	Impact on the ozone layer
REFRIGERATING SYSTEM DESIGN	Refrigerant selection to limit its contribution to environmental impacts
TARGET 5: WATER MANAGEMENT	
SUB-GOALS	**INDICATORS**
POTABLE WATER USE REDUCING	Limit water needs in toilets
	Limiting the drinking water use
	Knowing the overall consumption of potable and non-potable water
RAINWATER MANAGEMENT OF THE LAND PLOT	Limiting soil waterproofing of the plot land
	Storing enough volume of rain water to handle an exceptional rainfall event and manage storm water in an alternative way
	Fighting against chronic pollution
	Fighting against accidental pollution
WASTEWATER MANAGEMENT	Controlling of wastewater discharges
	Recycling of wastewater
	Limiting discharges storm water to the public system
TARGET 6: WASTE MANAGEMENT	
SUB-GOALS	**INDICATORS**
OPTIMIZING THE WASTE VALORIZATION	Recommend or select the waste removal channel focusing its valuation
	Promoting the organic waste recovery
	Helping to reduce the waste accumulation
THE QUALITY OF MANAGEMENT SYSTEM	Promoting waste separation in the source in place where waste is produced
	Design of adequate waste stocking spaces or areas
	Ensuring hygiene of waste stocking spaces or areas
	Optimizing channels of waste management

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TARGET 7: MAINTENANCE - SUSTAINABILITY ENVIRONMENTAL PERFORMANCE	
SUB-GOALS	**INDICATORS**
BUILDING DESIGN FOR A SIMPLIFIED SYSTEM MAINTENANCE	Design the structure to facilitate maintenance operations during the operation phase
BUILDING DESIGN FOR CONSUMPTION MONITORING AND CONTROL	Checking the feasibility of maintenance and performance operations
	Provide measuring means for monitoring energy consumption
	Provide measuring means for monitoring water consumption
BUILDING DESIGN FOR MONITORING AND CONTROL COMFORT CONDITIONS AND SIMPLIFIED MAINTENANCE	Providing means for monitoring conditions of comfort
	Providing means for optimizing the systems operation and failures detection
TARGET 8: HYGROTHERMAL COMFORT	
SUB-GOALS	**INDICATORS**
ARCHITECTURAL LAYOUTS TO OPTIMIZE HYGROTHERMAL COMFORT IN WINTER AND SUMMER	Consider the site potential climate
	Improving the buildings ability to foster good comfort hygrothermal conditions
	Regrouping local spaces to provide hygrothermal homogeneous
	Controlling the midseason discomfort
CREATING HYGROTHERMAL COMFORT CONDITIONS IN WINTER	Setting an adequate interior temperature level in spaces
	Ensuring stable interior temperatures during user's occupancy
	Ensuring an interior air speed not affecting comfort
	Thermal environment control by the users during winter period
	Controlling the temperature differences between the various zones
	Controlling the humidity in winter period
	Limiting the effects of cold walls
CREATING HYGROTHERMAL COMFORT CONDITIONS IN SUMMER IN THE LOCALS NOT PROVIDED BY A COOLING SYSTEM	Ensuring a minimum thermal comfort level and protection of the windows from the sun
	Ensuring adequate ventilation and controlling the air flow to achieve summer comfort by opening windows
CREATING HYGROTHERMAL COMFORT CONDITIONS IN SUMMER IN THE LOCALS PROVIDED BY A COOLING SYSTEM	Setting an adequate interior temperature level in spaces
	Ensuring an air speed temperature not affecting comfort
	Controlling solar gain, especially the localized discomfort due to the heat radiation
	Controlling of the interior temperature by users during the summer
	Controlling humidity in the interior spaces during the summer
	Controlling the temperature differences between the various zones
TARGET 9: ACOUSTIC COMFORT	
SUB-GOALS	**INDICATORS**
ARCHITECTURAL LAYOUTS OPTIMIZATION FOR ACOUSTIC QUALITY	Optimizing the interior layout according to the indoor disturbances
	Optimizing the interior layout according to the external disturbances
	Optimizing the shape and volume of the spaces when the internal acoustic is an issue
	Isolation of spaces located face-to-face exterior spaces
	Noise impact levels transmitted through interior spaces

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CREATING AN ACOUSTIC QUALITY ENVIRONMENT ADAPTED TO DIFFERENT LOCAL	Equipment's noise impact levels through interior spaces
	Internal acoustic spaces
	Isolation areas from aerial noise (reception) face-t-face areas of intense activities (emission)
	Walking sonority in spaces
	Optimization of acoustic ambience criteria in the interior spaces
TARGET 10: VISUAL COMFORT	
SUB-GOALS	**INDICATORS**
NATURAL LIGHTING OPTIMIZATION	Daylight access
	Outdoor views access
	Minimum illumination in natural light
	Avoid direct or indirect glare from natural light
	Controlling of the visual atmosphere by users
ARTIFICIAL LIGHTING OPTIMIZATION	Adequate minimum lighting by artificial light
	Ensuring proper uniformity of artificial lighting
	Avoiding direct or indirect glare from artificial lighting and seek a luminance balance
	Ensuring a pleasant artificial light quality
	Controlling of visual atmosphere by users
	Qualitative lighting enhancement
TARGET 11: OLFACTORY COMFORT	
SUB-GOALS	**INDICATORS**
ENSURING EFFECTIVE VENTILATION	Implemention of a suitable ventilation system
	Ensuring air flows adapted to the local activity (in the presence of mechanical ventilation)
	Management device
	Ensure the systems' sealing (in presence of mechanical ventilation)
	Ensuring quality of air control supplied through a pipe (presence of mechanical ventilation)
	Ensuring optimal indoor air spaces scanning
CONTROL THE SOURCES OF UNPLEASANT SMELLS	Identifying and reducing the effects of unpleasant smells sources
	Treating odorous emissions to avoid the dissemination of smells
TARGET 12: HEALTH QUALITY OF SPACES	
SUB-GOALS	**INDICATORS**
LIMITING ELECTROMAGNETIC EXPOSURE	Identifying sources of electromagnetic emissions
	Limiting the impact of electromagnetic emission sources
CREATION OF SPECIFIC HYGIENIC CONDITIONS	Creating specific hygiene conditions outside maintenance area
	Optimize the health conditions of maintenance area
	Selecting materials limiting fungal and bacterial growth
TARGET 13: HEALTH QUALITY OF AIR	
SUB-GOALS	**INDICATORS**
	Implementation of a suitable ventilation system

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ENSURING EFFECTIVE VENTILATION	Ensuring air flows adapted to the space activity of local (in the presence of mechanical ventilation)
	Management device
	Ensure the systems' sealing (in presence of mechanical ventilation)
	Ensuring quality of air control supplied through a pipe (presence of mechanical ventilation)
	Ensuring optimal indoor air spaces scanning
CONTROL OF INDOOR AIR POLLUTION SOURCES	Identifying and reducing the internal and external effects of pollution sources
	Choosing building products to reduce the structure health impacts
	Knowing the construction products health impact and its contribution to the indoor air quality
	Limiter la pollution par les éventuels traitements des bois
	Controlling occupant exposure to indoor air pollutants
	Prevent the air bacteria development
	Ensuring the effectiveness of the air treatment system
	Limiting the trichloramine content in the air in indoor swimming spaces
TARGET 14: HEALTH QUALITY OF WATER	
SUB-GOALS	**INDICATORS**
INTERNAL SYSTEM DESIGN QUALITY	Choosing materials in accordance with regulations and compatible with the nature of the water supply
	Respecting the rules of implementation of pipelines and water system
	Structuring and signalizing the internal system based on water use
	Protection of the internal system
TEMPERATURE CONTROL IN THE INTERNAL SYSTEM	Implementation of a domestic hot water system to ensure an optimal temperature
	Optimization the hot water system design system to limit the risk of legionella
	Maintaining and controlling the temperature of hot water systems
TREATMENTS CONTROL	Selecting the disinfection treatments and / or anti corrosion and / or anti tartar in accordance with regulations and compatible with the water supply nature
	Controlling the performance of disinfection treatments and / or anti corrosion and / or anti tartar
	Health risk control related to the recovery and reuse on site of a non-potable water
WATER QUALITY OF BATHING SPACES	Treating polluted bathing water in accordance with regulations
	Avoiding deposits of pollution in bathing water
	Controlling the chlorinated derivative content of bathing water

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ANNEX 5. STARS METHOD

A5.1 GOALS, SUB-GOALS AND INDICATORS OF THE STARS METHOD. SOURCE. ASHAAE, 2017.

GOALS	SUBGOALS	CREDITS
ACADEMICS - (AC)	CURRICULUM	AC 1: Academic Courses
		AC 2: Learning Outcomes
		AC 3: Undergraduate Program
		AC 4: Graduate Program
		AC 5: Immersive Experience
		AC 6: Sustainability Literacy Assessment
		AC 7: Incentives for Developing Courses
		AC 8: Campus as a Living Laboratory
	RESEARCH	AC 9: Research and Scholarship
		AC 10: Support for Research
		AC 11: Open Access to Research
ENGAGEMENT - (EN)	CAMPUS ENGAGEMENT	EN 1: Student Educators Program
		EN 2: Student Orientation
		EN 3: Student Life
		EN 4: Outreach Materials and Publications
		EN 5: Outreach Campaign
		EN 6: Assessing Sustainability Culture
		EN 7: Employee Educators Program
		EN 8: Employee Orientation
		EN 9: Staff Professional Development
	PUBLIC ENGAGEMENT	EN 10: Community
		EN 11: Inter-Campus Collaboration
		EN 12: Continuing Education
		EN 13: Community Service
		EN 14: Participation in Public Policy
		EN 15: Trademark Licensing
OPERATIONS - (OP)	AIR & CLIMATE	OP 1: Greenhouse Gas Emissions
		OP 2: Outdoor Air Quality

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	BUILDINGS	OP 3: Building Operations and Maintenance
		OP 4: Building Design and Construction
	ENERGY	OP 5: Building Energy Consumption
		OP 6: Clean and Renewable Energy
	FOOD & DINING	OP 7: Food and Beverage Purchasing
		OP 8: Sustainable Dining
	GROUNDS	OP 9: Landscape Management
		OP 10: Biodiversity
	PURCHASING	OP 11: Sustainable Procurement
		OP 12: Electronics Purchasing
		OP 13: Cleaning and Janitorial Purchasing
		OP 14: Office Paper Purchasing
	TRANSPORTATION	OP 15: Campus Fleet
		OP 16: Student Commute Modal Split
		OP 17: Employee Commute Modal Split
		OP 18: Support for Sustainable Transportation
	WASTE	OP 19: Waste Minimization and Diversion
		OP 20: Construction and Demolition Waste Diversion
		OP 21: Hazardous Waste Management
	WATER	OP 22: Water Use
		OP 23: Rainwater Management
PLANNING & ADMIN.- (PA)	**COORDINATION & PLANNING**	PA 1: Sustainability Coordination
		PA 2: Sustainability Planning
		PA 3: Participatory Governance
	DIVERSITY & AFFORDABILITY	PA 4: Diversity and Equity Coordination
		PA 5: Assessing Diversity and Equity
		PA 6: Support for Underrepresented Groups
		PA 7: Affordability and Access
	INVESTMENT	PA 8: Committee on Investor Responsibility
		PA 9: Sustainable Investment
		PA 10: Investment Disclosure
	WELLBEING & WORK	PA 11: Employee Compensation
		PA 12: Assessing Employee Satisfaction
		PA 13: Wellness Program

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		PA 14: Workplace Health and Safety
INSTITUTIONAL CHARACTERISTICS - (IC)		IC1: Institutional Boundary
		IC2: Operational Characteristics
		IC3: Academics and Demographics
INNOVATION & LEADERSHIP - (IL)		Exemplary Practice
		Innovation

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ANNEX 6. EVVADES TOOL

A6.1 STRATEGY AND OPERATIONAL RESPONSE LEVELS

		1. STRATEGY AND GOVERNANCE
	NO.	**DEFINITION OF RESPONSE LEVELS**
S	**1.1**	**Together with all stakeholders (internal and external), contribute to building a responsible society that balances economic, societal and environmental concerns**
O	1.1.1	Raise awareness of and secure the participation of the Institution's staff and students in fostering sustainable practices
O	1.1.2	Act alongside regional and international networks of actors to help influence behaviors and share sustainable performance to build a responsible corporate body.
S	**1.2**	**Formalize its sustainable development & corporate social responsibility (SD&SR) policy and make it an integral part of the Institution's activity**
O	1.2.1	Define its sustainable strategy and develop an action plan the covers the three aspects of SD&SR
O	1.2.2	Integrate the process into every department/management of the Institution's and its activities (purchasing policy, education, research, social procedures, public actions, etc.)
O	1.2.3	Communicate the meaning of the approach to all stakeholders, together with the targets and measured result of the Institution's SD&SR actions
S	**1.3**	**Deploy (human, technical and financial resources, etc.) and steer SD&SR within the Institution's (structures, staff, management charts, etc.)**
O	1.3.1	Assign the mean required to drive SD&SR aiming for continuous improvement
O	1.3.2	Assess, analyze and factor in approach performance
		2. TRAINING
S	**2.1**	**Integrate SD&SR issues into programmes and lessons / Create specialized training centers**
O	2.1.1	Adapt lessons from conventional programmes: integration of SD&SR issues in initial training programmes including apprenticeship, internship and doctoral programmes
O	2.1.2	Integrate SD&SR into further / vocational training programmes
O	2.1.3	Create a specialised training centre and/or a doctoral school on SD and/or SR issues
S	**2.2**	**Promote and support the development of students' SD&SR skills**
O	2.2.1	Learning in how to apply SD&SR teaching in all training missions and work, including within companies.
O	2.2.2	Support with student initiatives (during and outside of training) in producing SD&SR projects (student in normal programme (initial training) or life-long learning students (further training)
S	**2.3**	**Promote and support the development of SD&SR skills in institution personnel (teachers, researchers, administrative staff)**

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O	2.3.1	Encourage and support teachers to drive the integration of SD&SR and the cross-cutting nature of lessons
O	2.3.2	Integration of SD&SR training actions into staff training policy.
S	**2.4**	**Promote the development of a knowledge-based society that complies with SD&SR principles**
O	2.4.1	Develop and support approaches, methods and learning media that encourage the circulation and availability of knowledge to stakeholders.
O	2.4.2	Open up to international perspectives from the standpoint of co-development (particularly with developing countries) concerning students and staff
		3. RESEARCH
S	**3.1**	**Promote the institution's interdisciplinary SD&SR research at regional, national et international level**
0	3.1.1	Develop transdisciplinary research projects dedicated to SD & SR at territorial, national and international level
0	3.1.2	Identify and consider SD & SR impacts (environmental, social and economic) in territorial, national and international research projects
S	**3.2**	**Put SD & SR research, its approach and its tools at the service of initial and continuing trainings programs and education**
0	3.2.1	Integrates the results of SD & SR research into training programs and education
S	**3.3**	**Valorize, transfer the results of SD & SR research to stakeholders at both national and international level**
0	3.3.1	Diffuser les résultats de la recherche SD&SR auprès des stakeholders tant au niveau territorail, national qu'international
0	3.3.2	Transférer les résultats de la recherche
		4. ENVIRONMENTAL MANAGEMENT
S	**4.1**	**Develop a policy covering the reduction of greenhouse gas emissions and the sustainable use and limitation of resource consumption**
0	4.1.1	Limit emissions and practices that emit greenhouse gases
0	4.1.2	Implement and integrate environmental, social and use-related energy performance criteria into building specifications
0	4.1.3	Set up a management system covering employee and student mobility together with an incentives-based policy that promotes the use of soft transport modes
0	4.1.4	Set up a responsible purchasing policy
O	4.1.5	Set up an energy management system for institutions together with actions aimed at improving the behavior of students and staff
S	**4.2**	**Develop a policy for preventing and limiting environmental impacts (including pollution)**
0	4.2.1	Optimize the treatment of liquid organic effluents
0	4.2.2	Optimize the sorting and recovery of waste mixed in with household waste

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0	4.2.3	Optimize the treatment and limit the production of hazardous and specific waste (exc. W.E.E.E) and hazardous liquid effluents
0	4.2.4	Optimize the treatment and reduction of W.E.E.E.
0	4.2.5	Limit and optimize air pollution treatments
S	**4.3**	**Develop a policy that promotes biodiversity**
O	4.3.1	Set up a sustainable management system covering cultivated environments, green spaces and developed spaces (roads and car parks)
O	4.3.2	Set up a sustainable management system covering natural environments
		5. FOCUS ON SOCIAL POLICY AND REGIONAL PRESENCE
S	**5.1**	**Promote a human and social policy that focuses on parity and diversity within the workforce**
O	5.1.1.	Set up actions that promote parity in staff recruitment and promotions
O	5.1.2.	Set up actions that promote diversity in staff recruitment and promotions
S	**5.2**	**Enhance and develop internal mobility and skills**
O	5.2.1	Staff targeted vocational training
O	5.2.2	Enhance staff skills thus helping to drive mobility
S	**5.3**	**Develop a quality-of-life policy at the institution (staff and students)**
	5.3.1	Set up a prevention, health and safety policy
	5.3.2	Set up a quality-of-life policy
S	**5.4**	**Promote an equal opportunities policy for students**
O	5.4.1	Set up an equal opportunities policy for all students as soon as they enter the institution and up to their professional integration
O	5.4.2	Set up action(s) and services that promote the reception and integration of international students
O	5.4.3	Set up student support services (job offers, scholarships, solidarity funds ...)
S	**5.5**	**Commit the institution to developing SD&SR on its territories**
O	5.5.1	Commit the institution to developing SD&SR on its territories

ANNEX 7. THE B4U TOOL

A7.1 AXES AND WEIGHTING FACTOR OF B4U

Axes	**Weighting factor**
Ability to bring about change	1
Air pollution	0,5
Climate resilience	1
Employment	1
Energy	1
Ensuring a liveable area	1
Innovation characteristics	1
Leadership	1
Materials	0,8
Political climate	0,4
Poverty alleviation	0,5
Professional implementation	1
Project Performance	1
Project Team	1
Promotion of a feeling of community/home	1
Promotion of diversity	1
Stakeholder involvement	0,8
Value creation	1

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Version 3.1

Innovation case inventory of:

<‘Aile Sud’ Building>

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1. *General description of the Urban Innovation*

1.1 General information

Name of the Innovation case:

'Aile Sud' building

Acronym for the Innovation case: *REEDS*

Country: France	**City:** Rambouillet

if necessary more precise location, or name of living lab:

Laboratoire REEDS - OVSQ
Université Versailles Saint-Quentin-en-Yvelines
Bâtiment Aile Sud, 15 bergerie nationale
Parc du Château
78120 Rambouillet

Current project status:
Choose one category from the list to describe the degree of maturity of the project.

☐ In design phase

☐ Approval process underway

☐ Being implemented

■ Completed/operational

Start of design/planning (year): 2009

Date of completion (estimate if on-going) (year): 2011

Key words describing the project at glance:

Renovation, energy efficiency, public building, project management

Innovation certification (if the innovation has been certified, labelled or accredited, please specify the name of the certification and the score):

As the 'Aile Sud' building was renovated basically indoors, the project coordinator did not require an environmental certification. However, even without seeking certification, the case of study was renovated according to the principles of the French environmental certifications HQE (Haute Qualité Environmentale) and the BBC (Bâtiment de Basse Consommation) certification and has strong environmental goals as energy efficiency and improvement of indoor air quality.

1.2 Urban Innovation characteristics

Short description of the Urban Innovation (highlighting the main innovative features and outcomes of the project):

The 'Aile Sud' Building is located at the Bergerie Nationale Complex, inside the Parc du Château, in Rambouillet, France. This building was renovated in 2009 to become the International Centre for Research in Ecological Economics, Eco-innovation and Tool Development for Sustainability (REEDS). The case of study is a building of four floors, has a floor area of 1334m² and accommodates teaching and research activities.

The case of study was restored and a special care was taken in the execution phase. The project is in an historical heritage site of the 17th century. Because of this some boundaries have been established to keep untouched the hole historical site and to preserve the building architecture style. Beyond of the painting service realization there was not interference in the facade. Moreover, an asbestos removal process was carried out one entire building by a specialist company.

A big part of the renovations activities was made inside the building. An interior design project was elaborated to accommodates teaching and research activities, the electricity installations were renovated and the thermal and acoustic isolation were improved.

Some impacts of the construction site have been reduced to keep the building in activity during the renovation process. A careful analysis was carried out to separate the construction work flow from the daily activities flow, and a study was conducted to indicate the construction site access inside the Parc du Château. Also, noise and dust restrictions and waste management actions were established in the construction site.

Moreover, this renovation project prioritized sustainability goals through guidelines of energy efficiency, indoor environmental quality and users comfort improvement, as:

- Insulation performance improvement,

- Electricity installations renovation providing quality and energy economy assurance,

- Energy-saving lighting,

- Occupancy sensors in the rooms and corridors that turn on the light with the user's presence,

- Encouraging the use of natural lighting (especially in spaces of longer stay) for energy consumption reduction and users visual comfort,

- Building information centralization in a computer-based control system called BMS (Building management system) for monitoring the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security system,

- Installation of electricity meters to measure and control energy consummation,

- Use of sustainable and resistant material and products,

- Use of internal shading devices to improve the climate comfort during the summer,

- Healthy air quality in all the building, principally in the meeting rooms,

- Priority by natural air ventilation,

- Great acoustic and thermal performance through a great isolation system that keeps the heat inside the building during the winter and the cold air outside

The architectural project was developed with the objective to give some flexibility for the building. Some internal spaces divisions (for example: dry walls) can be changed or expanded depending of the user's needs. In addition, lighting, thermal treatment and electric distribution can be easily adapted to the internal changes of spaces. Furthermore, hydraulic, electrical and heating systems are apparent behind demountable structures. This enables a full accessibility of the building systems and facilitates maintenance services.

The project was renovated also to give total accessibility to wheelchair users and visually handicapped. The corridors and doors are properly large to allow the wheelchair users passage, an elevator ensures wheelchair users access from the basement until the third floor and the main building entrance has ramps to ensures the wheelchair users access. The building is equipped with tactile paving close to the stairs to warn and conduct visually handicapped.

Type of Innovation:
What is the novelty of this particular project/initiative/approach that makes it innovative? In other words, what is new in the project that has not been implemented before? Please select ***one*** *from the list of innovation types below:*

☐ Financial/Fiscal

☐ Technical

☐ Political/governance

☐ Business/Commercial

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☐ Behavioural/Ethical

■ Education/Knowhow (knowledge economy)

Type of solutions:
Select one or more categories from the list, to signal in which area(s) the innovation idea/project takes place:

☐ Agriculture (e.g. urban agriculture etc.)

■ Built Environment (e.g. energy efficient buildings etc.)

☐ Energy (e.g. smart grids, renewable energy etc.)

☐ Water (e.g. smart water, sustainable urban drainage etc.)

☐ Waste (e.g. recycling, up-cycling etc.)

☐ Transport, mobility and Logistics (e.g. low-carbon vehicles, public transport, parcel deliveries etc.)

☐ Adaptation to climate change (e.g. green infrastructure)

Spatial scale:

Please specify the spatial scale that best fits the application scale of the innovation.

■ Single building

☐ Neighborhood or District

☐ Town/City

☐ Multiple site with multiple contexts

☐ Higher scales (region, country, etc.)

☐ N/A

Project type:

Select one category to characterize the type of urban development in which the innovation has been applied.

■ Retrofit

☐ New build

☐ Both retrofit and new construction

☐ N/A

Project site characteristics:

Please select the typology that best fits the land on which the project is implemented. If a combination, select multiple:

■ Greenfield site (previously undeveloped land, e.g. agricultural lands or pristine nature)

☐ Brownfield site (industrial lands, e.g. former industrial harbour)

☐ Greyfield site (previously developed lands, e.g. residential or commercial inner-city development)

☐ N/A

Land use type:

Select <u>one</u> category from the list, to signal the land use type for the urban development to which the innovation applies.

☐ Residential

☐ Commercial

☐ Public

☐ Mixed uses

☐ Transport

■ Green/blue belt

1.3 Principal contact of the Urban Innovation and contact details for follow up

Name: Martin O´Connor

E-mail: martin.o-connor@reeds.uvsq.fr

Address:

Laboratoire REEDS - OVSQ

Université Versailles Saint-Quentin-en-Yvelines

Bâtiment Aile Sud, 15 bergerie nationale

Parc du Château

78120 Rambouillet

1.4 Case study describer

Name: Mariana Bittencourt

Institute: Laboratoire REEDS - OVSQ

Université Versailles Saint-Quentin-en-Yvelines

E-mail:

mariana.bittencourt@uvsq.fr

Date of completion: 30/01/2015

2. Basic project figures

2.1 Project size

A. Number of units (#)	01
B. Residential dwellings (#)	0

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C. *Social housing units (#)*	0
D. *Commercial units (#)*	0
E. *Usable Floor Area, UFA (m^2)*	1313.20m²
F. *Total area of the project (m^2), including outdoor spaces*	1313.20m²
G. *Total impervious space (m^2)*	1313.20m²
H. *Expected life-span of the project (yr.)*	More than 150 years

2. 2 Energy related figures

A. *Final energy consumption (per year)*

This table may be completed for the project as a whole, or for a standard unit (e.g. one house).

After project completion:

Energy source	use	Consumption in kWh, M^3, l, kg or J	Conversion factor	common unit: kWh
Electricity (kWh)	heating, cooling, hot water provision	75714 kWh	1	75714 kWh
Natural gas (m^3)	heating, cooling, hot water provision		8,8 kWh/m^3	
Heating oil (l)	heating, cooling, hot water provision		11,6 kWh/l	
Solid fuels (kg)	heating, cooling, hot water provision		7,5 kWh/kg	
Wood	heating, cooling, hot water provision		3,8 kWh/kg	
Heat (GJ)	heating, cooling, hot water provision		277,78 kWh/GJ	
TOTAL				75714

NOTES (on specific conventions used in completing the table above):

B. Final energy savings in the project (heating, cooling, hot water provision only); % compared to reference	The final energy savings comparing to the reference is 56.97% and the final energy savings comparing to the initial project is 79.24%
C. Resulting primary energy consumption (heating, cooling, hot water provision only) (kWh/m^2)	149.90 kWh/m2
If these data are not available complete also the table below:	
D. Final energy consumption per year in reference situationErro! Indicador não d efinido.. *This table may be completed for the project as a whole, or for a standard unit (e.g. one house).*	**In reference situationErro! Indicador não definido.:**

Energy source	use	Consumption in kWh, M^3, l, kg or J	Conversion factor	common unit: kWh
Electricity (kWh)	heating, cooling, hot water provision	118848,26 kWh	1	118848,26 kWh
Natural gas (m^3)	heating, cooling, hot water provision		8,8 kWh/m^3	
Heating oil (l)	heating, cooling, hot water provision		11,6 kWh/l	
Solid fuels (kg)	heating, cooling, hot water provision		7,5 kWh/kg	
Wood	heating, cooling, hot water provision		3,8 kWh/kg	
Heat (GJ)	heating, cooling, hot water provision		277,78 kWh/GJ	
TOTAL				118848,26

NOTES (on specific conventions used in completing the table above)**:**

E. Total amount of renewable energy produced on-site (kWh/year)	0
F. Recovered heat (GJ) from on-site CHP plant or from external industrial processes or waste incineration per year	0
G. Total energy costs for residents before the project (€ / per year)	26251,38 €/ per year
H. Total energy costs for residents after the project (€ / per year)	14645,94 €/ per year
I. CO_2 emission reduction compared to reference (tonnes/year): not available from the project this can be calculated.)	25,535 (tonnes/year)
2.2.1 People	
A. Fixed housing costs, such as rents and mortgage payments (€ / year)	0
B. Gross household income in the direct region of the project (€ / year)	60000 (€ / year) - couple with two children
C. Total cost savings per household, per year (€ / year)	0
2.2.2 Project's financials	
Total investment of low-carbon measures (€)	1 647 000,00€ (taxes included)
A. Total subsidies (€)	1 826 770,00€
B. Annual profits accruing for the investor because of the investment (€)	**0**
C. Total annual operating and maintenance costs (€)	16952,36€
2.3 Description of the Reference/Business as Usual	

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- *Thermal bridges: They are created when materials that are poor thermal insulators come into contact, allowing heat to flow through the path of least thermal resistance created, although nearby layers of material separated by airspace allow little heat transfer. Four types of thermal bridges where studied and the all the thermal bridges values were calculated.*
- *Glasses: A study of the existed glass system was studied and a glass modern system was installed without compromising the historical facade.*

The technical equipment studied are related with the heating, lighting and ventilation systems.

- *Heating and cooling system: Installation of an aerothermal heating system. The heat pump draws the*
- *air calories and made a heat exchange through a refrigerant fluids air system.*
- *Lighting system: An efficient lighting system was installed with presence detector.*
- *Ventilation system: Double flow ventilation system with a heat recover up to 89%.*

3. People, Planet & Profit indicators

3.1 People indicators	
3.1.1 Fuel Poverty	
What is the change in percentage of (gross) household income spent on energy bills?	..... % change in (gross) household income spent on energy bills.
	Further information:
3.1.2 Affordability of Housing	
To what extent are the housing costs considered affordable in the project? *The housing costs include all fixed expenditures on housing (such as rents and mortgage payments), and exclude expenditures for services or utilities. This usually differs between owner-occupiers (lower) and tenants (higher).* ***Note:*** *Please include an indication of the affordability by calculating the share of the average housing costs (in the project after its completion) in the regional household income.*	Not affordable — 1 — 2 — 3 — 4 — 5 — Very much affordable Not applicable— ☐
	Further information:

3.1.3 Social housing	
What is the percentage of social dwellings as share of the total housing stock in the project? *The indicator applies mostly to newly built neighbourhoods, or in renovation neighbourhoods where the housing structure is completely changed.* ***<u>Calculation note:</u>*** *The indicator can be calculated by taking the total units (A) and social housing units (C) under Project Size in the Basic Project Figures table.*	0% of total housing stock in the project are social dwellings. Further information: Not applicable for this project.
3.1.4 Connection to the existing cultural heritage on the premises by design	
To what extent was making a connection to the existing cultural heritage considered in the design of the project? *Heritage places are an important link between past and future generations. Keeping the location's special identity could bring economic as well as other benefits to the area.*	Not considered– 1 — 2 — 3 — 4 — ■ — Very much considered Not applicable— ☐ Further information: The design of the project has a strong connection with the existing cultural heritage since the 'Aile Sud' building renovation project retained the building historical façade in an act of recognition the history.
3.1.5 Design for a "sense of place"	
To what extent has the project team given attention to "a sense of place" in the design of the project? *Sense of place, describes the atmosphere to a place, the quality of its environment, containing certain characteristics that create a sense of authentic human attachment and a feeling of belonging/home.* *Important features that support a sense of place include vitality, safety, identity, proportion and visual variety.*	Not considered– 1 — 2 — 3 — 4 — ■ — Very much considered Not applicable— ☐ Further information: The attention paid during the project renovation concept on creating a "sense of place" is clearly and recognizagly, even for outsiders. During the 'Aile Sud' building renovation, a whole security system was instaled and a visual identity and interior design project were elaborated according to users needs.
3.1.6 Ensuring the Comfort & Image of Public Spaces	
Does the project have suitable management arrangements in place to ensure that the quality & image of public spaces is retained after project completion? *In order for public spaces such as streets, open green spaces, squares & plazas to*	■ **Yes:** The project includes a suitable management arrangement. ☐ **No:** The project does not include a suitable management arrangement.

fulfill their sociable role, they need to be comfortable and have a good image. This includes perceptions about cleanliness of the area, safety, as well as visual attractiveness, thermal comfort and shelter. A suitable management arrangement should be in place to ensure that they remain their quality and positive perception.	 Further information:
3.1.7 Availability of multi-modal mobility options	
To what extent are public transportation stops available within a radius of 500m from the central living area of the project? *The availability of alternatives to car use can lead to less car use and congestion, thereby contributing to an accessible, green and healthy neighbourhood.* *As local circumstances vary, no absolute benchmark is attached to this indicator, instead a qualitative impression is asked for.*	No stops – 1 — ■ — 3 — 4 — 5 — Relatively many stops Not applicable— ☐ Further information: As the project location is inside the Parc du Chateau, there is just one public transportation stop within a radius of 500 meters. However, in 2 kilometres it is possible to access Rambouillet downtown where there is two another bus stops.
3.1.8 Availability of Public Amenities	
To what extent are important public amenities (such as green public spaces, community centres, theatres or libraries) available within a radius of 500m from the central living area of the project? *As well as the availability of multi-modal mobility options, the availability of a variety of public amenities leads to a lively neighbourhood and less car use.* *As local circumstances vary, no absolute benchmark is attached to this indicator, instead a qualitative impression is asked for.*	No public amenities – 1 — 2 — 3 — 4 — ■ — Relatively many public amenities Not applicable— ☐ Further information: The 'Aile Sud' building is in the Bergerie Nationale Complex with other teaching activities buildings, general services, a restaurant and a grocery shop. Furthermore, the 'Aile Sud' Building is in a National Park with a green area of 100 acres.
3.1.9 Availability of Commercial Amenities	
	No commercial amenities – 1 — ■ — 3 — 4 — 5 — Relatively many commercial amenities

To what extent are commercial amenities available within a radius of 500m from the central living area of the project? *Commercial amenities are services/facilities which are provided by private actors. Typical commercial amenities include grocery stores, restaurants, bars, shops etc.* *As local circumstances vary, no absolute benchmark is attached to this indicator, instead a qualitative impression is asked for*	Not applicable— ☐ Further information: As the 'Aile Sud' building is located in the Bergerie Nationale Complex, inside the Parc du Chateau area, 2 kilometres far from downtown where is possible to find several commercial amenities. Within a radius of 500m there is just one grocery store with organic products and a restaurant.

4. Planet indicators

4.1 Annual primary energy consumption

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What is the annual primary energy consumption of all buildings on the project site? *Primary energy consumption, in contrast to final energy consumption (see 2), is regarded as the common indicator for measuring energy consumption. For comparability, the focus is on the annual consumption of all buildings on the project site and for building-related energy consumption: heating and water heating, and cooling.*	The annual primary energy consumption is 149.90 kWh/m^2 UFA. ***Calculation note:*** *If this indicator is not available from the project (see basic figures on p.9: 2.2 C), use the calculation help below:* Fill in the final energy use (in kWh) from the Basic figures on 2.2.C. Note that the calculation can be done for all buildings in the project or one (standard) unit only.

Energy source	use	Final energy use (kWh)	Conversion factor	Primary energy use (kWh)
Electricity	heating, cooling, hot water provision	75714	2,6	196856,4
Natural gas	heating, cooling, hot water provision		1,07	
Heating oil	heating, cooling, hot water provision		1,08	
Solid fuels	heating, cooling, hot water provision		1,07	
Wood	heating, cooling, hot water provision		1,01	
Heat	heating, cooling, hot water provision			
TOTAL				196856,4

Take the usable floor area (UFA) from the Basic figures on p. 9 (2.1 F), to calculate the total primary energy consumption in kwh/m^2 UFA.

Further information: The project is an office building located in the climate zone C (France).

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4.2 Annual final energy consumption	
What is the annual reduction percentage compared to the reference situation, for the final energy consumption for heating cooling and hot water provision of all buildings?	The reduction in annual final energy consumption is 56.97% Further information: The final energy savings comparing to the reference is 56.97% and the final energy savings comparing to the initial project is 79.24%
4.3 Primary energy use for transport	
What is the reduction in percentage per year, compared to the business as usual situation, for the primary energy use of transportation?	The annual primary energy use for transport is 0 % lower than the business-as-usual situation. Not applicable— ■ Further information:
4.4 Share of recovered heat	
What is the share of recovered heat in the total energy consumption? *This indicator includes two types of heat: (1) heat recovered from industrial processes or waste incineration delivered to the project and (2) heat resulting from cogeneration, or Combined Heat and Power (CHP) on-site.*	The share of recovered heat in the total energy consumption is 0 %. Further information:
4.5 Share of renewable energy produced on-site	
What is the renewable energy produced on-site as share of the total energy consumption?	Renewable energy produced on-site is 0 % of the total energy consumption. Further information: There is no renewable energy production for this project.
4.6 Carbon dioxide emissions	
What is the reduction of CO_2-emissions in metric tonnes CO_2 per year, that is achieved by the project?	The reduction in CO_2-emissions is nearly 25 metric tonnes per year. After project completion (use basic figures 2.2A):

Energy source	use	Final energy consumption in kWh, M3, l, kg or J	Conversion factor	CO_2 emissions (kg)

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Electricity (kWh)	heating, cooling, hot water provision	75714 kWh	0,592 kg CO_2/kWh	44822,688kg
Natural gas (m^3)	heating, cooling, hot water provision		2,650 kg CO_2/m^3	
Heating oil (l)	heating, cooling, hot water provision		3,164 kg CO_2/l	
Solid fuels (kg)	heating, cooling, hot water provision		2,339 kg CO_2/kg	
Wood (kg)	heating, cooling, hot water provision		0 kg CO_2/kg	
Heat (GJ)	heating, cooling, hot water provision			
TOTAL				44822,688kg

In reference situation (source: basic figures 2.2D):

Energy source	use	Final energy consumption in kWh, M3, l, kg or J	Conversion factor	CO_2 emissions (kg)
Electricity (kWh)	heating, cooling, hot water provision	118848.26 kWh	0,592 kg CO_2/kWh	70358.16kg
Natural gas (m^3)	heating, cooling, hot water provision		2,650 kg CO_2/m^3	
Heating oil (l)	heating, cooling, hot water provision		3,164 kg CO_2/l	

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Solid fuels (kg)	heating, cooling, hot water provision		2,339 kg CO_2/kg	
Wood (kg)	heating, cooling, hot water provision		0 kg CO_2/kg	
Heat (GJ)	heating, cooling, hot water provision			
TOTAL				70358.16kg

4.7 Materials used	
What is the reduction in material use when compared to the business as usual scenario?	The reduction in material use is 10 %, when compared to the business as usual scenario.
To assess whether material consumption is minimized in absolute terms, a fairly easy indicator is determining the average weight of the buildings on the project site per square meter.	Further information:
4.8 Share of Recycled Input Materials	
What is the percentage of recycled input materials in the total amount of materials used?	5% of the total materials used are recycled input materials.
Recycled materials are materials that have been used before and that can be re-used as they are (e.g. sinks) or can be reproduced/adjusted, requiring energy input, to fit their new destination (e.g. recycled concrete or aluminium). By using recycled materials in the process, the environmental impact will be reduced as less resources have to be exploited and less energy has be used to process the raw materials into useful products.	Further information: The old windows where repaired and reused in the new windows system.
4.9 Share of Renewable Materials	
What is the percentage of renewable materials in the total amount of materials used?	20% of the total materials used are renewable materials.
Renewable materials are natural materials that regrow themselves, like wood, hay, bamboo and flaxen. Processing these materials into useful products (e.g. wooden beam) requires less energy than mining non-renewable resources, like iron	Further information: Windows' frame, existing furniture and one part of the building framework are made of wood which is a renewable material. The new furniture is made by wood certified by the FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification).

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ore, processing these first into iron and then into useful products (e.g. iron beam).	
4.10 Share of Materials Recyclable	
What is the percentage of recyclable materials in the total amount of materials used? *Looking into the future, we should also already take into account to what extent the used materials can be recycled after the lifetime of the project, to enhance re-use and recycling for next projects. This is large part due to the design of the building and its elements. Foremost, the materials should be individually separable to be able to retrieve them in their purest form. So not only should the materials be intrinsically recyclable, they should also be practically retrievable. If the materials recyclable can't be separated during demolition, they will not be taken into account in this calculation.*	90% of the total materials used are recyclable materials. Further information: Doors, windows, frames, panels, plumbing fixtures, floor or ceiling tiles, sinks and other building elements (requiring energy input) to fit a new destination.
4.11 Embodied energy of materials	
What is the percentage of total embodied energy saved in the total embodied energy of all materials used? **(if quantitative data is not available use the indicator below)** *The primary focus of Eurbanlab is on mitigation, so it makes more sense to assess the indirect energy of the project then the weight of the materials used. Also, since more and more projects have the ambition to develop energy neutral buildings and passive houses, the direct, operational energy will be reduced or neutralized and the indirect, embodied energy of materials becomes more and more important.*	A reduction of 0% has been reached in the total embodied energy of all materials used. Further information:
To what extent have measures been taken to reduce the embodied energy of the materials used? *If quantitative figures of embodied energy are not available, a more qualitative approach would be to estimate to what extent measures have been taken to reduce the embodied energy of the materials used, such as re-use, recycling, renewable materials, extending the life time.* *Instead of checking the actual measures taken, the question here is geared towards*	Not at all — 1 — 2 — ■ — 4 — 5 — Very much Not applicable— ☐ Further information:

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the extent to which embodied energy was a factor in decision making.	
4.12 Climate resilient design neighbourhood	
To what extent have climate adaptation measures on neighbourhood scale been included in the design of the project? *To make neighbourhoods resilient to future changes in climate various measures can be taken to lower the sensitivity to high temperatures during heat waves and to prevent streets and cellars from flooding during extreme rainfall events. In some cases, measures need to be taken to prevent flooding from rivers or the sea. Taken the variety of possible options, and the relative newness of the issue, the indicator Is phrased as a qualitative question.*	Not at all — 1 — 2 — 3 — ■ — 5 — Very much Not applicable— ☐ Further information: The building was whole renovated to improve thermal insulation to reduce heat transfer and to promote thermal comfort for building users. Also, waterproof pavement was avoided around the building to prevent flooding from rivers.
4.13 Impervious surface	
What is the amount of impervious space after project completion as share of the total surface? *The surface cover of the area, the share of green, blue and impervious space, are important factors in determining the outdoor temperature and the potential of rainwater storage and infiltration during heavy precipitation.*	30% of the total surface area is impervious after project completion. Further information: As the project consists just in a building refurbishment and was not built anything new, the area and impervious space remained the same.
4.14 Climate resilient design buildings	
To what extent have climate adaptation measures been included in the building design? *Various measures can be taken to adapt the building envelope and prevent high indoor temperatures, such as extra insulation, extra thermal mass, southward orientation, implementing overhang, raising the albedo, green roof/facade, possibility to open windows for ventilation. However, since their impact depends on factors like the type of building and the energy performance of the building, it is difficult to determine one general indicator for an average building. A more qualitative description is therefore chosen for this indicator.*	Not at all — 1 — 2 — 3 — 4 — ■ — Very much Not applicable— ☐ Further information: During the renovation process, all the building (walls and ceiling) was insulated to improve the building energy efficiency. Natural insulation was used in the insulation system. The system is composed by 70% of plume, 20% of polyester and 10% of sheep wool. Furthermore, all the window´s glasses were replaced by the Thermal Reinforced Insulation system that is composed by a double-glazing technology and inert gas to fill the cavity within a low-emissivity.
4.15 Emission of NOx	

What is the reduction of NOx emissions on a yearly basis? *Emission of NOx by transport.*	A reduction of % in NOx emission per year has been reached, compared to business as usual. Not applicable— ■
	Further information: As the project did not interfere in the existing transportation system, this indicator is not applicable.
4.16 Emission of PM10	
What is the reduction of PM10 on a yearly basis? *Emission of PM10 by transport.*	A reduction of .....% in PM10 emissions per year has been reached, compared to business as usual. Not applicable— ■
	Further information: As the project did not interfere in the existing transportation system, this indicator is not applicable.
5. Profit indicators	
5.1 Use of Local workforce	
What is the expenditure in the project on local suppliers, contractors and services as share of total project costs? *Part of the value created by urban projects is the contribution to local employment. It is very difficult to compare the number of jobs generated after the project's completion, but we can evaluate the contribution to local employment during the project's execution. Local is loosely defined as "from the city or region", according to the local practice of looking at who comes from close by and who is from outside the area.*	It is estimated that 82% of the total project costs has been spent on local suppliers, contractors and service providers.
	Further information: These criteria were assessed regarding the companies that are situated in the same region of the project. The region in this context is called Île-de-France. The region is made up of eight administrative departments: Paris, Essonne, Hauts-de-Seine, Seine-Saint-Denis, Seine-et-Marne, Val-de-Marne, Val-d'Oise and Yvelines.
5.2 Total cost savings for end-user	
What are the total cost savings in euros for end-users per household, per year? *Another dimension of value creation is seen as the extent to which the urban project generated cost savings for end-users. End-users are seen as those people who will be living in the area and using the*	Total cost savings per household are € 11 605.44 on a yearly basis.
	Further information: These information is about the total cost savings with energy bills. Before the building renovation the energy bill was about

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techniques or concepts applied in the development of the area. Total cost savings, e.g., can be generated through a reduction in energy/water use or the generation of renewable energy on site.	€26 251.38/year and after the renovation, about €14 645.94/year
5.3 Net Present Value	
What is the calculated NPV of the innovation per m², over the lifespan of the project? *The Net Present Value (NPV) is a measure of financial project performance. The NPV is calculated by subtracting the net benefits of the project with the net costs, and applying a discount factor to take into account the capital value over time. If the benefits exceed the costs, the NPV is positive and the project is worth pursuing. In order to compare between projects, we ask for the calculated NPV per m², over the lifespan of the project.*	The calculated NPV of the innovation is .... per m² over the lifespan of the project. Further information: Net benefits = ? Net costs = €16 952.36 Net present value = €-5 346.92 Usable floor area (m2) = 1 313.20m2 It is difficult to calculate the NPV because as the building is an institutional site that depends of the development of projects for the annual budget it is not possible to calculate concrete data.
5.4 Payback Period	
What is the Payback Period of the project? *Although environmental burden reductions are a key benefit of investing in low-carbon urban development projects, the investment should also be justified financially. The simple Payback Period is the time required for owners/operators to get return on their investment, based upon their initial investment and the annual savings achieved as a result of the investment.* ***<u>Note:</u>*** *Within the context of Eurbanlab, the Payback Period refers to the disaggregated energy/low-carbon investments. The Payback Period should be calculated or provided as an estimate from the project documentation.*	The Payback Period of the project is ... years. Further information: This data needs to be review as we cannot assume the cash inflow per year of the REEDS centre. As much as we had the initial investments as €1 647 000.00 and the cash inflow per year it is not possible to assumed, it is not possible to calculate the payback period of the project.
5.5 Total Costs versus Subsidies	
What are the total subsidies as share of total investment and/or running costs for implementation of the project? *In relation to the funding of low-carbon*	The total required subsidies were 100 % of total investment and/or running costs for implementation of the project.

development projects, much of the low-carbon development projects to date rely to some extent on subsidies. However, too heavy a reliance on external funding might increase the perception of risk and create uncertainty in project development. The indicator 'total costs versus subsidies' therefore aims to provide an indication of the project's reliance on external funding mechanisms.	Further information:
5.6 CO_2 reduction cost efficiency	
What are the total costs of the additional low-carbon measures, in euros per ton of CO_2 saved, pear year? *Low-carbon urban development project are intrinsically aimed at reducing the amount of CO_2 emitted during their lifetime. Those projects which prove to be able to significantly reduce their carbon footprint, whilst keeping the related costs at a minimum, are considered to be interesting projects in the context of Eurbanlab. New concepts, practices and approaches to low-carbon urban development need to be economically attractive to be practical for up scaling. This indicator is calculated on an annual basis, taking the annual reduction in CO_2 emissions, and the annual costs of the project (which is the annualised investment plus current expenditures for a year).* ***Note:*** *Only the additional costs for energy/CO_2 related measures (to the extent discernible) are taken into account in the total costs calculation.*	The total cost of additional measures is €64,49 per tonne of CO_2 saved, per year. Further information:

6. Descriptive project assessment

6.1 Development process

6.1.1 Description of the context

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Planning context:
Describe the planning context that applies to the project, including relevant planning provisions that apply to the land, any relevant policies or strategies (e.g. for urban design or neighbourhood character), development demands on site and the surrounding area (e.g. residential uses, mixed use, high density building etc.).

The planning context applied to the project is described above:

- *Study phase of the project*

a) Diagnosis

b) Validation

c) Project's dossier development

d) Project's dossier deposit

e) Elaboration of a list of our companies involved in the project

f) Analysis of offers

g) Contracts

- *Project execution*

a) Preliminary activities

b) Asbestos removal

c) Construction site activities

- Facilities construction and preparation

- Deconstruction

- Unsealing and asbestos removal

Financing context:
Describe how the project was financed (e.g. what were the financing options, what hampered or enabled project financing, did economic incentives such as subsidies or taxes play a role?).

The Bergerie Nationale site, in Rambouillet, was renewed to become a pole of excellence and benchmark for the development of a sustainable territory. This strategic choice was reaffirmed by the President of the Republic in 2008.
In this context, it was decided to create a training and research centre in the Bergerie Nationale in Rambouillet, involving the Ministry of Agriculture (owner of the Bergerie Nationale site) and the University of Versailles Saint- Quentin-en-Yvelines (UVSQ). The Ministry of Agriculture through an agreement gave the ‘Aile Sud’ building of the Bergerie Nationale temporarily to the UVSQ for the implementation of REEDS. The UVSQ, as the project owner and coordinator, financed the renovation project of the ‘Aile Sud’ building.
As the fiber connection was also one interesting of the municipality, it was financed a half by the UVSQ and a half by the Community of Municipalities of and Forests of Yvelines (CCPFY).

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Governance context:

Describe how the governance context influenced the project (e.g. roles, strategies and interests of actors, the influence of existing urban policies, routines and practices of local or regional governments etc.).

- *Financial context: The government (Conseil General des Yvelines and the Ile-de-France Department) financed the project through the UVSQ.*
- *Building's concession context: The 'Aile Sud' building was temporarily conceded by the Ministry of Agriculture to the UVSQ to develop researching and teaching activities.*
- *Norms, roles, laws and regulation context: In the study phase of the project and in the execution phase, all the activities and design project followed norms (for instance: ISO 11801 for communication infrastructure installation and the NF EN 81-70 related to the building accessibility), and laws and regulations (Urban Planning Code, Construction Code, Conditions of Work Code). It is important to highlight that all this norms and regulations are related with different stakeholders, for instance: building occupants and workers of the construction site (in this case the governance needs to follow the construction site to check if the essential conditions of health and safety are being followed).*
- *Influence of existing urban policies context: As the 'Aile Sud' building is inserted in the historical heritage of Bergerie Nationale and is protected by an existing urban policy, the building was entire renovated inside but the exterior façade was maintained the same, to protect the Bergerie Nationale heritage.*

6.1.2 Leadership 'Framing'	
To what extent is/are the leader(s) of the project successful in explaining why this urban development is better than the 'old' way of doing things?	Not at all — 1 — 2 — 3 — 4 — **5** — Very much Not applicable— ☐
An important characteristic of leadership is the ability to promote and create support for the project. Through framing, leaders can promote their preferred institutional arrangement as appealing to the widest possible audience.	Further information: The Leadership 'Framing characteristic is very strong in the 'Aile Sud' building project. During the conception phase a study of energy efficiency improvement was made and some different solutions of isolation, heating and ventilation system was made regarding benefits and costs to choose the best solution for the case of study. The solutions regarding the energy efficient system chosen was legitimized through the analyse of effects. It is correct to affirm that the 'Aile Sud' building engage different stakeholders from different sectors and that its conception created enthusiasm for these different stakeholders, especially the University of Versailles. Without successful project management that engaged all the stakeholders the 'Aile Sud' building project conclusion will not be possible.
6.1.3 Leadership 'Bridging'	
To what extent is/are the leader(s) of the project successful in fostering collaboration, bringing	Not at all — 1 — 2 — 3 — **4** — 5 — Very much Not applicable— ☐

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people together, connecting different interests, and forming a supportive group of stakeholders? *Through cooperation and collective action, leaders bring together the interests of different groups, e.g., by providing common meaning or identities or sketching a pervasive vision on a common development path. To reach this goal, leaders should collaborate with other actors, such as local authorities, to influence macro level institutions and to connect previously unconnected actors such as users, universities, authorities and NGO's. Through the distributed agency in this collaborative process, opportunities are discovered and created, tools and knowledge are accumulated and development paths emerge.*	Further information: Through the cooperation and collective action, the 'Aile Sud' building renovation brought together stakeholders in a regional and national scale and from different sectors (institutional, cultural, entrepreneurial, educational.) to work in a collaborative way in the development of this project.
6.1.4 Leadership 'Lobbying'	
To what extent is/are the project leader(s) successful in creating the right connections to government officials (municipalities etc.) and creating support for the project'? *Lobbying, using political tactics and power, can be employed to bring forward the vision and interests of the collective, or of the single, entrepreneurs. Institutional theory describes how the degree to which such power can be employed depends on the resources and social or network position of the leader or their capacity to mobilize actors and resources. As the role of politics, government policies and regulations in the built environment is large, we expect the role of lobbying to play an important role (also in the form of advocacy advertising, constituency building and coalition formation).*	Not at all — 1 — 2 — 3 — 4 — 5 — Very much Not applicable— ☐ Further information: As the project was developed by the University of Versailles in a presidential site (Parc du Chateau), it is possible to affirm that the project leader was very much succeeded in creating the right connections to governments officials and creates also considerable governmental support for the project. In each meeting during the 'Aile Sud' Building development phase, representatives of the state, the regional and national council, the city hall, the presidential domain and the university were discussing together their interesting and the challenges for the project development. All the rules, policies and regulations were respected.
6.1.5 Leadership 'Persistency'	
To what extent did the project benefit from a leader who persevered in his/her endeavour to realize the project plan (including its ambitions & targets), also in adverse conditions, to ensure the continuity of the project? *Leadership appears to be critical in different phases of project development. In the first stages of low-carbon development projects, leadership often provides the first 'spark' for low-carbon development. However, urban development with a significant low-carbon component requires significant 'leadership' from certain actors who have 'the determination' and desire to create something new and challenging, and for such a process to succeed. This desire requires persistency*	Not at all — 1 — 2 — 3 — 4 — 5 — Very much Not applicable— ☐ Further information: As the project involved lot of different stakeholders because it is a university building financed by the government in a presidential domain and in a historic site, it is possible to affirm that it was challenging to deliberate with all the stakeholders and find every time ways to take decision considering everyone. Lot of organization was required to succeed in this project and without persistency of the project manager it will not be possible.

in the recurrent stages of project development, in which leader's function as a sustained catalyst for change, working in a facilitative way and mediating between different parties.	The project leader/manager showed important determination to keep the project going even with difficult circumstances (lack of funds, lack of cooperation, delays in the work).
6.1.6 Involvement of public stakeholders	
To what extent have tenants, the local community been involved in project planning and execution? *The need for timely and effective public involvement has been identified for successful sustainable urban development initiatives as user behaviour is an essential component of the project's performance in the use phase.*	Not at all — 1 — 2 — 3 — **4** — 5 — Very much Not applicable— ☐ Further information: Community actors were asked by the project planners to participate in the planning process by prioritizing issues and planning actions. This local community is represented by the REEDS' members that were in other building before to come to the Bergerie National site. The interior design concept and spaces division were made regarding their needs. Besides that, the Rambouillet city hall was involved in the decisions of the internet network extension.
6.1.7 Involvement of professional stakeholders outside the project team	
To what extent have professional stakeholders outside the project team been involved in planning and execution? *The indicator aims to provide an indication of the extent to which a range of different professional stakeholders <u>outside the project team itself</u> have been involved in the planning and execution process of the project.*	No involvement — 1 — 2 — 3 — 4 — **5** — High involvement Not applicable— ☐ Further information: The project of the renovation of the Aile Sud building will not be possible without the fully involvement of the professional stakeholders, for instance: architects, local councils, project developers. The stakeholders were involved actively through meetings in developing the project plan and advising on its implementation.
6.1.8 Government Vision	
To what extent has the project been hampered by or has the project benefitted from a long-term sustainability vision from the government? *The existence of a long-term sustainability vision provides ways in which low-carbon urban development initiatives can connect to larger development aims within the city, as well as benefit from supporting measures. Unfortunately, present responses to climate change are often hampered by short term politics, rather than realistic long-term visions that support low-carbon urban development.*	Very much hampered — 1 — 2 — 3 — **4** — 5 — Very much benefitted Not applicable— ☐ Further information: The long-term vision of the government must some extent benefited the project in the development of the project or in achieving its ambitions. An example of this can be perceived it is in the scenario that the energy efficiency buildings are inserted. About the French government there is an incentive for this type of renovation provided by the 'Grenelle' set of laws. At the same way, in the European scale it is possible to mention the '2010 Energy Performance of Buildings Directive' and the '2012 Energy Efficiency Directive' that constitutes the EU's main legislation when it comes to reducing the energy consumption of buildings.

6.1.9 Prior experience with the innovation	
To what extent has the project team prior experience with the innovation(s) applied in the project? *The indicator aims to provide an indication of the extent to which the project team is accustomed to working with or implementing the technologies, principles and/or practices applied in the project.*	No experience — 1 — 2 — 3 — 4 — 5 — Extensive experience Not applicable— ☐
	Further information: The project team is familiar with the building renovation process and technologies (insulation, efficiency lighting.) and accustomed to this and have worked before in other projects of renovation.
6.1.10 Prior collaboration between team members	
To what extent have the members of the project team worked together before the project? *The indicator aims to provide an indication of the extent to which the project team had prior collaboration experiences before conducting the project in question.*	None — 1 — 2 — 3 — ■ — 5 — Extensive prior collaboration Not applicable— ☐
	Further information:
6.1.11 Training	
To what extent has the project team provided training of the workforce before project development? *New approaches, processes, technologies or practices require adjustments in the regular way of doing things. In order to correctly implement, for example, new technologies, the project team must strengthen its workforce in terms of skills and knowledge when necessary.*	No training — 1 — 2 — 3 — 4 — 5 — Extensive training Not applicable— ☐
	Further information:
6.1.12 Clear division of responsibility	
Has the responsibility for achieving the sustainability goals & ambitions clearly been assigned to (a) specific actor(s) in the project? *This indicator aims to provide an indication of the extent to which the responsibility for the sustainable (low-carbon) component of the urban development project was clearly defined. Alternatively, the responsibility for monitoring of environmental targets is also covered by this indicator.*	■ **Yes:** The responsibility was clearly assigned and known to all stakeholders in the project. ☐ **No:** The responsibility was not clearly assigned and was unclear to stakeholders in the project. Not applicable— ☐
	Further information: It was well disseminated between the stakeholders the intention of creating a energy efficiency building through documentation and all the stakeholders responsibility were clearly assigned.
6.1.13 Balanced Team in the Design Phase	
To what extent did the project team include a wide variety of experts in the earliest stages of the project's design?	The project team did not include a wide variety of experts — 1 — 2 — 3 — 4 — 5 —

Particularly in light of the non-standard approach to urban development, it is useful to include different areas of expertise early on in the process to help keep the project affordable and effective in linking together its different aims.	The project team included a wide variety of experts Not applicable— ☐
	Further information: The project team included experts and expertise from a variety of possibly relevant fields, for instance: architects, structural and mechanical engineers, building project manager... To achieve sustainability in the construction is very important to have a multidisciplinary team capable to study and develop the project regarding all the aspects.
6.1.14 Degree of Testing	
To what extent have the applied technologies / methods been tested before project planning / realization? *Innovations vary in the degree to which they have been experimented with. Depending on the level of innovation, whether the applied concept or technology is very new to the context in which it is applied, more experimentation might be necessary in order to avoid problems in later stages of the project.* *This indicator aims to provide an indication of the extent to which the applied innovations have been researched, prepared and testing with in the local context, before full implementation*	No testing and research before implementation – 1 — 2 — 3 — **4** — 5 — Extreme testing and research before implementation. Not applicable— ☐
	Further information: Technologies and methods used were tested in a larger scale pilot.
6.1.15 User Training	
To what extent have the tenants been informed or trained about the correct use of new technologies/concepts/products in their living environment? *This indicator aims to provide an indication of the extent to which tenants have been informed about the proper use of new technologies or principles in their living environment, to underpin the low-carbon functioning.*	No user training has been conducted – 1 — 2 —**3** — 4 — 5 — Users were extremely well trained. Not applicable— ☐
	Further information: The residents received some necessary information about the correct use of technologies/concepts/products in the form of written information.
6.1.16 Continued monitoring and reporting	
To what extent has continuous monitoring and reporting been used to verify that the project was executed according to ambitions, rules & regulations? *Continued monitoring of performance and compliance with the requirements is an essential stimulating factor for project success. As much of the low-carbon reduction potential is incorporated in the physical built environment, monitoring*	There was no continued monitoring during the different development stages – 1 — 2 — 3 — 4 —**5**— Continued monitoring has been a consistent concern during the development stages. Not applicable— ☐

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should be aimed at checking whether building is done along the lines of the plans and requirements, in order to prevent construction errors. Monitoring and reporting is "the only way to consistently asses the different options arising during the process and thus making adequate choices	Further information: It is possible to say that the continued monitoring and reporting aligned with a good communication were essential stimulating factor for the 'Aile Sud'' building renovation project success. This monitoring can be noticed in two different moments: • *Projects schedule and budget: through a restrict monitoring and reporting plan it was ensured the project schedule and budget. At this moment, the reports elaborations and meeting were very important ways of communication.* • *Monitoring progress versus project goals: monitoring energy consumption it was a good way to verify the continuo success of the energy efficiency system.*
6.2 Propagation indicators	
6.2.1 Social Compatibility of the Innovation	
To what extent does the project's innovation fit with people's values and 'frame of mind'? *The indicator 'social compatibility' aims to provide an indication of the extent to which the innovation fits with the values and norms of its potential adopters. If an innovation requires people to significantly think different and challenges assumptions, its implementation in society will be more difficult.*	No social compatibility – 1 — 2 — 3 — 4 — 5 — Very high social compatibility Not applicable— ☐ Further information: The innovation is largely compatible with the current way of doing things, or with existing norms and values. Only slight adjustments are needed.
6.2.2 Technical Compatibility of the Innovation	
To what extent does the project's innovation fit with current practices, existing technological standards and infrastructures? *This indicator aims to provide an indication of the technical compatibility of the innovation, meaning the extent to which the innovation fits with current practices, administrative and existing technological standards/infrastructures.*	No technical compatibility — 1 — 2 — 3 — 4 — 5 — High technical compatibility Not applicable— ☐ Further information: The innovation had a low compatibility, it means that to achieve the energy efficiency aimed it was necessary to make a couple of adjustments, for instance: all the insulation system was improved, all the lighting and electrical system was re-installed, all the windows were adjusted to achieve a good thermal performance.
6.2.3 Complexity for end-users of the Innovation	
	No complexity for end users – 1 — 2 — 3 — 4 — 5 — Very high complexity for end users

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To what extent is the innovation perceived as difficult to understand and use for potential end-stage adopters (i.e. during use phase)? *End-users are conceptualized as those individuals who will be using/working with the innovation. Some innovations are perceived as relatively difficult to understand and use while others are clear and easy to the adopters.*	Not applicable— ☐ Further information: A small investment in time is required of the end users to understand the innovation and get accustomed to it, but they are familiar to work with the innovation. For instance, regarding the new energy efficiency system of the building, if the user has cold he needs to close the door to keep the heat inside the room and if it is a day with lot of sunlight the user can replace the artificial light to the natural light to work.
6.2.4 Complexity for professional stakeholders of the Innovation	
To what extent is the innovation perceived as difficult to understand and use for professional users of the innovation (i.e. for installation, maintenance)? *This indicator aims to provide an indication of the complexity for professional stakeholders of the innovation, those who are responsible for its supply, installation and/or maintenance. Professional stakeholders can be local politicians, project managers, construction companies, suppliers etc.*	No complexity for professional stakeholders – 1 — 2 — 3 — 4 — 5 — High complexity for professional stakeholders. Not applicable— ☐ Further information: A moderate level of additional expertise is required, which can be attained by reading /receiving a comprehensive instruction, and may require some trial and error before. It is possible to affirm that the main difficulty regarding the installation of the innovation for the stakeholders was the price.
6.2.5 Trialability	
To what extent can the innovation be experimented with on a limited basis in the local context before full implementation? *The indicator 'trialability' is perceived as the degree to which an innovation may be experimented with in the local context on a limited basis. An innovation that can be experimented with, will represent less uncertainty for the potential adopter.*	No possibility for experimentation – 1 — 2 — 3 — 4 — 5 — High possibilities for experimentation Not applicable— ☐ Further information: As the renovation of a building is still very expensive in France, it is possible to affirm that the innovation has a moderate opportunity for experimentation at the local level. It was difficult to implement the innovation on a limited basis but it was only possible with some extra resources. All the renovation work to achieve energy efficiency required: an important budget; time for activities planning, execution, studies; expertise: specially in the BMS.
6.2.6 Advantage for end-users	
Does the project make use of new technologies and principles that offer clear advantages for end users (cheaper, comfort etc.)? *Some environmental innovations offer a clear advantage to those using the innovation. In the*	No advantage to end-users—1—2—3—4—5— High advantage to end-users Not applicable— ☐

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context of solar PV for example, environmental benefits can be combined with user benefits through the reduction of energy bills.	Further information: The project offers a high advantage to end users who benefit mostly from applied technologies or principles for instance: through the reduction of energy bills, improvement of the indoor environment quality and the consequently improvement of health quality. Also, end-users can control and observe the energy use.
6.2.7 Advantage for stakeholders	
Does the project make use of new technologies and principles that offer clear advantages for stakeholders (ease of management, maintenance costs etc.)? *While some environmental innovations offer a clear advantage to using an innovation, some innovations also offer a clear advantage to those investing in innovations.*	No advantage for stakeholders—1—2—3—4—5— High advantage for stakeholders Not applicable— ☐
	Further information: The project offers some a high advantage to stakeholders who benefit mostly from the applied technologies/principles as all theses has a positive effect on stakeholders. This is the case of the lighting system that are efficient and has also a big durability, decreasing the maintenance costs with the lighting system. Also, the BMS (Building management system) implemented associated with the electricity meters to measure and control energy consummation helps to manage the energy use and costs.
6.2.8 Visibility of Results	
To what extent are the results of the innovation visible to external actors? *The indicator 'observability' aims to give an indication of "the degree to which the results of an innovation are visible to others." While some innovations are easily observed and communicated to other people, other innovations can be difficult to observe.*	No visibility—1—2—3—4—5—High visibility Not applicable— ☐
	Further information: The results of the innovation are highly visible to external actors. All the building was internal renovated, the walls were painted, the lighting system was modernized, all the interior design was made and all the visual identity also. All this is very visible for an external actor.
6.2.8 Solution(s) to development issues	
To what extent does the innovation offer a solution to problems common to European cities? *The indicator aims to provide an indication of the extent to which the offered innovation(s) provide a solution to a specific (local) context or a solution to problems experienced in more European cities.*	Not a solution for common problems —1—2—3—4—5— Very much a solution to common problems Not applicable— ☐
	Further information:

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	The innovation offers a solution for a problem common to most European cities that is the building retrofit to improve the building energy efficiency and reduce the greenhouse gas emissions.
6.2.9 Current market demand for the solution	
To what extent is there a general demand for the offered solution? *An important characteristic of innovations for the rate of adoption is the extent to which the innovation meets the needs of its potential adopters. It is possible that innovation can have a distinctive connection to generic problems in European cities, but that the demand for a solution is relatively low.*	No demand—1—2—3—4—**5**—High demand Not applicable— ☐ Further information: As the building is situated in France that has strong needs for energy efficiency improvement and mainly in buildings located inside historical sites, it is possible to affirm that there is a widespread market demand for the offered solution.
6.2.10 Changing Professional Norms	
Does the project change the professional 'state of the art', thereby inspiring a new or improved norm of what a good urban development should look like? *These norms can refer to the industry norm, i.e. what the companies and industry consider the 'state of the art' for urban development. Take as an example the car industry: now cars can function well on very low fuel consumption, cars that consume a lot of fuel per kilometre have become 'old-fashioned'. Designing a new fuel inefficient car is not a serious option anymore for a car manufacturer, with the only exception perhaps if the car would be designed for a small niche (e.g. a race car). In other words, a new development can de-legitimize an old solution, and thereby set a new norm for performance.*	No impact on professional norms —1—**2**—3—4—5— High impact on professional norms Not applicable— ☐ Further information: The project has been positively featured in one or two professional magazines/conferences/trade fairs and had minor role in inspiring a new or improved norm.
6.2.11 Changing Societal Norms	
To what extent does the project change the norms and values on what a good urban development should look like of those directly and indirectly involved? *A new urban development can also set a new norm for the public, i.e. a level of performance that a customer, end-user, or 'the society' sees as acceptable. If we take the car industry as an example again: whereas fuel inefficient cars can be considered old-fashioned from a technological and professional point of view, they might be considered anti-social by the public. As better solutions are available, old solutions are not accepted anymore which might result in protest*	No impact on societal norms —1—**2**—3—4—5— High impact on societal norms Not applicable— ☐ Further information: The project sparked the attention of a few who were directly involved. The project, however, was not positively featured in magazines/the public media, and did not raise general debate about what good urban development should look like.

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against the old, and support and demand for the new solution.	
6.2.12 Diffusion to other locations	
Is the project copied in other cities and regions? *A sustainable concept can be copied by other cities or regions. This can entail both the innovation(s) within the project (e.g. technology, new product) as the institutional aspects of the project. The latter can for instance be the copying the procurement process, mimicking the way in which civil servants' support for a new development was created, creating a culture conducive of change, or changing regulations in another location to free the way for a new development.*	Not copied in other locations —1—2—3—4—**5**— Very much copied in other locations Not applicable— ☐ Further information: The renovation of the Batiment Aile Sud, due to the successful energy save and consequently in the energy bills, it is an important case of reference that most have copied in the other buildings inside the Bergerie National Domain, inside the Parc du Chateau and in any other case of building renovation in any other city and state. The same variety of retrofit project has been copied in France and also in the other countries as Germany.
6.2.13 Diffusion to other actors	
Are the new technologies, principles and/ or practices in this project copied by other commercial parties (e.g. developers or builders)? *The innovations within the project can be copied by other companies, whereas the adoption of technologies can be copied by e.g. end users. Companies will generally follow the leading companies and adopt technologies for which the leaders set the standard.*	Not copied by commercial parties — 1 — 2 —**3** — 4 — 5 — Very much copied by commercial parties Not applicable— ☐ Further information:
6.2.13 Change in Rules & Regulations	
Has the project contributed to, or inspired, changes in rules & regulations (at local -city planning, zoning- or national-, -spatial law, energy laws- level)? *The realization of projects will often involve the alteration or different interpretations of rules and regulations. The fact that the development is 'on the edge' often means that it is innovative and that it can fulfil an important signalling function for new developments: here are the barriers for the solutions of the future. As existing rules and regulations are based upon old systems*	No impact on rules & regulations – **1**— 2 — 3 — 4 — 5 — High impact on rules & regulations. Not applicable— ☐ Further information: The project has not, any level, inspired changes in rules and regulations.

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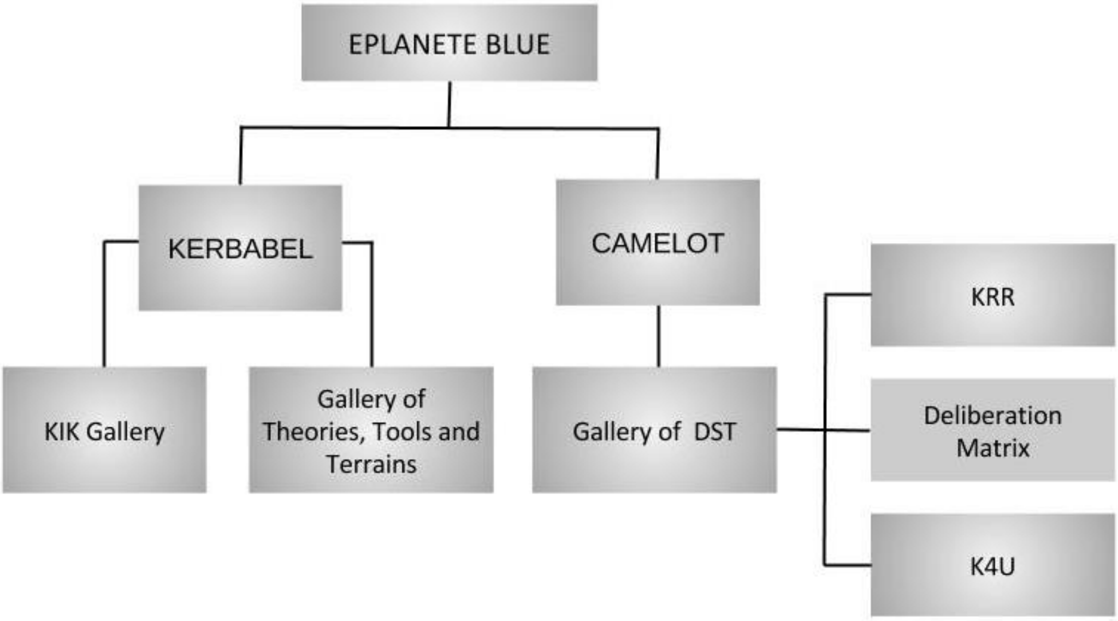
(centralizes energy networks, traditional building processes), true innovations often break the rules.	
6.2.14 Change in public procurement procedures	
Has the project inspired new forms of public procurement procedures? *Public procurement can be an important driver for innovation. As procurement procedures are often very precise in detailing all requirements of a building, it rules out innovations. Often building materials and installations are specified ex ante, whereas giving freedom to market parties to come up with new solutions could be more effective for getting the optimal solution.*	Has not inspired new public procurement procedures – 1 — 2 — 3 — 4 — 5 — Highly inspirational for new public procurement procedures. Not applicable— ☐
	Further information: The project developed and used a new procurement procedure and has received some professional attention because of this.
6.2.15 New forms of Financing	
Has the project contributed to- or inspired- the development of new forms of financing? *New financial arrangements refer to the importance of new contractual forms, property rights and financial arrangements that help in realizing new ventures. New business models can emerge when, for instance, buildings are transformed to produce energy and both owners and tenants share in realized production or profits.*	Has not inspired new forms of financing – 1 — 2 — 3 — 4 — 5 — Highly inspirational for new forms of financing. Not applicable— ☐
	Further information:

ANNEX 8. EPLANETE BLUE

A8.1 EPLANETE BLUE AND THE MAIN GALLERIES AND DOORWAYS MOBILIZED



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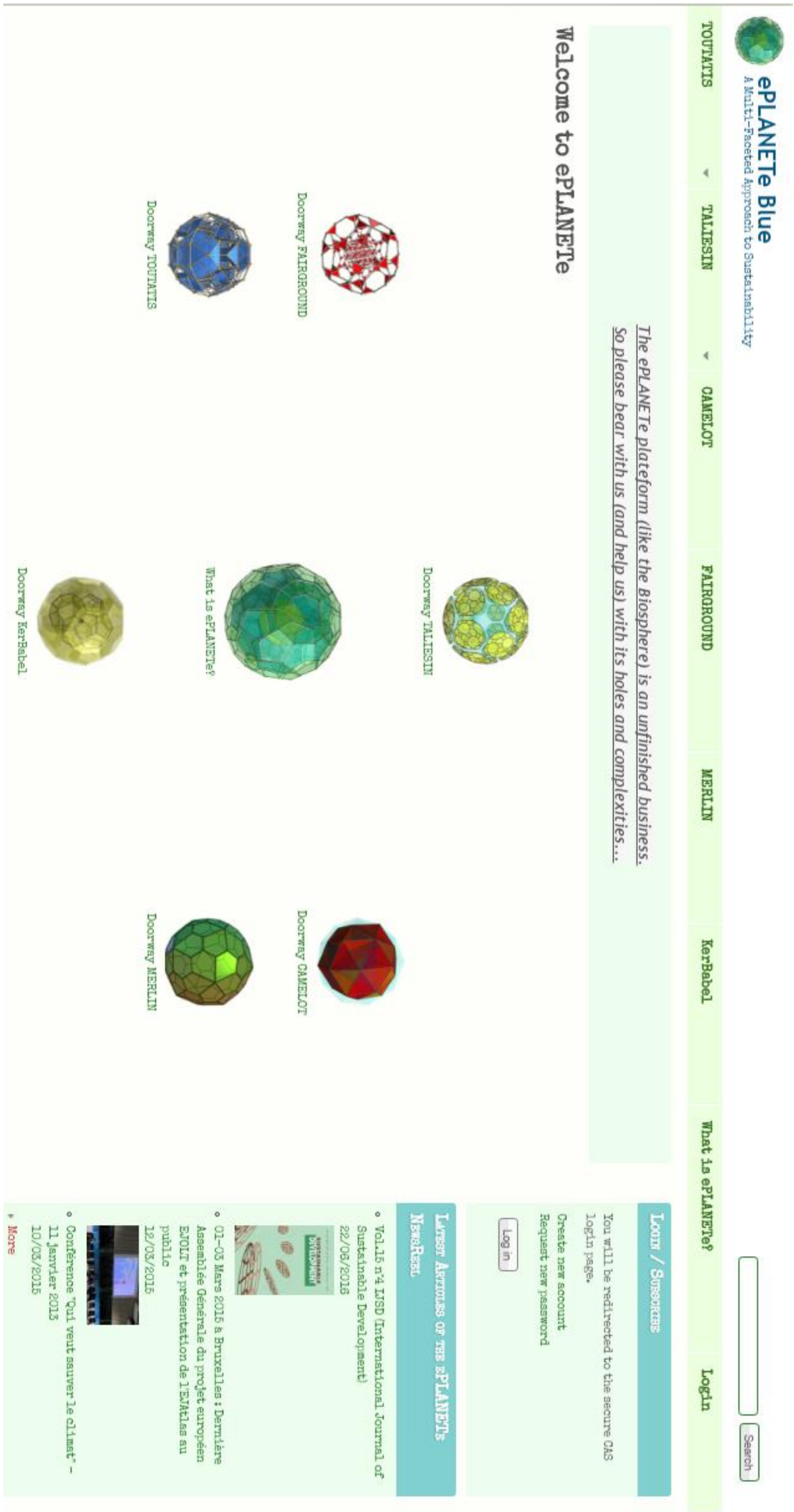
A8.2 WELCOME PAGE OF EPLANETE BLUE WITH ALL THE DOORWAYS



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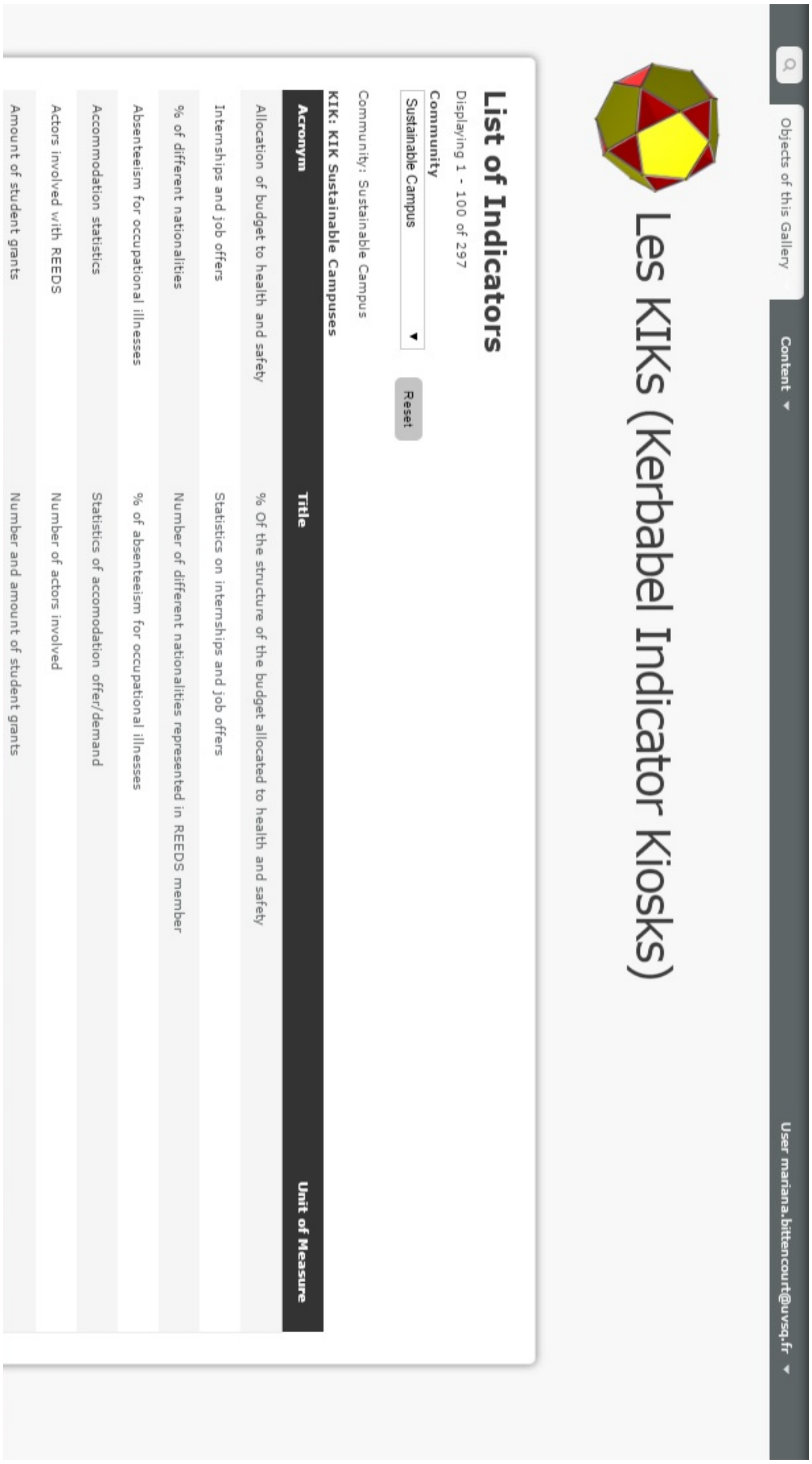
A8.3 LIST OF INDICATORS IN THE KIKS GALLERY



Objects of this Gallery | Content | User mariana.bittencourt@uvsq.fr

Les KIKs (Kerbabel Indicator Kiosks)

List of Indicators

Displaying 1 - 100 of 297

Community

Sustainable Campus

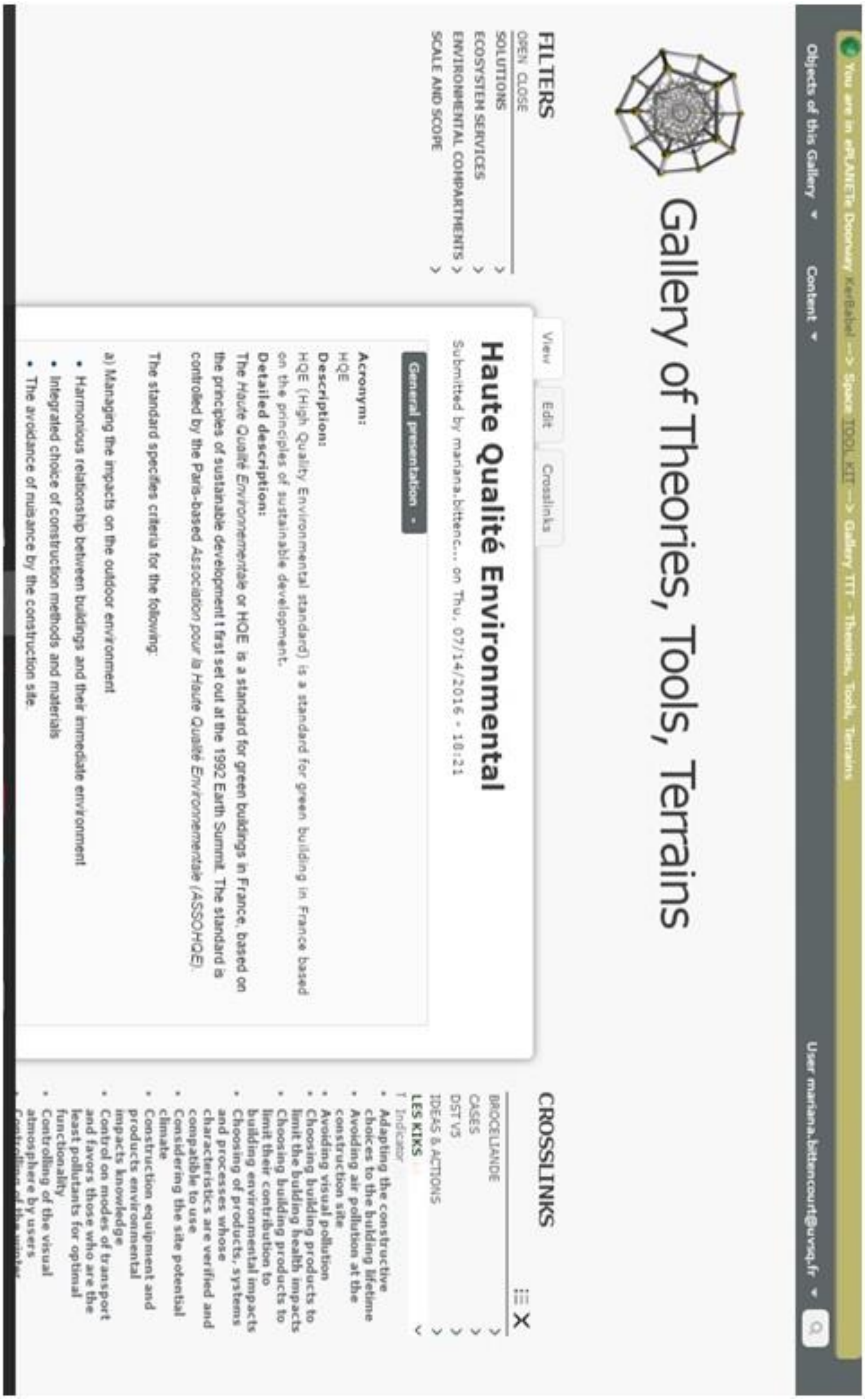
Reset

Community: Sustainable Campus

KIK: KIK Sustainable Campuses

Acronym	Title	Unit of Measure
Allocation of budget to health and safety	% Of the structure of the budget allocated to health and safety	
Internships and job offers	Statistics on internships and job offers	
% of different nationalities	Number of different nationalities represented in REEDS member	
Absenteeism for occupational illnesses	% of absenteeism for occupational illnesses	
Accommodation statistics	Statistics of accomodation offer/demand	
Actors involved with REEDS	Number of actors involved	
Amount of student grants	Number and amount of student grants	

A8.4 PROFILE OF AN INDICATOR IN THE KIKS GALLERY



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A8.5 KRR WITH THE LIST INDICATOR SELECTOR BOX TO PERFORM THE PERTINENCE ANALYSIS

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ANNEX 9. DEFINING PERFORMANCE ISSUES

PERTINENCE ANALYSIS OF B4U'S SUB-GOALS

TOP-GOAL	PERFORMANCE ISSUES' NAME	PERTINENCE
PEOPLE	Availability of commercial amenities	Yes
	Availability of public amenities	Yes
	Availability multi-modal mobility options	Yes
	Ensuring the comfort and image of public spaces	Yes
	Design for a sense of place	Yes
	Connection to the existing cultural heritage	Yes
	Social housing	No
	Affordability of housing	No
	Fuel poverty	No
PLANET	Emissions PM10	Yes
	Emissions NOx	Yes
	Climate resilient design building	Yes
	Share of impervious surface	Yes
	Climate resilient design neighborhood	Yes
	Embodied energy of materials-qualitative	No
	Embodied energy of materials-quantitative	No
	Share of recyclable materials	Yes
	Share of renewable materials	Yes
	Share of recycled input materials	Yes
	Reduction of materials used	Yes
	Share of renewable energy produced on-site	No
	Share of recovered heat	No
	Primary energy use for transport	No
	Annual final energy consumption of buildings	Yes
	Annual primary energy consumption of buildins	Yes
PROFIT	CO2 emission reduction cost efficiency	Yes
	Total cost vs. subsidies	No
	Payback Period	Yes
	Net Present Value (NPV)	No
	Total cost savings for end-user	Yes
	Use of Local workforce	Yes
PROCESS	Continued monitoring/reporting	Yes
	User training	Yes
	Degree of testing	Yes
	Balanced team in design phase	Yes
	Clear division of responsibility	Yes
	Training of the workforce	Yes
	Prior collaboration between team members	Yes
	Prior experience with the innovation	Yes
	Government vision	Yes
	Professional stakeholder involvement	Yes
	Local community involvement	Yes
	Leadership	Yes
PROPAGATION	New forms of financing	Yes
	Change public procurement	Yes
	Change in rules and regulations	No

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	Diffusion of products, concepts and technologies to other actors	Yes
	Diffusion of products, concepts and technologies to other Locations	Yes
	Changing societal norms	Yes
	Changing professional norms	Yes
	Current market demand for the solution	Yes
	Solution(s) to development issues	Yes
	Visibility of results	Yes
	Advantages for stakeholders	Yes
	Advantages for end users	Yes
	Trialability	Yes
	Complexity for professional stakeholders	Yes
	Complexity for end users of the technology	Yes
	Technical compatibility of Innovation	Yes
	Social compatibility of Innovation	Yes

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Annex 10. LIST OF INDICATORS

A.10.1.BUILDING'S INDICATORS

№	INDICATOR NAME	SOURCE
1	LEED for neighborhood development location	LEED
2	Sensitive land protection	LEED
3	High priority site	LEED
4	Surrounding density and diverse uses	LEED
5	Access to quality transit	LEED
6	Bicycle facilities	LEED
7	Reduced parking footprint	LEED
8	Green vehicles	LEED
9	Construction activity pollution prevention	LEED
10	Environmental Site Assessment	LEED
11	Site Assessment	LEED
12	Site development - protect or restore habitat	LEED
13	Open space	LEED
14	Rainwater management	LEED
15	Heat island reduction	LEED
16	Light pollution reduction	LEED
17	Site master plan	LEED
18	Joint use of facilities	LEED
19	Outdoor water use reduction	LEED
20	Indoor water use reduction	LEED
21	Building-level water metering	LEED
22	Outdoor water use reduction	LEED
23	Indoor water use reduction	LEED
24	Cooling tower water use	LEED
25	Water metering	LEED
26	Fundamental commissioning and verification	LEED
27	Minimum energy performance	LEED
28	Building-level energy metering	LEED
29	Fundamental refrigerant management	LEED
30	Enhanced commissioning	LEED
31	Optimize energy performance	LEED
32	Advanced energy metering	LEED
33	Demand response	LEED
34	Renewable energy production	LEED

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35	Enhanced refrigerant management	LEED
36	Green carbon and carbon offsets	LEED
37	Storage and collection of recyclables	LEED
38	Construction and demolition waste management planning	LEED
39	Building life-cycle impact reduction	LEED
40	Building product disclosure and optimization - Environmental product declarations	LEED
41	Building product disclosure and optimization - Sourcing of raw materials	LEED
42	Building product disclosure and optimization - Material ingredients	LEED
43	Construction and demolition waste management	LEED
44	Minimum indoor air quality performance	LEED
45	Environmental tobacco smoke control	LEED
46	Minimum acoustic performance	LEED
47	Enhanced indoor air quality strategies	LEED
48	Low-emitting materials	LEED
49	Construction indoor air quality management plan	LEED
50	Indoor air quality assessment	LEED
51	Thermal comfort	LEED
52	Interior lighting	LEED
53	Daylight	LEED
54	Quality views	LEED
55	Acoustic performance	LEED
56	Innovation	LEED
57	LEED Accredited Professional	LEED
58	Regional Priority: Specific Credit	LEED
59	Project brief and design	BREEAM
60	Life cycle cost and service life planning	BREEAM
61	Responsible construction practices	BREEAM
62	Commissioning and handover	BREEAM
63	Aftercare	BREEAM
64	Reduction of energy use and carbon emissions	BREEAM
65	Energy monitoring	BREEAM
66	External lighting	BREEAM
67	Low carbon design	BREEAM
68	Energy efficient cold storage	BREEAM
69	Energy efficient transportation systems	BREEAM
70	Energy efficient laboratory systems	BREEAM
71	Energy efficient equipment	BREEAM
72	Drying space	BREEAM
73	Visual comfort	BREEAM

74	Indoor air quality	BREEAM
75	Safe containment in laboratories	BREEAM
76	Thermal comfort	BREEAM
77	Acoustic performance	BREEAM
78	Safety and security	BREEAM
79	Public transport accessibility	BREEAM
80	Proximity to amenities	BREEAM
81	Cyclist facilities	BREEAM
82	Maximum car parking capacity	BREEAM
83	Travel plan	BREEAM
84	Water consumption	BREEAM
85	Water monitoring	BREEAM
86	Water leak detection	BREEAM
87	Water efficient equipment	BREEAM
88	Life cycle impacts	BREEAM
89	Hard landscaping and boundary protection	BREEAM
90	Responsible sourcing of materials	BREEAM
91	Insulation	BREEAM
92	Designing for durability and resilience	BREEAM
93	Material efficiency	BREEAM
94	Construction waste management	BREEAM
95	Recycled aggregates	BREEAM
96	Operational waste	BREEAM
97	Speculative floor and ceiling finishes	BREEAM
98	Adaptation to climate change	BREEAM
99	Functional adaptability	BREEAM
100	Site selection	BREEAM
101	Ecological value of site and protection of ecological features	BREEAM
102	Minimizing impact on existing site ecology	BREEAM
103	Enhancing site ecology	BREEAM
104	Long term impact on biodiversity	BREEAM
105	Impact of refrigerants	BREEAM
106	NOx emissions	BREEAM
107	Surface water run-off	BREEAM
108	Reduction of night time light pollution	BREEAM
109	Reduction of noise pollution	BREEAM
110	Innovation	BREEAM
111	Ensuring consistency between the urban development and the community politics	HQE
112	Optimizing access and manage the flows	HQE

113	Control on modes of transport and favors those who are the least pollutants for optimal functionality	HQE
114	Vegetation of surfaces	HQE
115	Maintain and improve biodiversity	HQE
116	Landscape integration of outdoor facilities	HQE
117	Preserving biodiversity during construction site	HQE
118	Creating a satisfying outdoor climate atmosphere	HQE
119	Creating a satisfactory outdoor acoustic environment	HQE
120	Creating a satisfactory visual atmosphere	HQE
121	Ensuring healthy outdoor spaces	HQE
122	Ensuring adequate night outdoor lighting	HQE
123	Avoiding visual pollution	HQE
124	Ensuring the right to the sun and natural light to local residents	HQE
125	Ensuring the right to peaceful to local residents	HQE
126	Ensuring the right to the views of local residents	HQE
127	Ensuring the right to health quality of outdoor spaces for local residents	HQE
161	Reducing the primary energy consumption due to heating, cooling, lighting, ECS, ventilation, and other operations activities (depending on the building type)	HQE
162	Implementing innovative (s) system (s)	HQE
163	Limiting the consumption of equipments not-included in the thermal regulation	HQE
164	Use of local renewable energy	HQE
165	Limiting the artificial lighting included in the thermal regulations	HQE
166	Improving the data center's energy efficiency	HQE
167	CO2 equivalent amounts generated by the energy use	HQE
168	SO2 equivalent amounts generated by the energy use	HQE
169	Quantities of radioactive waste generated by the electricity network use	HQE
170	Impact on the ozone layer	HQE
171	Refrigerant selection to limit its contribution to environmental impacts	HQE
172	Limit water needs in toilets	HQE
173	Limiting the drinking water use	HQE
174	Knowing the overall consumption of potable and non-potable water	HQE
175	Limiting soil waterproofing of the plot land	HQE
176	Storing enough volume of rain water to handle an exceptional rainfall event and manage storm water in an alternative way	HQE
177	Fighting against chronic pollution	HQE
178	Fighting against accidental pollution	HQE
179	Controlling of wastewater discharges	HQE
180	Recycling of wastewater	HQE
181	Limiting discharges storm water to the public system	HQE
182	Recommend or select the waste removal channel focusing its valuation	HQE

183	Promoting the organic waste recovery	HQE
184	Helping to reduce the waste accumulation	HQE
185	Promoting waste separation in the source in place where waste is produced	HQE
186	Design of adequate waste stocking spaces or areas	HQE
187	Ensuring hygiene of waste stocking spaces or areas	HQE
188	Optimizing channels of waste management	HQE
189	Design the structure to facilitate maintenance operations during the operation phase	HQE
190	Checking the feasibility of maintenance and performance operations	HQE
191	Provide measuring means for monitoring energy consumption	HQE
192	Provide measuring means for monitoring water consumption	HQE
193	Providing means for monitoring conditions of comfort	HQE
194	Providing means for optimizing the systems operation and failures detection	HQE
195	Consider the site potential climate	HQE
196	Improving the buildings ability to foster good comfort hygrothermal conditions	HQE
197	Regrouping local spaces to provide hygrothermal homogeneous	HQE
198	Controlling the midseason discomfort	HQE
199	Setting an adequate interior temperature level in spaces	HQE
200	Ensuring stable interior temperatures during user's occupancy	HQE
201	Ensuring an interior air speed not affecting comfort	HQE
202	Thermal environment control by the users during winter period	HQE
203	Controlling the temperature differences between the various zones	HQE
204	Controlling the humidity in winter period	HQE
205	Limiting the effects of cold walls	HQE
206	Ensuring a minimum thermal comfort level and protection of the windows from the sun	HQE
207	Ensuring adequate ventilation and controlling the air flow to achieve summer comfort by opening windows	HQE
208	Setting an adequate interior temperature level in spaces	HQE
209	Ensuring an air speed temperature not affecting comfort	HQE
210	Controlling solar gain, especially the localized discomfort due to the heat radiation	HQE
211	Controlling of the interior temperature by users during the summer	HQE
212	Controlling humidity in the interior spaces during the summer	HQE
213	Controlling the temperature differences between the various zones	HQE
214	Optimizing the interior layout according to the indoor disturbances	HQE
215	Optimizing the interior layout according to the external disturbances	HQE
216	Optimizing the shape and volume of the spaces when the internal acoustic is an issue	HQE
217	Isolation of spaces located face-to-face exterior spaces	HQE
218	Noise impact levels transmitted through interior spaces	HQE
219	Equipment's noise impact levels through interior spaces	HQE

220	Internal acoustic spaces	HQE
221	Isolation areas from aerial noise (reception) face-t-face areas of intense activities (emission)	HQE
222	Walking sonority in spaces	HQE
223	Optimization of acoustic ambience criteria in the interior spaces	HQE
224	Daylight access	HQE
225	Outdoor views access	HQE
226	Minimum illumination in natural light	HQE
227	Avoid direct or indirect glare from natural light	HQE
228	Controlling of the visual atmosphere by users	HQE
229	Adequate minimum lighting by artificial light	HQE
230	Ensuring proper uniformity of artificial lighting	HQE
231	Avoiding direct or indirect glare from artificial lighting and seek a luminance balance	HQE
232	Ensuring a pleasant artificial light quality	HQE
233	Controlling of visual atmosphere by users	HQE
234	Qualitative lighting enhancement	HQE
235	Implemention of a suitable ventilation system	HQE
236	Ensuring air flows adapted to the local activity (in the presence of mechanical ventilation)	HQE
237	Management device	HQE
238	Ensure the systems' sealing (in presence of mechanical ventilation)	HQE
239	Ensuring quality of air control supplied through a pipe (presence of mechanical ventilation)	HQE
240	Ensuring optimal indoor air spaces scanning	HQE
241	Identifying and reducing the effects of unpleasant smells sources	HQE
242	Treating odorous emissions to avoid the dissemination of smells	HQE
243	Identifying sources of electromagnetic emissions	HQE
244	Limiting the impact of electromagnetic emission sources	HQE
245	Creating specific hygiene conditions outside maintenance area	HQE
246	Optimize the health conditions of maintenance area	HQE
247	Selecting materials limiting fungal and bacterial growth	HQE
248	Implementation of a suitable ventilation system	HQE
249	Ensuring air flows adapted to the space activity of local (in the presence of mechanical ventilation)	HQE
250	Management device	HQE
251	Ensure the systems' sealing (in presence of mechanical ventilation)	HQE
252	Ensuring quality of air control supplied through a pipe (presence of mechanical ventilation)	HQE
253	Ensuring optimal indoor air spaces scanning	HQE
254	Identifying and reducing the internal and external effects of pollution sources	HQE
255	Choosing building products to reduce the structure health impacts	HQE

256	Knowing the construction products health impact and its contribution to the indoor air quality	HQE
257	Limiter la pollution par les éventuels traitements des bois	HQE
258	Controlling occupant exposure to indoor air pollutants	HQE
259	Prevent the air bacteria development	HQE
260	Ensuring the effectiveness of the air treatment system	HQE
261	Limiting the trichloramine content in the air in indoor swimming spaces	HQE
262	Choosing materials in accordance with regulations and compatible with the nature of the water supply	HQE
263	Respecting the rules of implementation of pipelines and water system	HQE
264	Structuring and signalizing the internal system based on water use	HQE
265	Protection of the internal system	HQE
266	Implementation of a domestic hot water system to ensure an optimal temperature	HQE
267	Optimization the hot water system design system to limit the risk of legionella	HQE
268	Maintaining and controlling the temperature of hot water systems	HQE
269	Selecting the disinfection treatments and / or anti corrosion and / or anti tartar in accordance with regulations and compatible with the water supply nature	HQE
270	Controlling the performance of disinfection treatments and / or anti corrosion and / or anti tartar	HQE
271	Health risk control related to the recovery and reuse on site of a non-potable water	HQE
272	Treating polluted bathing water in accordance with regulations	HQE
273	Avoiding deposits of pollution in bathing water	HQE
274	Controlling the chlorinated derivative content of bathing water	HQE
275	Environnment management	Nguyen and Altan, 2012
276	Field Study	Nguyen and Altan, 2012
277	Global approach to Life	Nguyen and Altan, 2012
278	Evaluation of the design site	Nguyen and Altan, 2012
279	The choice of the construction process	Nguyen and Altan, 2012
280	Site impacts	Nguyen and Altan, 2012
281	Construction safety	Nguyen and Altan, 2012
282	Contracts and markets	Nguyen and Altan, 2012
283	Commissioning	Nguyen and Altan, 2012
284	How to use the building	Nguyen and Altan, 2012
285	Demolition management plan	Nguyen and Altan, 2012
286	Water quality	Nguyen and Altan, 2012
287	Plumbing and drainage	Nguyen and Altan, 2012
288	Biological contamination	Nguyen and Altan, 2012
289	Project changes	Yuan, 2013
290	Waste reduction considerations in the design phase	Yuan, 2013
291	Investment in waste management	Yuan, 2013

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292	Waste management regulations	Yuan, 2013
293	Site size for good waste management performance	Yuan, 2013
294	Adoption of construction technologies with generation of waste	Yuan, 2013
295	The culture of waste management within an organization	Yuan, 2013
296	Cost of waste management	Yuan, 2013
297	Land consumption due to landfilling of waste	Yuan, 2013
298	Water pollution	Yuan, 2013
299	Environmental Impacts of illegal dumping of waste on the environment of public life	Yuan, 2013
300	The practitioner's awareness of waste management	Yuan, 2013
301	Employment Opportunities	Yuan, 2013
302	Physical working conditions	Yuan, 2013
303	Long-term health impacts	Yuan, 2013
304	Safety of operators in waste management	Yuan, 2013
305	Public satisfaction with waste management	Yuan, 2013
306	Impacts of the illegal dumping of waste on the social image	Yuan, 2013
307	Acoustic comfort inside the building	Silva and Almeida (2010); Legifrance (2003)
308	Bio-based use in the building materials	Bio-based building
309	Life expectancy of construction site workers	European Commission (2016), OECD (2016) and Eurofound (2012).
310	Security of construction site workers	République Française (2017b) and INRS (2012)
311	Work satisfaction inside the construction site	OECD (2016)
312	Buildings accessible to people with disabilities	in MLHD (2006)
313	Social equity with the supply chain	USGBC (2014)
314	Potable water use reduction inside the construction site	Darkos and Chan (2016)
315	Use of local suppliers of products and materials	Darkos and Chan (2016)
316	Productivity in the construction site	Federation Française du Batiment (2015); Wittle and Jones (2013)
317	Construction management strategies	Anikeeff and Sriram (2008)
318	Sustainable sites management implementation	Based in Travis (2003)
319	Diffusion of sustainable construction site	Based in Travis (2003)

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ANNEX 11. C4U TUTORIAL GUIDE

1. TOP-GOAL « PEOPLE »

1.1 COMFORT

a) Thermal comfort

Description	Thermal comfort is a combination of the right temperature, thermal radiation, humidity and air speed and is assessed by subjective evaluation.
Nature	Qualitative
Source	USGBC (2014) and ASHRAE (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Thermal comfort' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building contributes to providing an excellent indoor thermal comfort to the users? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Thermal comfort.' 1. Not at all: The building does not provide at all thermal comfort to the occupants in the development of their activities. Users are not satisfied with the indoor air temperature, neither with the humidity and the air speed. 2. Little: The building provides a little bit of thermal comfort to the occupants in the development of their activities. 3. Average: The thermal comfort of the building has some importance in the elaboration of the user's activities. The building can bring together thermal comfort regarding indoor air temperature, humidity, and air speed. 4. Much: The thermal comfort of the building has a critical role in the development of user’s activities. The building has a positive influence regarding indoor air temperature, humidity, and air speed. 5. Very much: The building provides to the users an excellent thermal comfort to develop their activities. Strategies previewed in the design process were critical and supported the building reaches the right indoor air temperature, humidity and air speed to keep users very satisfied.

b) Considering the potential site climate

Description	The goal of this indicator is to measure the capacity of the project in optimizing the potential site climate when developing architectural layouts. Some concerns about the architectural project are sun orientation, surfaces of glass, and prevailing winds.
Nature	Qualitative

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Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Considering the potential site climate' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the architectural project optimized the potential site climate? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Considering the potential site climate.' 1. Not at all: There were no concerns in optimizing the potential site climate when developing the architectural project. 2. Little: There were a little of concerns about optimizing the potential site climate when developing the architectural project. 3. Average: Architectural project considered the concerns about the optimizing the potential site climate. 4. Much: Architectural project much considered the concerns about the optimizing the potential site climate. 5. Very much: Architectural project very much considered the concerns about the optimizing the potential site climate.

c) Ensuring a minimum thermal comfort level and windows protection from the sun

Description	The goal of this indicator is to make sure that the temperature level in the different areas of the building does not exceed the limit. Furthermore, building project previewed to protect glass walls from direct sunlight.
Nature	Qualitative
Source	Based in Certivéa (2011), MEDDE and ADEME (2011).
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Ensuring a minimum thermal comfort level and protection of the windows from the sun' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building ensures that the temperature level in the different areas of the building does not exceed the limit, and also that the windows and glass walls are protected from direct sunlight.? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Ensuring a minimum thermal comfort level and protection of the windows from the sun' 1. Not at all: There were no concerns in ensuring a minimum thermal comfort level and windows protection from the sun.

	2. Little: There were a little of concerns about in ensuring a minimum thermal comfort level and windows protection from the sun. 3. Average: Concerns about in ensuring a minimum thermal comfort level and windows protection from the sun were taken into account in the architectural project. 4. Much: Concerns about in ensuring a minimum thermal comfort level and windows protection from the sun were much taken into account in the architectural project. The university building can assures almost a thermal comfort in at least 5 days a week and from 8 am to 6 pm. 5. Very much: Concerns about in ensuring a minimum thermal comfort level and windows protection from the sun were very much taken into account in the architectural project. The university building can assures a thermal comfort at least 5 days a week and from 8 am to 6 pm.

d) Ensuring adequate ventilation

Description	The goal of this indicator is to ensure that summer comfort is achieved by opening the windows.
Nature	Qualitative
Source	Based in Certivéa (2011), MEDDE and ADEME (2011).
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Ensuring adequate ventilation' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the project building ensures the summer comfort by opening the windows? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Ensuring adequate ventilation' 1. Not at all: The project building does not ensure at all the summer comfort by opening the windows. Mechanical ventilation needs to be used. 2. Little: The project building ensures a little bit of the summer comfort by opening the windows. 3. Average: The project building ensures the summer comfort by opening the windows. 4. Much: The project building ensures much the summer comfort by opening the windows. 5. Very much: The project building ensures the summer comfort very much by opening the windows. Mechanical ventilation are not necessary.

e) Acoustic comfort inside the building

Description	This indicator aims to measure the acoustic comfort from the users point of view.
Nature	Qualitative
Source	Silva and Almeida (2010); Legifrance (2003)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Buildings acoustic comfort' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building contributes to provide acoustic comfort to the users? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Buildings acoustic comfort' 1. Not at all: The building does not provide any acoustic comfort to the users. Users are not satisfied with the noises from the interior space. 2. Little: The building provides a little bit of acoustic comfort to the occupants. Users are a little bit satisfied or with the acoustic comfort however there are still some noises that could be avoided. 3. Average: The acoustic comfort of the building has some importance in the development of the users activities. The building is able to control the majority of noises. 4. Much: The acoustic comfort of the building has a very important role in the development of user's activities. The building has a positive influence regarding the control of most noises in all classrooms and workspaces. 5. Very much: The building provides to the users a great acoustic comfort to develop their activities. Strategies previewed in the design process were very important to isolate the building from interior noises.

f) Limiting noise pollution at the construction site

Description	This indicator aims to decrease the noise pollution at the construction site from the point of view of worker's safety, but also to avoid disturbing neighborhood.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Limit noise pollution at the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the noises pollution are avoided in the construction site? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Limit noise pollution at the construction site'

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	1. Not at all: Noises pollution are not at all avoided in the construction site. 2. Little: Noises pollution are a little bit avoided at the construction site. 3. Average: Noises pollution are avoided at the construction site. Sources of noise that were affecting local residents and workers were identified during the construction site and an acoustic strategy were implemented in order to meet comfort limit determinate by the regulatory requirements. 4. Much: Noises pollution are much avoided at the construction site. The study of noises sources were made but also an acoustic map that analyzed all the building type and façade of the immediate neighborhood. A noise limit were in the whole construction site. 5. Very much: Noises pollution are very much avoided at the construction site. The study of noises sources and an assessment of the immediate neighborhood by an acoustic map were performed. Furthermore, noise levels are periodically checked through a continuous measuring device and techniques choose in the construction site consider limit noise levels established.

g) Daylight access

Description	This indicator aims to ensure that classrooms and workspaces has direct (daylight entries direct from exterior) or indirect (daylight comes from another space that receives direct light) daylight access.
Nature	Quantitative
Source	Based in Certivéa (2011) and Legifrance (2017)
Unity	%
Normalisation	1 – 10 (1 → 10%; 2 → 20%; 3 → 30%; 4 → 40%; 5 → 50%; 6 → 60%; 7 → 70%; 8 → 80%; 9 → 90%; 10 → 100%)
Guidelines	The indicator 'Daylight access' provides a qualitative measure and is rated on a five-point Linkert scale: How many % of classrooms and workspaces are provided by direct or indirect daylight ? Guidelines for 'Daylight access' 1 → 10% of classrooms and workspaces 2 → 20% of classrooms and workspaces 3 → 30% of classrooms and workspaces 4 → 40% of classrooms and workspaces 5 → 50% of classrooms and workspaces 6 → 60% of classrooms and workspaces

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	7 → 70% of classrooms and workspaces 8 → 80% of classrooms and workspaces 9 → 90% of classrooms and workspaces 10 → 100% of classrooms and workspaces

h) Controlling of the visual atmosphere by users

Description	This indicator aims to ensure that the users can control the natural and artificial light into the spaces to avoid the glaring effect.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Controlling of the visual atmosphere by users' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building provides a control of the visual atmosphere by users? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Controlling of the visual atmosphere by users' 1. Not at all: The building does not provide monitoring of the visual atmosphere by users. Users are unable to control artificial and natural lighting. There is no balance between both. 2. Little: The building provides a little bit of control of the visual atmosphere by users. Users can control artificial or natural lighting, but there is still no balance between both. 3. Average: The building provides a control of the visual atmosphere by users. Users can control artificial or natural lighting, and there is a balance between both. 4. Much: The building provides much of control of the visual atmosphere by users. The balance between natural and artificial light allow users to improve their visual comfort when exercising their activities. 5. Very much: The building provides very much of control of the visual atmosphere by users. Roller shades systems, curtains, and portable outdoor shading devices were installed to control natural light, and a control of artificial lighting level and a system that combines both were installed. Users have an optimal visual comfort when exercising their activities.

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i) Adequate minimum lighting

Description	This indicator aims to evaluate the capacity of the building to provide a correct and comfort luminance levels.
Nature	Qualitative
Source	AFNOR (2011), IES (2013); USGBC (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Adequate minimum lighting' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building provides a correct and comfort luminance levels? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Adequate minimum lighting' 1. Not at all: The building does not provide at all enough light for the user's activities. Users are not satisfied with the balance of quantity of artificial or daylight. 2. Little: The building provides a little bit of visual comfort to the occupants in the development of their activities. Users are somewhat satisfied with the balance of quantity of artificial or daylight. 3. Average: The visual comfort of the building has some importance in the development of the user's activities. The building can bring together some balance between artificial and day lighting. 4. Much: The visual comfort of the building has a imperative role in the development of users activities. The building has positive influence regarding the balance between artificial and day lighting. 5. Very much: The building provides to the users an excellent visual comfort to develop their activities. Strategies previewed in the design process, for instance, emplacement and size of windows, the right choose of the artificial lighting helped the building to reach a considerable balance between the light needed and day lighting.

1.2 INDOOR ENVIRONMENTAL QUALITY

a) Low-emitting materials

Description	Requirements to reduce the quantity of indoor air contaminants and to improve the indoor air quality.
Nature	Quantitative
Source	Based in EPA (2017), ADEME (2015), USGBC (2014)
Unity	Number of requirements followed
Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)

Guidelines	The indicator 'Low-emitting materials' verifies if the building complies with the LEED requirements. Guidelines for 'Low-emitting materials': 1 → If the building project follows one requirement of low-emitting materials or components 2 → If the building project follows two requirements of low-emitting materials or components 3 → If the building project follows three requirements of low-emitting materials or components 4 → If the building project follows four requirements of low-emitting materials or components 5 → If the building project follows five requirements of low-emitting materials or components

b) Bio-based use in the building materials

Description	The goal of this indicator is to measure the bio-based materials use in the building construction.
Nature	Quantitative
Source	Certivéa (2014)
Unity	kg/m²
Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Bio-based use in the building materials' provides a quantitative measure and is rated on a five-point Linkert scale: How much of bio-based material were incorporated in the building, in a kg/m² of floor area? Guidelines for 'Bio-based use in the building materials ' 1 → 0 kg/m² 2 → Between 9 kg/m² and 18 kg/m² 3 → Between 18 kg/m² and 24 kg/m² 4 → Between 24 kg/m² and 36 kg/m² 5 → Level 3: More than 36 kg/m².

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c) Air quality management plan of the construction site

Description	The goal of this indicator is to measure the control of air quality inside the building site to promote health security and well-being of the workers through the use of safety equipment when handling toxic products and the promotion of a minimum of ventilation.
Nature	Qualitative
Source	USGBC (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Air quality management plan of the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the Air quality management plan of the construction site promoted the health security and well-being of workers ? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for ' Air quality management plan of the construction site' 1. Not at all: There were no concerns about the air quality control during the construction site management. Workers health security and well-being are not assured. 2. Little: There were a little of concerns about the air quality control during the construction site management. Workers health security and well-being were a little bit were considered. 3. Average: Concerns about the air quality control during the construction site management were taken into account in the establishment of construction site management strategies. Workers health security and well-being were considered. 4. Much: Concerns about the air quality control during the construction site management were much taken into account in the establishment of construction site management strategies. Workers health security and well-being were much considered. 5. Very much: Concerns about the air quality control during the construction site management were very much considered in the establishment of construction site management strategies. Workers health security and well

1.3 SUB-GOAL: HEALTH AND SECURITY

a) Life expectancy of construction site workers

Description	The goal of this indicator is to measure the accident rate that occurred on the building construction site.
Nature	Quantitative
Source	Based on European Commission (2016), OECD (2016) and Eurofound (2012).
Unity	Number of accidents

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Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Life expectancy of the construction site workers' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the construction site contributes positively with the life expectancy of the construction site workers? Guidelines for 'Life expectancy of the construction site workers' 1 → The construction site had more than three accidents involving workers. 2 → The construction site had three accidents involving workers 3 → The construction site had two accidents involving workers. 4 → The construction site had just one accident involving workers. 5 → The construction site did not have any accident involving workers.

b) Security of construction site workers

Description	This indicator aims to investigate if the security measures and risk prevention previewed in the *Code du Travail* (Labor Code, Legifrance, 2017) are being respected inside the construction site.
Nature	Qualitative
Source	Legifrance (2017) and INRS (2012)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Security of construction site workers' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent does the construction site respected security measures and risk prevention? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Security of construction site workers' 1. Not at all: The construction site did not respect at all security measures and risk prevention. 2. Little: The construction site respected a little bit of security measures and risk prevention. 3. Average: The construction site respected the security measures and risk prevention. 4. Much: The construction site much respected the security measures and risk prevention. 5. Very much: The construction site very much respected the security measures and risk prevention.

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c) Choosing building products to limit health impacts

Description	This indicator ensures that the choose of building products made were considered in the limits on human health impacts and the possibility of existence of VOC and formaldehyde were previously analyzed.
Nature	Qualitative
Source	Based on Certivèa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Choosing building products to limit the health impacts' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent does the health impact was a parameter for choosing building products? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Choosing building products to limit the health impacts.' 1. Not at all: Health impact was not at all a parameter when choosing building products. 2. Little: Health impact was a little bit a parameter when choosing building products. 3. Average: Health impact was a parameter when choosing building products. 4. Much: Health impact was much a parameter when choosing building products and VOC and formaldehyde emissions are known. 5. Very much: Health impact was very much a parameter when choosing building products. VOC, formaldehyde and CMR (Carcinogenic, mutagenic, reprotoxic) emissions are known.

d) Optimize cleanliness of the construction site

Description	The goal of this indicator is to ensure the cleanliness of the construction site by limiting the pollution due to dust, mud and concrete waste.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Optimize cleanliness of the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the construction site optimized cleanliness? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Optimize cleanliness of the construction site' 1. Not at all: The building construction site did not optimize at all cleanliness.

	2. Little: The building construction site optimized a little bit of cleanliness. 3. Average: The building construction site optimized cleanliness. 4. Much: The building construction site much optimized cleanliness. Typical actions as regular watering the soil especially in summer, dust collector installation, and cleaning the interior areas of the site with a vacuum cleaner, between others, ensures the cleanliness in the construction site. 5. Very much: The building construction site very much optimized cleanliness. In addition to the typical action mentioned before, the cleaning of the machinery and equipment were optimized as well. For instance, the implementation of cistern for cleaning tools and dumpsters, a mobile truck washing system and others.

1.4 WORK CONDITIONS

a) Work satisfaction inside the construction site

Description	This indicator aims to measure the job quality inside the construction site. The quality of jobs is associated with the level of earnings, security a job provides, work conditions and quality of workplace.
Nature	Qualitative
Source	Based in OECD (2016)
Unity	Linkert scale
Normalisation	1 1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Work satisfaction inside the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent did the construction site provide a job quality between workers? (Not at all - 1 - 2 - 3 - 4 - 5 - Satisfactory). Guidelines for 'Work satisfaction inside the construction site' 1. Not at all: The construction site did not provide at all job quality between workers. 2. Little: The construction site provided a little bit of job quality between workers. 3. Average: The construction site provided job quality between workers. 4. Satisfactory: The construction site provided satisfactory job quality between workers. 5. Very satisfactory: The construction site provided very satisfactory job quality between workers. Social support at work, received from the manager or colleagues, made a remarkable difference in employee satisfaction and mental well-being.

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1.5 ENSURING A LIVABLE AREA

a) Availability of public amenities

Description	This indicator is described as "*the number of public amenities, including public spaces, parks, public recreation, open green areas, community centres or libraries, located within 500m of the central living area of the project*" (Bosch et al., 2013, page 20).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Availability of Public Amenities' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent are important public amenities (such as green public spaces, community centres, theatres or libraries) available within a radius of 500m from the central living area of the project? (No public amenities - 1 - 2 - 3 - 4 - 5 - Relatively many public amenities). Guidelines for 'Availability of Public Amenities' 1. No amenities: no public amenities whatsoever are available (e.g. no basic nor additional). 2. Relatively few amenities: only few basic public amenities are available (e.g. a small park). 3. A reasonable number of amenities: basic public amenities are available including a few important amenities such as a primary school, library or community centres. 4. Enough amenities: basic public amenities are widely available (e.g. open green spaces, public recreation) as well as many important public amenities (e.g. libraries, primaries school, public sports centres). 5. Relatively many amenities: the area surrounding the project's central living area includes a wide variety of public amenities including numerous basic amenities (e.g. green spaces, public recreation facilities) as well as numerous important public amenities (e.g. theatres, public libraries, public health care services).

b) Availability of commercial amenities

Description	This indicator is described as *"the number of commercial amenities (such as shops, restaurants, bars, groceries) located within 500m of the central living area of the project"* (Bosch et al., 2013, page 21).
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	Linkert scale

Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Availability of commercial amenities' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent are commercial amenities available within a radius of 500m from the central living area of the project? (No commercial amenities - 1 - 2 - 3 - 4 - 5 - Relatively many commercial amenities). Guidelines for 'Availability of commercial amenities' 1 → More than 1000m of walking distance of existing bus or metro stops. 2 → Between 800m and 1000m of walking distance of existing bus or metro stops. 3 → Between 400m and 800m of walking distance of existing bus or metro stops. 4 → Between 200m and 400m of walking distance of existing bus or metro stops. 5 → Less than 200m of walking distance of existing bus or metro stops.

1.6 LAND DESIGN FOR SUSTAINABLE URBAN DEVELOPMENT

a) Access to quality transit

Description	This indicator wants to encourage the reduction of vehicle use and promotion of other public transport systems as bus and metro. The goal is to reduce greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.
Nature	Quantitative
Source	USGBC (2014)
Unity	Meters (m)
Normalisation	1 to 10 (1 → 0; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Access to quality transit' provides a quantitative measure and is rated on a five-point Linkert scale: How much far is the building, in a walking distance, from a bus or metro stop? Guidelines for 'Access to quality transit' 1 → More than 1200m of walking distance of existing bus or metro stops. 2 → Between 1000m and 1200m of walking distance of existing bus or metro stops. 3 → Between 800m and 1000m of walking distance of existing bus or metro stops. 4 → Between 400m and 800m of walking distance of existing bus or metro stops. 5 → Less than 400m of walking distance of existing bus or metro stops.

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b) Bicycle facilities

Description	This indicator wants to promote bicycling and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging utilitarian and recreational physical activity. three important issues are analyzed: the public bicycle network, bicycle storage and building shower rooms.
Nature	Qualitative
Source	USGBC (2014)
Unity	Likert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Bicycle facilities' provides a qualitative measure and is rated on a five-point Linkert scale: In what way the building provides bicycle facilities? Guidelines for 'Bicycle facilities' 1. Not at all: The building does not provide at all bicycle facilities. There is no shower in the building for cyclists, any bicycle storage and either a bike lane leading to the building. 2. Little: The building provides a little bit of bicycle facilities but the infrastructure is not complete and there is a lack in the equipment available. 3. Average: Concerns about the bicycle facilities were considered in the building conception. Showers for cyclists were installed to promote cycling. The building provides long-term bicycle storage for at least 5% of all regular building occupants. The building was located close to a bike lane to improve accessibility of the building. 4. Much: Concerns about the bicycle facilities were much considered in the building conception. The numbers of showers and storage in the building are enough to all the users. The building provides long-term bicycle storage for more than 5% of all regular building occupants. The building was located close to more than one option of bike lane to improve accessibility of the building. 5. Very much: Concerns about the bicycle facilities were very much considered in the building conception. The numbers of showers and storage in the building are enough to all the users. The building provides long-term bicycle storage for more than 5% of all regular building occupants and extra storage for visitors. The building was located close to more than one option of bike lane to improve accessibility of the building.

c) Green vehicles

Description	This indicator has as main goal the pollution reduction by promoting alternatives to conventionally fueled automobiles, in order words, provide the right infrastructure in the parking area for these green vehicles, for instance: designate 5% of all parking spaces used by the project as preferred parking for green vehicles and installation of electrical vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project - electric vehicle charging.
Nature	Qualitative

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Source	USGBC (2014)
Unity	Likert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Green vehicles' provides a qualitative measure and is rated on a five-point Linkert scale: In what way the building promotes alternatives to conventionally fueled automobiles? Guidelines for 'Green vehicles' 1. Not at all: The building does not provide at all green vehicles facilities. There is no parking space preference for green vehicles and there is no installation of EVSE. 2. Little: The building provides at little bit of green vehicles facilities. There is some parking space preference for green vehicles but less than 5%. EVSE were installed in the parking spaces. 3. Average: The building provides the minimum of green vehicles facilities. 5% of parking space are destined for green vehicles and EVSE were installed in 2% of all parking spaces. 4. Much: The building provides much green vehicles facilities. More than 5% of parking space are destined for green vehicles and EVSE were installed in more than 2% of all parking spaces. 5. Very much: The building provides very much green vehicles facilities. More than 5% of parking space are destined for green vehicles and EVSE were installed in more than 2% of all parking spaces. The building is an example of green vehicles promotion.

1.7 PROMOTION OF A FEELING OF COMMUNITY/HOME

a) Connection to the existing cultural heritage

Description	This indicator is defined as "*the extent to which the design of the project reflects the distinctive physical and cultural values of the existing land and community*" (Bosch et al., 2013). When designing a project architects should consider that heritage places are an important link between past and future generations. Keeping the location's special identity could bring economic as well as other benefits to the area.
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Connection to the existing cultural heritage' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the design of the

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	project made a connection to the existing cultural heritage? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Connection to the existing cultural heritage' 1. Not at all: No attention has been paid to existing cultural heritage 2. Little: Heritage places have received some attention in the project, but not as an important element. 3. Average: Somme attention has been given to the conservation of heritage places. 4. Much: Heritage places are reflected in the project design. 5. Very much: Heritage places are included in the project as clear and recognizable landmarks.

b) Openness to the city

Description	This indicator aims to evaluate the connection between university and the city concerning the space sharing.
Nature	Qualitative
Source	Based in CPU (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Openness to the city' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the design of the project made a connection to the city concerning the space sharing? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Openness to the city' 1. Not at all: No attention has been paid to openness the university campus to the city. 2. Little: Little attention has been paid to openness the university campus to the city. 3. Average: Somme attention has been paid to openness the university campus to the city. 4. Much: Much attention has been paid to openness the university campus to the city. 5. Very much: Very much attention has been paid to openness the university campus to the city.

c) Design for a sense of place

Description	According to Bosch et al. (2013, page 17), 'sense of place' is defined as "*details in the design that make a place distinctive which fosters a sense of authentic human attachment and create a feeling of belonging/home*". Important features that support a sense of place include vitality, safety, identity, proportion and visual variety.
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Design for a sense of place' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the has the project team given attention to a 'sense of place' in the design of the project? (Not at all considered in the design - 1 - 2 - 3 - 4 - 5 - Very much considered in the design). Guidelines for 'Design for a sense of place' 1. Poor: No attention has been paid to the idea of creating a "sense of place" in the design of the project, even residents are not able to identify any elements. 2. Fair: The idea of creating a "sense of place" has received some attention 3. Average: Somme attention has been given in the design to the idea of creating a "sense of place". 4. Good: Much attention has been given to the idea of creating a "sense of place" in the project design. 5. Very good: The attention paid to the aim of creating a "sense of place" in the design is clearly and recognizably present in the project, even for outsiders.

1.8 SOCIAL JUSTICE

a) Making buildings accessible to people with disabilities

Description	This indicator aims to evaluate the universities strategies to improve their building accessibility.
Nature	Qualitative
Source	Based in MLHD (2006)
Unity	Linkert scale
Normalization	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Making buildings accessible to people with disabilities' provides a qualitative measure and is rated on a five-point Linkert scale: In what extent do

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	universities buildings provide buildings accessible to people with disabilities? (Not at all - 1 - 2 - 3 - 4 - 5 - Very satisfactory). Guidelines for 'Making buildings accessible to people with disabilities'. 1. Not at all: The universities buildings are not at all accessible to people with disabilities. 2. Little: The universities buildings are little accessible to people with disabilities. 3. Average: The universities buildings are accessible to people with disabilities. 4. Satisfactory: The universities buildings are satisfactory accessible to people with disabilities. 5. Very satisfactory: The universities buildings are very satisfactory accessible to people with disabilities.

b) Social equity within the supply chain

Description	This indicator aims to encourage members of the project team to work with product suppliers that promote and further social equity by integrating GSR strategies that address identified social and community issues, needs and disparities among those affected by the project by: • *Promoting fair trade, respect for human rights, and other equity practices among disadvantaged communities* • *Creating more equitable, healthier environments for those affected by manufacturing of the materials created for the project.*
Nature	Qualitative
Source	Based in USGBC (2014)
Unity	Linkert scale
Normalization	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Social equity within the supply chain' provides a qualitative measure and is rated on a five-point Linkert scale: In what extent do the project's suppliers promote social equity within the supply chain? (Not at all - 1 - 2 - 3 - 4 - 5 - Very satisfactory). Guidelines for 'Social equity within the supply chain' 1. Not at all: Project's suppliers do not at all promote social equity. 2. Little: Project's suppliers promote little social equity. 3. Average: Project's suppliers promote social equity. 4. Satisfactory: Project's suppliers promote satisfactory social equity. 5. Very satisfactory: Project's suppliers promote very satisfactory social equity.

2. TOP-GOAL « PLANET »

2.1 ENERGY

a) Annual primary energy consumption of buildings

Description	This indicator assesses the annual primary energy consumption of buildings on the project site for building-related energy consumption -space heating and cooling, and hot water provision (Bosch et al., 2013). Variables as building function (residential or office buildings), and with the climatic characteristics of its location needs to be considered. **Different climate zones (Bosch et al., 2013)** Climate Zone / Climatic description / Energy need for heating and cooling / Example countries: A / CDD = 0 and HDD ≥ 5000 / Very high / Finland, Sweden, Norway B / CDD = 0 and 3500≤HDD≤5000 / High / Lithuania, Estonia, Latvia C / 0 ≤ CDD ≤ 400 and 2000 ≤ HDD < 3500 / Medium / France, UK, Luxembourg, Belgium, Netherlands, Poland, Czech Republic D / 400 < CDD ≤ 1020 and HDD < 2000 / Low / Spain, Italy, Greece, Malta
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	kWh/m/year
Normalization	1 – 10 (1 → >90; 2 → 80-90; 3 → 70-80; 4 → 60-70; 5 → 50-60; 6 → 40-50; 7 → 30-40; 8 → 20-30; 9 → 10-20; 10 → <10)
Guidelines	The indicator 'Annual primary energy consumption of buildings' provides a quantitative measure and is scored according to the Climate Zone C for France and as office buildings for universities case. Guidelines for 'Annual primary energy consumption of buildings' 1 → >90 kWh/m /year 2 → 80-90 kWh/m /year 3 → 70-80 kWh/m /year 4 → 60-70 kWh/m /year 5 → 50-60 kWh/m /year 6 → 40-50 kWh/m /year 7 → 30-40 kWh/m /year

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	8 → 20-30 kWh/m /year 9 → 10-20 kWh/m /year 10 → <10 kWh/m /year

b) Annual final energy consumption of buildings

Description	The indicator is defined as *"the % reduction in energy consumption of all buildings, for heating cooling and hot water provision*" (Bosch et al., 2013, page 27) compared to business as usual situation.
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	%
Normalization	1 – 10 (1 → 10%; 2 → 20%; 3 → 30%; 4 → 40%; 5 → 50%; 6 → 60%; 7 → 70%; 8 → 80%; 9 → 90%; 10 → 100%)
Guidelines	The indicator 'Annual final energy consumption of buildings' provides a quantitative measure and is scored according to the guidelines below. Guidelines for 'Annual final energy consumption of buildings' 1 → 10% of improvement or less 2 → 10-20% of improvement 3 → 20-30% of improvement 4 → 30-40% of improvement 5 → 40-50% of improvement 6 → 50-60% of improvement 7 → 60-70% of improvement 8 → 70-80% of improvement 9 → 80-90% of improvement 10 → 90-100% of improvement

c) Renewable energy production

Description	This indicator has as main goal the reduction in the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewables. The LEED rating system considers that we can measure the renewable energy production using the equation bellow:

	$\% \text{ renewable energy} = \frac{\text{Equivalent cost of usable energy produced by the renewable energy system}}{\text{Total building annual energy cost}}$
Nature	Quantitative
Source	USGBC (2014)
Unity	%
Normalization	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Renewable energy production' provides a quantitative measure and is rated on a five-point Linkert scale: How much of renewable energy the building has been producing? Guidelines for 'Renewable energy production.' 1 → Less than 1% of renewable energy production 2 → Between 1% and 2% of renewable energy production 3 → Between 2% and 3% of renewable energy production 4 → Between 3% and 4% of renewable energy production 5 → More than 4% of renewable energy production

d) Reducing construction site energy consumption

Description	The goal of this indicator is to ensure that the electromechanical equipment of the construction site will be energy efficient.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Reducing construction site energy consumption' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the electromechanical equipment used on the construction site are efficient? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Reducing construction site energy consumption' 1. Not at all: The construction site equipments had a D energy label. 2. Little: The construction site equipments had a C energy label. 3. Average: The construction site equipments had a B energy label.

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	4. Much: The construction site equipments had a A+ or a A++ energy label. 5. Very much: The construction site equipments had a A+++ energy label.

e) Optimizing energy performance

Description	This indicator has as main goal the evaluation and identification of the energy performance optimization strategies: • *building envelope opaque with important thermal isolation, identification of thermal bridges and proper sealing;* • *insulated glazing;* • *efficient interior and exterior lighting;* • *efficient cooling and heating system;* • *moreover, low energy equipment choices (i.e., energy star)*
Nature	Qualitative
Source	Based in USGBC (2014) and RT (2012)
Unity	Linkert Scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Optimizing energy performance' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building project allowed an optimization of energy performance? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Optimizing energy performance' 1. Not at all: Any optimization energy performance strategy was used in the project. 2. Little: One or two optimization energy performance strategy were used in the project. 3. Average: At least three optimization energy performance strategy were used in the project. 4. Much: Four optimization energy performance strategy were used in the project. 5. Very much: Five optimization energy performance strategy were used in the project.

2.2 BIODIVERSITY

a) Preserving biodiversity during construction site

Description	This indicator aims to ensure that the building project allows maintaining and to improve site's biodiversity.
Nature	Qualitative
Source	Based in Certivéa (2011)

Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Preserving biodiversity during construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building site allowed an improvement and conservation of local biodiversity? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Preserving biodiversity during construction site.' 1. Not at all: The construction site did not allow an improvement and conservation of local biodiversity. 2. Little: The construction site allowed a little bit of improvement and conservation of local biodiversity. 3. Average: The construction site allowed some improvement and conservation of local biodiversity. An inventory of the fauna and flora was made and the new species planted were previous studied for a good integration with the existents species and the local soil and climate. 4. Much: The construction site much-allowed improvement and conservation of local biodiversity. An assessment was conducted to evaluate if the project ensures ecological continuity with existing green spaces on neighboring plots. 5. Very much: The construction site very much allowed improvement and conservation of local biodiversity through an accurate ecologic diagnostic.

b) Construction site assessment

Description	This indicator aims to evaluate the site assessment conditions before the construction to analyze sustainable options for the site.
Nature	Qualitative
Source	Based in USGBC (2014)
Unity	Linkert scale
Normalization	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Construction site assessment' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the construction site planning enrolled a complete site assessment to evaluate sustainable options? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Construction site assessment.' 1. Not at all: Any previous analysis was enrolled in order to evaluate sustainable options. 2. Little: At list one analysis were made in order to evaluate sustainable options.

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	3. Average: Two analysis were made in order to evaluate sustainable options. 4. Much: Three or four analysis were made in order to evaluate sustainable options. 5. Very much: Five analysis were made in order to evaluate sustainable options.

2.3 SOIL

a) Vegetation of surfaces

Description	This indicator aims to limit soil sealing of the building project by the establishment of porous surfaces, to promote maximum percolation of rainwater into the ground and keep as much as possible the natural water cycle.
Nature	Quantitative
Source	Based in Certivéa (2011)
Unity	%
Normalization	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Vegetation of surfaces' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the soil sealing of the building project was limited? Guidelines for 'Vegetation of surfaces' 1 → If the global waterproofing coefficient is superior to 90% 2 → If the global waterproofing coefficient is inferior or equal to 90% 3 → If the global waterproofing coefficient is inferior or equal to 80% 4 → If the global waterproofing coefficient is inferior or equal to 70% 5 → If the global waterproofing coefficient is inferior or equal to 65%

b) Water and soil pollution prevention from the construction site

Description	This indicator aims to limit water and soil pollution inside the construction site.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Water and soil pollution prevention from the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the

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	construction site prevented water and soil pollution? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Water and soil pollution prevention from the construction site' 1. Not at all: The construction site did not prevent at all water and soil contamination. 2. Little: The construction impeded a little bit of water and soil contamination. 3. Average: The construction prevented water and soil pollution according to the limits required by the local regulation. 4. Much: The construction much prevented water and soil pollution according to the limits requested by the local regulation and utilized products with low toxicity to respect the construction site vulnerability previewed by a preliminary study. 5. Very much: The construction very much prevented a little bit of water and soil pollution according to the limits required by the local regulation and utilized products with low toxicity to respect the construction site vulnerability previewed by a preliminary study. Furthermore, the construction site is equipped with a system of polluting effluents recovery.

2.4 WATER

a) Limiting the water use for gardening and cleaning

Description	This indicator aims to ensure the reduction of potable water consumption in gardens and also for cleaning by rainwater recovery.
Nature	Quantitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Limiting the water use for gardening and cleaning' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's project limits the potable water use for gardening and cleaning? Guidelines for ‘Limiting the water use for gardening and cleaning.' 1 → 10% of potable water economy 2 → 20% of potable water economy 3 → 30% of potable water economy 4 → 40% of potable water economy 5 → 50% of potable water economy or more

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b) Limiting water needs in toilets

Description	This indicator aims to limit water needs in toilets. The goal of this indicator is to ensure that the WC's equipment have a limit water needs. To verify this, some references values of water needs are used according to Certivéa (2011): • *Toilet flush: 6 liters / flush* • *Urinal flush: 3 liters / flush* • *Faucet: 10 liters / minute* • *Shower: 12 liters / minute* • *Bath: 150 liters* • *Sink: 12 liters / minute*
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Limiting water needs in toilets' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's project limits water needs in toilets? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Limiting water needs in toilets' 1. Not at all: WC's water needs ≥ WC's water needs of reference 2. Little: WC's water needs ≤ WC's water needs of reference 3. Average: WC's water needs ≤ 0,70 WC's water needs of reference 4. Much: WC's water needs ≤ 0,60 WC's water needs of reference 5. Very much: WC's water needs ≤ 0,50 WC's water needs of reference

c) Potable water use reduction inside the construction site

Description	This indicator aims to identify opportunities to reduce water consumption inside the building site.
Nature	Qualitative
Source	Darkos and Chan (2016)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Potable water use reduction inside the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the

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	construction site workers reduced the drinkable water consumption inside the site? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Potable water use reduction inside the construction site' 1. Not at all: The construction site workers did not at all reduce the potable water consumption inside the site. 2. Little: The construction site workers reduced a little the drinkable water consumption inside the site. 3. Average: The construction site workers reduced the drinkable water consumption inside the site. 4. Much: The construction site workers much reduced the drinkable water consumption inside the site. 5. Very much: The construction site workers very much reduced the drinkable water consumption inside the site. The building team worked together through information campaigns.

2.5 POLLUTANTS EMISSIONS INTO THE ATMOSPHERE

a) Air pollution emissions in the construction site

Description	This indicator aims to evaluate the reduction of air pollution emissions by transport inside the construction site.
Nature	Qualitative
Source	Based in Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Air pollution emissions in the construction site' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building site prevented air pollution emissions by transport? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Air pollution emissions in the construction site' 1. Not at all: The construction site did not prevent at all air pollution emissions by transport inside the construction site. 2. Little: The construction prevented a little bit of air pollution emissions by transport inside the construction site. 3. Average: The construction prevented in average air pollution emissions by transport inside the construction site. 4. Much: The construction much-prevented air pollution emissions by transport inside the construction site.

	5. Very much: The construction very much prevented air pollution emissions by transport inside the construction site. The plan of construction site previewed trucks flow reduction and employees are warned to turn off the trucks when discharging.

b) Carbon dioxide emissions

Description	This indicator aims to evaluate the reduction carbon dioxide emissions achieved by the project in metric tons CO /year. The carbon dioxide emissions are directly related to energy use.
Nature	Quantitative
Source	Based in Bosch et al. (2013)
Unity	Metric tons CO /year.
Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Carbon dioxide emissions' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the project achieved a reduction in the carbon dioxide emissions? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Carbon dioxide emissions.' 1 → Less than 12 metric tons CO/year. 2 → 12 to 18 metric tons CO/year. 3 → 18 to 24 metric tons CO/year. 4 → 24 to 30 metric tons CO/year. 5 → More than 30 metric tons CO/year.

2.6 CLIMATE SYSTEM

a) Climate resilient design neighborhood

Description	This indicator aims to evaluate the capacity of the project in taking into account the climate adaptation at the neighborhood to make neighborhoods resilient to future changes in climate.
Nature	Qualitative
Source	Based in Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Climate resilient design neighborhood' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent climate adaptation measures on

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	neighborhood scale have been included in the design of the project? (Not taken into consideration - 1 - 2 - 3 - 4 - 5 - Very much considered). Guidelines for 'Climate resilient design neighborhood' 1. Adaptation measures at neighborhood scale were not taken into consideration. 2. Adaptation measures at neighborhood scale were of minor importance in the project. A gut feeling was followed when making decisions on this topic. 3. Adaptation measures at neighborhood scale were taken into consideration. Some basic information (e.g. from literature) was followed when making decisions on this subject, for example adding a line of trees to a road. 4. Adaptation measures at neighborhood scale were an important consideration for decisions made in the project. 5. Adaptation measures at neighborhood scale were a major consideration for decisions made in the project, as an adaptation to climate change was a specific goal of the project. Extensive information (e.g. calculations, integral planning) was followed when making decisions on this topic.

b) Climate resilient design building

Description	This indicator aims to evaluate the ability of inclusion of climate adaptation measures in the building design.
Nature	Qualitative
Source	Based in Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Climate resilient design building' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have climate adaptation measures been included in the building design? (Not taken into consideration - 1 - 2 - 3 - 4 - 5 - Very much considered). Guidelines for 'Climate resilient design building' 1. Adaptation measures at building scale were not taken into consideration; 2. Adaptation measures at building scale were of minor importance in the project. A gut feeling was followed when making decisions on this topic; 3. Adaptation measures at building scale were taken into consideration. Some basic information (e.g. from literature) was followed when making decisions on this subject, for example, a green roof;

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	4. Adaptation measures at building scale were an important consideration for decisions made in the project. Extensive information (e.g. calculations, planning etc.) was followed when making decisions on this topic, for the reuse of rainwater; 5. Adaptation measures at building scale were a major consideration for decisions made in the project, as adaptation to climate change was a specific goal of the project. Extensive information (e.g. calculations, integral planning etc.) was followed when making decisions on this topic.

2.7 SUB-GOAL: WASTE

a) Identify and quantify the construction waste by typologies

Description	This indicator aims to identify and qualify the construction waste by typologies in the construction site. In France, the construction and demolition waste (CDW) are classified by: (1) Hazardous waste, these include waste containing asbestos and hazardous industrial waste: paints, solvents, glues, varnishes and sealants containing organic solvents, oils, and batteries; (2) Inert waste, concrete, bricks, tiles and ceramics, land and unpolluted aggregates, mineral insulation, and glass waste; (3) Non-Hazardous waste that is not packaging waste, glass, plastics, and metals, also called industrial waste.; and (4) Packaging waste.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Identify and quantify the construction waste by typologies' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the construction site identified and quantified the construction waste by typologies? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Identify and quantify the construction waste by typologies' 1. Not at all: The construction site did not provide any identification and neither quantification of construction waste by typologies. 2. Little: The construction site provided a little bit of identification and quantification of construction waste by typologies. 3. Average: The construction site provided identification and quantification of construction waste by typologies according to regulations. 4. Much: The construction site much provided identification and quantification of construction waste by typologies according to regulations and to possibilities of waste valorization.

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	5. Very much: The construction site provided very much identification and quantification of construction waste by typologies according to regulations and to possibilities of waste valorization.

b) Reducing construction waste at the source

Description	This indicator aims to evaluate the actions to reduce construction waste at the source, as for instance: construction site disposition, modular construction design, optimization of materials storage and in the construction site activities, actor's awareness about avoiding waste and emphasize on off-site materials manufacture, especially the concrete production off-site.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Reducing construction waste at the source' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building project team and the construction site workers developed actions to reduce construction waste at the source? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Reducing construction waste at the source.' 1. Not at all: The project team and the construction site workers have not developed at all actions to reduce construction waste at the source. 2. Little: The project team and the construction site workers have developed a few measures to reduce construction waste at the source. 3. Average: The project team and the construction site workers developed measures to reduce construction waste at the source. 4. Much: The project team and the construction site workers much-developed measures to reduce construction waste at the source. 5. Very much: The project team and the construction site workers very much developed measures to reduce construction waste at the source.

c) Reduction of materials used

Description	The goal of this indicator is to analyze the total amount of materials used at the project site to calculate the reduction compared to the business-as-usual situation (Bosch et al., 2013). We considered that the reduction of materials is related with the % of recyclable materials used.
Nature	Quantitative

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Source	Based in Bosch et al. (2013)
Unity	% reduction compared to business-as-usual situation
Normalisation	1 to 10 (1→0-5%; 2→5-10%; 3→10-15%; 4→15-20%; 5→20-25%; 6→25-30%; 7→30-35%; 8→35-40%; 9→40-45%; 10→>45%)
Guidelines	The indicator 'Reduction of materials used' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the project reduced the materials used in the construction site? Guidelines for 'Reduction of materials used.' 1 → 0-5% of reduction 2 → 5-10% of reduction 3 → 10-15% of reduction 4 → 15-20% of reduction 5 → 20-25% of reduction 6 → 25-30% of reduction 7 → 30-35% of reduction 8 → 35-40% of reduction 9 → 40-55% of reduction 10 → >45% of reduction

d) Optimize the treatment and reduction of W.E.E.E. (Waste Electrical and Electronic Equipment)

Description	This indicator aims to measure the optimization of treatment and reduction of W.E.E.E inside the university campus.
Nature	Qualitative
Source	FONDaTERRA (2011b)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Optimize the treatment and reduction of W.E.E.E' provides a qualitative measure and is rated on a five-point Linkert scale: How many actions the education institution has to optimize the treatment and reduction of W.E.E.E.? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Optimize the treatment and reduction of W.E.E.E' 1. Awareness: There are a few minor or unorganized actions, but no tracked measures have been set up.

	2. Initiation: An inventory of the institution’s electrical and electronic equipment is carried out (new, at end-of-life, networked). 3. Conformity to Green Plan scheme targets: All W.E.E.E. are treated according to current law. 4. Control: Actions are deployed to limit the renewal of W.E.E.E. and improve their internal or external re-use. 5. Leadership: W.E.E.E. management (optimization and reduction) and innovative recovery techniques are being trialed.

2.8 MATERIALS AND RESOURCES

a) Share of renewable materials

Description	The goal of this indicator is to analyze the total amount of renewable materials used in the building project (as for instance, wood, hay, bamboo and flaxen).
Nature	Quantitative
Source	Based in Bosch et al. (2013)
Unity	% of total materials used
Normalisation	1 to 10 (1→ 0-5%; 2→ 5-10%; 3→ 10-15%; 4→ 15-20%; 5→ 20-25%; 6→ 25-30%; 7→ 30-40%; 8→ 40-50%; 9→ 50-70%; 10→ >70%)
Guidelines	The indicator 'Share of renewable materials' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the project used renewable materials in the building project? Guidelines for 'Share of renewable materials' 1 → 0-5% of total materials used 2 → 5-10% of total materials used 3 → 10-15% of total materials used 4 → 15-20% of total material consumption 5 → 20-25% of total material consumption 6 → 25-30% of total material consumption 7 → 30-40% of total material consumption 8 → 40-50% of total material consumption 9 → 50-70% of total material consumption 10 → >70% of total material consumption

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b) Share of materials recyclable

Description	The indicator is expressed as the percentage of materials used that can be recycled (metric ton/ton of total materials used).
Nature	Quantitative
Source	Based in Bosch et al. (2013)
Unity	% of total materials used
Normalisation	1 to 10 according to the Likert scale (1→ 0-10%; 2→ 10-20%; 3→ 20-30%; 4→ 30-40%; 5→ 40-50%; 6→ 50-60%; 7→ 60-70%; 8→70-80%; 9→ 80-90%; 10→ 90%-100%)
Guidelines	The indicator 'Share of materials recyclable' provides a quantitative measure and is rated on a five-point Linkert scale: To what extent the project used materials that can be recycled ? Guidelines for 'Share of materials recyclable.' 1 → 0-10% of total material consumption 2 → 10-20% of total material consumption 3 → 20-30% of total material consumption 4 → 30-40% of total material consumption 5 → 40-50% of total material consumption 6 → 50-60% of total material consumption 7 → 60-70% of total material consumption 8 → 70-80% of total material consumption 9 → 80-90% of total material consumption 10 → 90-100% of total material consumption

3. TOP-GOAL « PROFIT »

3.1 CREATING LOCAL VALUE

a) Use of local workforce in the construction site

Description	This indicator evaluates the contribution to local employment (from the city or region) during the project's execution (Bosch et al., 2013)
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	%

Normalisation	1 to 10 (2→ <20%; 4→ 20-40%; 6→ 40-60%; 8→ 60-80%; 10→ >80%)
Guidelines	The indicator 'Use of local workforce in the construction site' provides a quantitative measure: How much the project contributed to the local employment during the construction site stage? Guidelines for 'Use of local workforce in the construction site' 2 → < 20% spent on local employment 4 → 20-40% spent on local employment 6 → 40-60% spent on local employment 8 → 60-80% spent on local employment 10 → > 80% spent on local employment

b) Use of local providers of products and equipment

Description	This indicator evaluates the contribution to local providers of product and equipment to the project development.
Nature	Quantitative
Source	Darkos and Chan (2016)
Unity	%
Normalisation	1 to 10 (2→ <20%; 4→ 20-40%; 6→ 40-60%; 8→ 60-80%; 10→ >80%)
Guidelines	The indicator 'Use of local suppliers of products and materials' provides a quantitative measure: How many of the suppliers of products and materials are local based? Guidelines for 'Use of local suppliers of products and materials' 2 → < 20% of the suppliers of products and materials are local based. 4 → 20-40% of the suppliers of products and materials are local based. 6 → 40-60% of the suppliers of products and materials are local based. 8 → 60-80% of the suppliers of products and materials are local based. 10 → > 80% of the suppliers of products and materials are local based.

3.2 CREATING VALUE FOR THE SECTOR

a) Total cost saving for the end users

Description	This indicator aims to evaluate the total of costs saving, regarding the energy/ water use reduction or generation of renewable energy on site., in Euros for residents per year.

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Nature	Quantitative
Source	Based on Bosch et al. (2013)
Unity	Euros/year
Normalisation	-
Guidelines	The indicator 'Total cost saving for the end users' provides a quantitative measure: How much is the total cost savings in Euros for end users, per year? Guidelines for 'Total cost saving for the end users' 1 → 0-1000 Euros in cost savings 2 → 1000-2000 Euros in cost savings 3 → 2000-3000 Euros in cost savings 4 → 3000-4000 Euros in cost savings 5 → 4000-5000 Euros in cost savings 6 → 5000-6000 Euros in cost savings 7 → 6000-7000 Euros in cost savings 8 → 7000-8000 Euros in cost savings 9 → 8000-10000 Euros in cost savings 10 → > 10000 Euros in cost savings

3.3 TIME OPTIMIZATION

a) Productivity in the construction site

Description	This indicator aims to evaluate the construction site performance regarding the time required to finish the construction site activities.
Nature	Qualitative
Source	Based in Federation Française du Batiment (2015); Wittle and Jones (2013)
Unity	Likert scale
Normalisation	1 to 10 according to the Likert scale (1→1; 2→3; 3→5; 4→7; 5→10)
Guidelines	The indicator 'Productivity in the construction site' provides a qualitative measure: To what extent the construction site had a high productivity in its activities? (Not at all - 1 - 2 - 3 - 4 - 5 - Very satisfactory). Guidelines for 'Productivity in the construction site' 1. Not at all: The construction site had a low productivity and it was in general 1 to 2 months late with its activities.

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	2. Little: The construction site had some performance and it was some weeks late with its activities. 3. Average: The construction site had a normal performance and retard was in the average. 4. Satisfactory: The construction site had a satisfactory productivity and the construction site activities were accomplished on time. 5. Very satisfactory: The construction site had a very satisfactory productivity and the construction site activities were accomplished earlier than planned.

b) Construction management strategies

Description	This indicator aims to evaluate the efficiency of the construction management plan regarding the design, pré-construction and construction stages.
Nature	Qualitative
Source	Anikeeff and Sriram (2008)
Unity	Likert scale
Normalisation	1 to 10 according to the Likert scale (1→1; 2→3; 3→5; 4→7; 5→10)
Guidelines	The indicator 'Construction management strategies' provides a qualitative measure: To what extent the construction management plan was satisfactory during the all construction stages? (Not at all - 1 - 2 - 3 - 4 - 5 - Very satisfactory). Guidelines for 'Construction management strategies' 1. Not at all: The construction management plan was not at all satisfactory during the construction stages. 2. Little: The construction management plan was little satisfactory during some construction stages. 3. Average: The construction management plan had some efficiency during the construction stages. 4. Satisfactory: The construction management plan was satisfactory during all the construction stages. 5. Very satisfactory: The construction management plan was very satisfactory during all the construction stages.

3.4 COSTS

a) Payback period of the building

Description	The 'Payback Period' is used to provide an indication of perceived risk as well. High initial investment costs combined with a long payback period reduce the opportunities for up scaling (Bosch et al., 2013).
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	Years
Normalisation	1 – 10 (1 → > 30; 2 → 25-30; 3 → 21-25; 4 → 18-21; 5 → 15-18; 6 → 12-15; 7 → 9-12; 8 → 6-9; 9 → 3-6; 10 → 0-3)
Guidelines	The indicator 'Payback Period of the building' provides a quantitative measure: How many time is needed for owners/operators to get return on their investment? Guidelines for 'Payback Period of the building' 1 → > 30 years 2 → 25-30 years 3 → 21-25 years 4 → 18-21 years 5 → 15-18 years 6 → 12-15 years 7 → 9-12 years 8 → 6-9 years 9 → 3-6 years 10 → 0-3 years

b) CO2 emissions reduction cost efficiency

Description	This indicator aims to calculate the costs in euros per ton of CO2 saved, per year of the low-carbon urban development project. Only the additional costs for energy/CO2 related measures are considered in the total costs calculation. This indicator is calculated on an annual basis, taking the annual reduction in CO emissions, and the annual costs of the project
Nature	Quantitative
Source	Bosch et al. (2013)
Unity	Euros/ton of CO2 saved per year

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Normalisation	1 – 10 (1 → 0-10; 2 → 10-20; 3 → 20-30; 4 → 30-40; 5 → 40-50; 6 → 50-60; 7 → 60-70; 8 → 70-80; 9 → 80-90; 10 → >90)
Guidelines	The indicator 'CO2 emissions reduction cost efficiency' provides a quantitative measure: How much is the costs in euros per ton of CO2 saved, per year ? Guidelines for 'CO2 emissions reduction cost efficiency' 1 → 0 - 10 Euro/ton CO2 2 → 10 - 20 Euro/ton CO2 3 → 20 - 30 Euro/ton CO2 4 → 30 - 40 Euro/ton CO2 5 → 40 - 50 Euro/ton CO2 6 → 50 - 60 Euro/ton CO2 7 → 60 - 70 Euro/ton CO2 8 → 70 - 80 Euro/ton CO2 9 → 80 - 90 Euro/ton CO2 10 → > 90 Euro/ton CO2

3.5 ADAPTABILITY AND FLEXIBILITY

a) Adapting the construction choices to the building lifetime

Description	This indicator aims to evaluate the building capacity of adaptation according to its lifetime.
Nature	Qualitative
Source	Based in Certivèa (2011) and CPU (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Adapting the construction choices to the building lifetime' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building team adapted the construction choices to the building lifetime? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Adapting the construction choices to the building lifetime' 1. Not at all: The building team did not adapt at all the construction choices to the building lifetime. 2. Little: The building team adapted a little the construction choices to the building lifetime.

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	3. Average: The building team adapted the construction choices to the building lifetime. 4. Much: The building team much adapted the construction choices to the building lifetime. Some internal spaces were designed to adapt to different activities and to possible renovation work for enlarging interior spaces. 5. Very much: The building team very much adapted the construction choices to the building lifetime. Not just the internal spaces are designed and adapted to different activities and to renovation possibilities but also the hydraulic and electrical systems.

b) Adapting building interior spaces to digital innovation

Description	This indicator aims to evaluate the building capacity of adaptation according to digital innovation.
Nature	Qualitative
Source	Based in Campus Responsables (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Adapting building interior spaces to digital innovation' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the university building is adapted to the digital innovation? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Adapting building interior spaces to the digital innovation' 1. Not at all: The university building is not adapted at all to the digital innovation. 2. Little: The university building is little adapted at all to the digital innovation. 3. Average: The university building is adapted at all to the digital innovation. 4. Much: The university building is much adapted at all to the digital innovation. 5. Very much: The university building is very much adapted at all to the digital innovation.

c) Incorporating the principle of 'flexibility' in the design of interior spaces

Description	This indicator aims to evaluate the incorporation of the principle of 'flexibility' in the design of interior spaces in the sense that pedagogical and didactic activities are continuously changing and the use of the spaces can also change during the day (OECD, 2005).
Nature	Qualitative
Source	Based in CPU (2014), Legifrance (2017) and OECD (2005).
Unity	Linkert scale

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Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Incorporating the principle of flexibility in the design of interior spaces' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building team optimized the interior spaces of the university building? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Incorporating the principle of flexibility in the design of interior spaces' 1. Not at all: The building team did not incorporate at all the interior design spaces of the university building. 2. Little: The building team incorporated a little the interior design spaces of the university building. 3. Average: The building team incorporated the interior design spaces of the university building. 4. Much: The building team much incorporated the interior design spaces of the university building. 5. Very much: The building team very much incorporated the interior design spaces of the university building.

3.6 CONSTRUCTION CHOICE FOR THE ACCESSIBILITY DURING MAINTENANCE WORKS

a) Ensuring accessibility for building maintenance

Description	This indicator aims to ensures that building's maintenance works can be achieved under correct conditions of access.
Nature	Qualitative
Source	Certivèa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Ensuring accessibility for building maintenance' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's maintenance works can be achieved under correct conditions of access? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Ensuring accessibility for building maintenance' 1. Not at all: The building's maintenance works cannot be achieved at all under correct conditions of access. 2. Little: The building's maintenance works can little bit be achieved under correct conditions of access.

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	3. Average: The building's maintenance works can be achieved under correct conditions of access. 4. Much: The building's maintenance works can much be achieved under correct conditions of access. 5. Very much: The building's maintenance works can very much be achieved under correct conditions of access.

b) Products, systems and construction processes

Description	This indicator aims to evaluate how the products, systems and construction processes are easy to maintain limiting the costs of maintenance.
Nature	Qualitative
Source	Certivèa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Products, systems and construction processes' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent products, systems and construction processes are easy to maintain limiting the costs of maintenance? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Products, systems and construction processes' 1. Not at all: Products, systems, and construction processes are not at all easy to maintain and increase the overall costs of maintenance. 2. Little: Products, systems, and construction processes are a little bit easy to maintain and increase the overall costs of maintenance. 3. Average: Products, systems, and construction processes are easy to maintain limiting the overall costs of maintenance. 4. Much: Products, systems, and construction processes are much easy to maintain limiting the overall costs of maintenance. 5. Very much: Products, systems, and construction processes are very much easy to maintain limiting the overall costs of maintenance.

4. TOP-GOAL « PROCESS »

4.1 GOVERNANCE MODEL

a) Leadership 'bridging'

Description	This indicator has as main goal the evaluation of the involvement of the users in the planning process (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Leadership bridging' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent is/are the leader(s) of the project successful in fostering collaboration, bringing people together, connecting different interests, and forming a supportive group of stakeholders? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Leadership bridging' 1. Not at all: The project leader is not at all instrumental in connecting previously unconnected actors (such as users, experts, universities, authorities and NGO's) who might be of positive influence for the development of the project. 2. Little: The project leader has little importance in connecting previously unconnected actors (such as users, experts, universities, authorities and NGO's) who might be of positive influence for the development of the project). The project leader is somewhat able to bring together 'the usual suspects' in a supportive group of stakeholders and fostering the collaboration between actors of similar interests. 3. Average: The project leader has some importance in actively connecting previously unconnected actors who might be of positive influence for the development of the project. The project leader is very able to bring together 'the usual suspects' in a supportive group of stakeholders and fostering the collaboration between actors of similar interests. 4. Much: The project leader has a very important role in actively connecting previously unconnected actors who might be of positive influence for the development of the project. The project leader easily brings together 'the usual suspects' in a supportive group of stakeholders and fosters the collaboration between actors of similar interests. Moreover, the project leader can foster collaboration between some actors with opposing interest. 5. Very much: The project leader enthusiastically seeks to connect stakeholders with divergent interests and is very much instrumental in fostering collaboration in a supportive group of stakeholders throughout the process. The supportive group of stakeholders goes beyond 'the usual suspects' which allows different outcomes to be reached than normally would.

b) Leadership 'lobbying'

Description	Lobbying is the capacity to create political support for the project (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Leadership lobbying' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent is/are the project leader(s) successful in creating the right connections to government officials (municipalities etc.) and creating support for the project'? (Not at all - 1 - 2 - 3 - 4 - 5 - Vey much). Guidelines for 'Leadership lobbying' 1. Not at all: The project leader is not at all instrumental in creating the right connections to government officials and creating support for the project. 2. Little: The project leader has little success in creating the right connections and creates only a limited support for the project at the side of the government. Resultantly, the project is very much hampered in its development because of lengthy discussions and procedures. 3. Average: The project leader has some success in creating the right connections to government officials and creating moderate governmental support for the project. Resultantly, the project is somewhat hampered in its development because of lengthy discussions and procedures. 4. Much: The project leader is largely successful in creating the right connections to government officials and creates considerable governmental support for the project. Resultantly, the project somewhat benefits from governmental support. 5. Very much: The project leader is very much successful in creating the right connections to government officials and creates extensive governmental support for the project. Resultantly, the project very much benefits from governmental support, which substantially assisted the project in its development

c) Leadership 'persistence'

Description	Persistency is the capacity to persevere in adverse times (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale

Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Leadership persistence' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent did the project benefit from a leader who persevered in his/her endeavor to realize the project plan (including its ambitions & targets), also in adverse conditions, to ensure the continuity of the project? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Leadership persistence' 1. Not at all: the project leader was not able to persevere in difficult circumstances, when few people still believed in its ambitions or a successful result, resulting in important components of the project to be significantly altered or fail entirely. 2. Little: the project leader has kept the project going throughout the full execution phase, but did not demonstrate exceptional determination to keep the project going or continuously motivated the parties involved. 3. Average: the project leader has brought the project to a successful end, but did not demonstrate substantial determination to keep the project going or be successful. 4. Much: the project leader shows substantial determination and manages to keep the project going, even in difficult circumstances (e.g. lack of funds, lack of cooperation, delays in the work). 5. Very much: the project leader shows exceptional determination and manages to keep the project going, even in very difficult circumstances when few people still believed in its ambitions or a successful result.

d) Involvement of public stakeholders

Description	This indicator 'Involvement of public stakeholders' aims to provide an indication of the extent to which a range of different public stakeholders have been consulted or involved in the planning and execution process of the project.
Nature	Qualitative
Source	Based on Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Involvement of public stakeholders'' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have public stakeholders been consulted or involved in the planning and execution process of the project.? (No involvement - 1 - 2 - 3 - 4 - 5 - High involvement). Guidelines for 'Involvement of public stakeholders' 1. No involvement: public stakeholders were not involved in the planning and execution process of the project.

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	2. Inform: public stakeholders were informed about the planning and execution process of the project. 3. Advise: public stakeholders were invited to ask questions, provide feedback and give advice. 4. Partnership: public stakeholders were involved in developing the project plan. Stakeholders can effectively influence the planning process. 5. High involvement: a fully integrated planning process, whereby a wide range of public stakeholders were actively involved in developing the project plan and advising on its implementation.

e) Involvement of professional stakeholders

Description	This indicator aims to provide an indication of the extent to which a range of different professional stakeholders outside the project team itself have been involved in the planning and execution process of the project (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Involvement of professional stakeholders' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have professional stakeholders outside the project team been involved in planning and execution? (No involvement - 1 - 2 - 3 - 4 - 5 - High involvement). Guidelines for 'Involvement of professional stakeholders' 1. No involvement: apart from the project team no other professional stakeholders outside the project team are involved. 2. Inform: a select group of professional stakeholders is informed about the project plan. Consultation, however, is merely intended at seeking acceptance amongst these stakeholders. 3. Advise: the project plan is presented to professional stakeholders (representatives of industry, local councils, environmental organizations), who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project plan. 4. Partnership: in several sessions, professional stakeholders are involved in developing the project plan. Stakeholders are able to effectively influence the planning process. 5. High involvement: a fully integrated planning process, whereby a wide range of professional stakeholders are actively involved on an almost day-to-day basis in developing the project plan and advising on its implementation.

4.2 STRATEGY

a) Define a sustainable strategy

Description	This indicator aims to provide a definition of the sustainable strategies of the education institution, considering the development of an action plan that covers the three aspects of SD&SR. In the case of new buildings, this action plan will present the points that the university wants to prioritize to improve, and in the case of new buildings the points the sustainable strategy that the university wants to implement.
Nature	Qualitative
Source	Based in FONDaTERRA (2011b)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Define its sustainable strategy' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent does the education institution is committed to define an action plan of SD strategy for the existing and future buildings? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Define its sustainable strategy' 1. Awareness: One-off actions carried out by staff and/or the Management Committee in all or part of the 3 strands of SD&SR (environmental, economic and social). 2. Initiation: Diagnostic established: external Stakeholders identified and sphere of influence integrated into the Institution's social considerations. One-off actions are listed, appearance of a line of governance SD&SR. 3. Conformity to Green Plan scheme targets: Strategy closely aligned with the challenges and general advantages of SD&SR, integration of sustainable missions and skills. 4. Control: The SD&SR strategy can be measured and compared. Indicators are based on international criteria for assessing sustainable performance (e.g. ISO 26000, Global Reporting Initiative (GRI)...). 5. Leadership: Building of a program of innovative actions; implementation of an exemplary methodology for collaborative efforts with public/private partners in the sphere of influence.

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4.3 MATURITY OF THE PROCESS

a) Prior experience with the solution

Description	This indicator aims to investigate how the project team is accustomed to working with or implementing the technologies, principles and/or practices applied in the project (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Prior experience with the solution' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent has the project team prior experience with the innovation(s) applied in the project? (No experience - 1 - 2 - 3 - 4 - 5 - Extensive experience). Guidelines for 'Prior experience with the solution' 1. No experience: Not having worked with the innovation(s) before in previous projects, the project team is entirely new to the innovation(s) and entirely unaccustomed to its workings. 2. Relatively little experience: The project team is largely new to the innovation(s), hardly having applied the innovation(s) before, and is mostly unaccustomed to its workings. 3. Reasonable experience: The innovation(s) are known to the team and is somewhat accustomed to its workings, having worked with the innovation(s) before in few previous projects. 4. Very much experience: The project team is familiar with the innovation(s) and accustomed to its workings, having worked with the innovation(s) in several projects before. 5. Extensive experience: The project team is extremely familiar and well accustomed to the innovation(s) applied in the project, having applied the innovation(s) in many projects before.

b) Degree of testing

Description	This indicator aims to provide an indication of in what manner the applied innovations have been largely researched, prepared and testing within the local context, before full implementation (Bosch et al., 2013)
Nature	Qualitative

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Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Degree of testing' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have the applied technologies / methods been tested before project planning / realization? (No testing and research before implementation - 1 - 2 - 3 - 4 - 5 - Extreme testing and research before implementation). Guidelines for 'Degree of testing' 1. No testing and research before implementation: No pilot was performed. The project was immediately carried out at the intended scale. 2. Relatively little testing and research before implementation: Some aspects of the innovation were tested in a single pilot. 3. Reasonable testing and research before implementation: Technologies and methods used were tested in a small-scale pilot. 4. Relatively sufficient testing and research before implementation: Technologies and methods used were tested in a larger scale pilot. 5. Extreme testing and research before full implementation: Full testing of technologies and methods used was an important element of the project.

c) User training

Description	This indicator has as main goal the evaluation of the extent to which users have been informed about the proper use of new technologies or principles in their living environment (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'User training' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have the tenants been informed or trained about the correct use of new technologies/concepts/products in their living environment? (No user training has been conducted - 1 - 2 - 3 - 4 - 5 - Users were extremely well trained). Guidelines for 'User training' 1. No user training: the users have not been informed/trained at all by the project team about the correct use of new sustainable technologies/concepts/products.

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	2. Little training: the users received elementary and limited information about the correct use of new sustainable technologies/concepts/products, possibly some written information. 3. Some training: the residents received some necessary information about the correct use of new sustainable technologies/concepts/products in the form of written information. 4. Very much training: Residents received comprehensive information about the correct use of the applied sustainable technologies/concepts/products in their living environment, as well as instructions by a designated person. 5. Extensive training: residents received extensive information and instructions during meetings, workshops and/or instruction evenings, and have the possibility to go to an environmental manager/centre with additional questions during the occupancy phase.

d) Continued monitoring/reporting

Description	This indicator has as main goal the evaluation of the extent to which users have been informed about the proper use of new technologies or principles in their living environment (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Continued monitoring/reporting' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent has continuous monitoring and reporting been used to verify that the project was executed according to ambitions, rules & regulations? (There was no continued monitoring - 1 - 2 - 3 - 4 - 5 - Continued monitoring has been a consistent concern). Guidelines for 'Continued monitoring/reporting' 1. Any: No monitoring and reporting at all was used to verify that the project was executed according to the sustainability ambitions, rules & regulations. 2. Little: monitoring and reporting was of minor importance in the project's development, and only carried out once, on a limited basis. 3. Some: monitoring and reporting was of some importance in the project's development. Monitoring and reporting was infrequent, and not carried out at set intervals. The scope of the monitoring activities was limited, including only some facets of the project's development.

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	4. Very much: monitoring and reporting was of great importance in the project's development. Monitoring and reporting was frequent, and carried out at set intervals. Most of the project's facets were monitored. 5. Extensive: monitoring and reporting to ensure that the project was executed according to the established sustainability ambitions, rules & regulations was a central and consistent concern during all stages of the project's development. Monitoring and reporting was frequent, and carried out at set intervals. The scope of the monitoring activities was extensive, including all facets of the project's development.

4.4 SUSTAINABLE SITES

a) Sustainable sites management implementation

Description	This indicator aims to measure the degree of effectiveness of the construction management plan inside the construction site.
Nature	Qualitative
Source	Based in Travis (2003)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Sustainable sites management implementation' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent was the implementation of sustainable management plan effective in the construction site? (Not effective at all - 1 - 2 - 3 - 4 - 5 - Very much effective). Guidelines for 'Sustainable sites management implementation' 1. Not effective at all: The sustainable management plan used in the construction site was not effective at all. 2. Low effectiveness: The sustainable management plan used in the construction site was poorly effective. 3. Moderate effectiveness: The sustainable management plan used in the construction site was effective. 4. High effectiveness: The sustainable management plan used in the construction site was reasonably effective. 5. Very high effectiveness: The sustainable management plan used in the construction site was highly effective.

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b) Training of the workforce

Description	This indicator aims to measure the degree of training provided by the project team to the workforce before the beginning of the construction site.
Nature	Qualitative
Source	Based in Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Training of the workforce' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent has the project team provided training of the workforce before project development? (No training - 1 - 2 - 3 - 4 - 5 - Extensive training). Guidelines for 'Sustainable sites management implementation' 1. No training 2. Limited instruction was provided on implementing the innovations to relevant members of the team/contractors 3. Training was provided on the technical implementation of the innovations to relevant members of the team/contractors 4. Training was provided on the (theoretical) principles of the innovations and on the technical implementation of the innovations to the work team involved 5. Extensive training improving theoretical knowledge on the innovations as well as practical skills in implementing the innovations was provided to the complete work team involved.

4.5 WATER AND ENERGY MANAGEMENT

a) Water metering

Description	The main goal of this indicator is to support water management and identify opportunities for additional water savings by tracking water consumption.
Nature	Qualitative
Source	Based in USGBC (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Water metering' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's team project considered the water metering as a strategy of water savings? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much).

	Guidelines for 'Water metering' 1. Not at all: The building's project team did not consider water metering as a strategy of water savings. 2. Little: The building's team project considered water metering as an important strategy of water savings but does not have installed any water metering inside the building. 3. Average: The building's team project considered water metering as a strategy of water savings and has installed at least one water metering inside the building. 4. Satisfactory: The building's team project considered water metering as a satisfactory water management and water metering were installed as a strategy of water savings in more than one place inside the building. 5. Very satisfactory: The building's team project considered water metering as a very satisfactory water management and water metering were installed as a strategy of water savings in at least two or three places inside the building (specially for water irrigation and domestic hot water).

b) Building-level energy metering

Description	The main goal of this indicator is to support energy management and identify opportunities for additional energy savings by tracking building-level energy use.
Nature	Qualitative
Source	Based in USGBC (2014)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Building-level energy metering' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's team project considered the energy metering as an opportunity for additional energy savings? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Building-level energy metering' 1. Not at all: The building's team project did not consider energy metering as an opportunity for additional energy savings. 2. Little: The building's team project considered energy metering as an important opportunity for additional energy savings but does not have installed any inside the building. 3. Average: The building's team project considered energy metering as an important opportunity for additional energy savings and installed energy metering that tracked energy consumption at a minimum of one-month intervals.

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	4. Satisfactory: The building's team project considered energy metering as a satisfactory method for additional energy savings and installed energy metering that tracked energy consumption at a minimum of once a week interval. 5. Very satisfactory: The building's team project considered energy metering as a very satisfactory method for additional energy savings and installed energy metering that tracked energy consumption daily.

4.6 INTERIOR AIR QUALITY AND TEMPERATURE CONTROL

a) Controlling of winter interior temperature

Description	This indicator is intended to provide to users a control of the thermal environment in their spaces during cold period. The indoor interior temperature control is important for meeting rooms and specially for classrooms that must be equipped of a dispositive that allows users to control heating system when necessary.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Controlling of winter interior temperature' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building's users are able to control the heating system when necessary during the winter? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Controlling of winter interior temperature' 1. Not at all: The building does not provide any interior dispositive in any space that allows users to control the heating system during the winter. Users feel could in lot of spaces inside the building. 2. Little: The building provides some interior dispositive in some spaces that allows users to control the heating system during the winter but there is still a lack in the capacity to control the heating system. Users might feel could in some spaces. 3. Average: The building provides interior dispositive in some spaces which is allowing users to control the heating system during the winter. 4. Satisfactory: The building provides satisfactory heating system equipped with a dispositive that allows users to control the interior temperature during the winter. 5. Very satisfactory: The building provides a very satisfactory heating system equipped with a dispositive that allows users to control the interior temperature during the winter.

b) Management device to ensure effective ventilation

Description	This indicator aims to evaluate the existence of management devices to monitor CO2 levels and humidity to activate mechanical ventilation system when is necessary or to warm users to open the windows for renewing air by natural ventilation. This indicator also considers the importance of having a Building Management Systems (BMS) to automatically manage buildings parameters and is especially important for classrooms and workspaces.
Nature	Qualitative
Source	Based in Certivéa (2011)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Management device to ensure effective ventilation' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent the building has a management device to control the ventilation system? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Management device to ensure effective ventilation' 1. Not at all: The building does not have a device to control the ventilation system. 2. Little: The building does have some devices to control the ventilation system however the devices are not installed in all classrooms and workspaces and do not control CO2 and humidity levels properly. 3. Average: The building does have devices to control the ventilation system. The devices are installed in all classrooms and workspaces and control CO2 and humidity levels. 4. Satisfactory: The building provides satisfactory devices to control the ventilation system. The devices are installed in all classrooms and workspaces and are optimal when controlling CO2 and humidity levels. 5. Very satisfactory: The building provides a very satisfactory device to control the ventilation system. The building is equipped with a Building Management Systems (BMS) to automatically manage buildings parameters.

4.7 SUSTAINABLE TEACHING AND RESEARCH

a) Campus as a living laboratory

Description	This indicator aims to evaluate the ability of the institution in using its infrastructure and operations for multidisciplinary student learning and applied research that contributes to understanding campus sustainability challenges or advancing sustainability on campus.
Nature	Qualitative

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Source	Based in AASHE (2016)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Campus as a living laboratory' provides a qualitative measure and is rated on a five-point Linkert scale: Is the institution using its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability? (Not at all - 1 - 2 - 3 - 4 - 5 - Very much). Guidelines for 'Campus as a living laboratory' 1. Not at all: The institution does not at all use its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability 2. Little: The institution uses a little its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability 3. Average: The institution uses its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability 4. Much: The institution much uses its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability 5. Very much: The institution very much uses its campus as a living laboratory for multidisciplinary student learning and applied research in relation to sustainability

4.8 PUBLIC ENGAGEMENT

a) Local community involvement

Description	This indicator has as main goal the evaluation of the involvement of the users in the planning process (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Local community involvement' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent have tenants/the local community been involved in project planning and execution? (No involvement - 1 - 2 - 3 - 4 - 5 - High involvement). Guidelines for ‘Local community involvement ' 1. Not at all: No community involvement.

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	2. Inform and consult: The completed project plan is announced to the community either for information only, or for receiving community views. The consultation, however, is mainly seeking community acceptance of the plan. 3. Advise: the project plan is drafted by a project team and then presented to community actors, who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project plan. 4. Partnership: community actors are asked by the project planners to participate in the planning process by prioritizing issues and planning actions. The local community can influence the planning process. 5. Community self-development: the project planners have empowered community actors to outline their needs, to make action plans, to manage the project and evaluate the results

4.9 SUB-GOAL: CAMPUS ENGAGEMENT

a) Student life

Description	For the STARS tool, this indicator aims to measure the number of programs and initiatives from university focused on sustainability, for instance: active student groups, gardens, farms, cultural art events, conferences, co-curricular sustainability programs and initiatives, and others. For the C4U tool, this indicator is related with the physical space inside the campus building designated to these activities.
Nature	Quantitative
Source	Based in AASHE (2016)
Unity	Number of spaces
Normalisation	1 to 10 (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Student life' provides a quantitative measure and is rated on a five-point Linkert scale: How many physical spaces focused on sustainability the campus building has? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Student life' 1→ One space 2→ Two spaces 3→ Three spaces 4 → Four spaces 5 → Five spaces or more

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b) Sustainable management system

Description	This indicator aims to measure the institution education of setting up a sustainable management system covering natural environment.
Nature	Qualitative
Source	Based in FONDaTERRA (2011b)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Sustainable management system' provides a qualitative measure and is rated on a five-point Linkert scale: How much the education institution is able to set up a sustainable management system? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Sustainable management system' 1. Awareness: There are a few minor or unorganized actions, but currently, no responsible management. 2. Initiation: A biodiversity inventory and an assessment of current maintenance practices are carried out. 3. Conformity to Green Plan scheme targets: There is a formalized responsible management system, but this is not monitored. 4. Control: The sustainable management method is formalized and tracked. Specifications are required for outsourced services, which are monitored. 5. Leadership: Sustainable management of spaces is experimental or innovative.

c) Raise awareness

Description	This indicator aims to raise awareness of and secure the participation of the institution's staff and students in fostering sustainable practices.
Nature	Qualitative
Source	Based in FONDaTERRA (2011b)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator ‘Raise awareness' provides a qualitative measure and is rated on a five-point Linkert scale: How much the education institution is able to raise awareness of and secure the participation of the institution's staff and students in fostering sustainable practices? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership). Guidelines for 'Raise awareness'

	1. Awareness: Growing number of staff who are aware of SD&SR practices in their business area. the Institution's HRD recognizes the needs and skills required for their development…. 2. Initiation: Diagnostic established: external Stakeholders identified and sphere of influence integrated into the Institution's social considerations. One-off actions are listed, appearance of a line of governance SD&SR. 3. Conformity to Green Plan scheme targets: Action plan committed to. Performance scale determined. Taking account of regulations and national and international corporate social responsibility standards (Human rights, working conditions, environment, fair practices). 4. Control: SD&SR is built into the Institution's strategy. Continuous improvement tracking process in place. Progress objectives set. Active and dynamic social contribution both locally and toward all the Institution's stakeholders. 5. Leadership: Quality of the approach is controlled and publicly recognized. Impacts on the sphere of influence are measured and corrected where necessary. The institution's expertise in SD&SR is requested externally. SD&SR dynamic carried and supported by external stakeholder's externals.

5. TOP-GOAL « PROPAGATION »

5.1 COMPLEXITY

a) Complexity for end-users

Description	This indicator has as main goal to provide an indication of the complexity for end-users of the innovation. End- users are those individuals who will be using or working with the innovation. Some innovations are perceived as difficult to understand and use while others are more clear and easy to the adopters (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Complexity for end-users' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent is the innovation perceived as difficult to understand and use for potential end-stage adopters (i.e. during use phase)? (No complexity for end users - 1 - 2 - 3 - 4 - 5 - Very high complexity for end users). Guidelines for 'Complexity for end-users' 1. No complexity: the innovation is as easy to understand and use.

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	2. Low: a small investment in time is required of the end users to understand the innovation and get accustomed to it, but they are fairly quickly familiar to work with the innovation. 3. Moderate: users must invest some time to understand the innovation and get accustomed to working with the innovation. Some time is needed before the innovation has become fully familiar to end users. 4. High: users need to be well instructed to be able to understand and use the innovation properly. Considerable time is required to familiarize themselves with the innovation. 5. Very high complexity: users need extensive and sustained instructions to understand the innovation and without these the innovations cannot be understood or used.

b) Complexity for professional stakeholders

Description	The main goal of this indicator is to provide an indication of the complexity for professional stakeholders of the innovation, those who are responsible for its supply, installation and maintenance. Professional stakeholders can be local project managers, construction companies, suppliers, politicians, etc. (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Complexity for professional stakeholders' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent is the innovation perceived as difficult to understand and use for professional users of the innovation (i.e. for installation, maintenance)? (No complexity for professional stakeholders - 1 - 2 - 3 - 4 - 5 - High complexity for professional stakeholders). Guidelines for 'Complexity for professional stakeholders' 1. No complexity at all: The innovation does not require any specific level of expertise and could, theoretically, be implemented/installed/maintained by non-professionals. 2. Very low complexity: The innovation requires only a very low level of additional expertise, which can be easily attained by reading/receiving a very short instruction. 3. Moderate complexity: A moderate level of additional expertise is required, which can be attained by reading/receiving a comprehensive instruction, and may require some trial and error before it can be used. 4. High complexity: Substantial extra effort is required from professional users to work with the innovation, who need some additional training to understand the innovations before working with the innovation.

	5. Very high complexity: The innovation can only be installed/implemented/maintained by experts who have been explicitly trained to work with this innovation. Training requires numerous workshops/lectures before the users are familiar enough the work with the innovation.

5.2 SUB-GOAL: RELATIVE ADVANTAGE

a) Advantage for end-users

Description	This indicator aims to provide an indication for the extent to which an innovation provides clear advantages to end users (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Advantage for end-users' provides a qualitative measure and is rated on a five-point Linkert scale: Does the project make use of new technologies and principles that offer clear advantages for end users (cheaper, comfort etc.)? (No advantage to end users - 1 - 2 - 3 - 4 - 5 - High advantage to end users). Guidelines for 'Advantage for end-users' 1. The project does not offer clear advantages for end users. The technologies or principles applied in the project are not at all beneficial to end users. 2. The project offers very little advantage to end users. Most of the technologies/principles offer an indirect and insignificant advantage to end users. 3. The project offers some advantage to end users who to a certain extent experience direct benefits from the technologies/principles applied in the project. 4. The project offers a high advantage to end users who benefit mostly from the applied technologies or principles as the applied technologies/principles have a direct and high positive effect on end users. 5. The project offers a very high advantage to end users as the applied technologies/principles have a direct and an extremely positive effect on end users (e.g. cheaper housing costs, increased comfort, increased quality of the living environment etc.).

b) Advantage for stakeholders

Description	The main goal of this indicator is to provide an indication for the extent to which an innovation provides clear advantages to stakeholders (Bosch et al., 2013)

Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Advantage for stakeholders' provides a qualitative measure and is rated on a five-point Linkert scale: Does the project make use of new technologies and principles that offer clear advantages for stakeholders (ease of management, maintenance costs etc.)? (No advantage to stakeholders - 1 - 2 - 3 - 4 - 5 - High advantage to stakeholders). Guidelines for 'Advantage for stakeholders' 1. The project does not offer clear advantages to any of the stakeholders. The technologies or principles applied in the project are not at all beneficial to stakeholders. 2. The project offers very little advantage to stakeholders. The majority of the technologies/principles offer an indirect and insignificant advantage. 3. The project offers some advantage to stakeholders who, to a certain extent, experience direct benefits from the technologies/principles applied in the project. 4. The project offers a high advantage to stakeholders who benefit mostly from the applied technologies or principles as the applied technologies/principles have a direct and high positive effect on stakeholders. 5. The project offers a very high advantage to stakeholders as the applied technologies/principles have a direct and an extremely positive effect on stakeholders.

5.3 DISSEMINATION

a) Act alongside regional and international networks of actors

Description	This indicator aims to provide some information about how the regional and international networks of actors act alongside to help influence behaviors and share sustainable performance to build a responsible corporate body.
Nature	Qualitative
Source	Based in FONDaTERRA (2011b)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Act alongside regional and international' provides a qualitative measure and is rated on a five-point Linkert scale: How the regional and international networks of actors act alongside to help influence behaviors and share sustainable performance to build a responsible corporate body? (Awareness - 1 - 2 - 3 - 4 - 5 - Leadership).

	Guidelines for ‘Act alongside regional and international' 1. Awareness: Most local actors are gradually identified and contacted to single out which regional actions should be shared, etc. 2. Initiation: Mapping of local skills bases (actors and networks) available for SD&SR projects. Theme-based actions listed. Organization around a group of actors in SD&SR. Sharing of feedback and ad hoc commitments with the group as part of the deployment of actions... 3. Conformity to Green Plan targets: Taking account of social, environmental and economic impacts stemming from decisions and activities. Compliance with the CSR duty of care set by ISO 26000. with partners, participation in local policies most closely aligned with SD&SR and with responsible regional development... 4. Control: SD&SR charter of commitment and good practices. Effectiveness of the approach and continuous improvement via analyses, measurements and regular consultations with stakeholders with whom the Institution is trying out new ways forward… 5. Leadership: SD&SR charter of commitment and good practices. Effectiveness of the approach and continuous improvement via analyses, measurements and regular consultations with stakeholders with whom the Institution is trying out new ways forward…

5.4 STANDARDS EVOLUTION

a) Change in public procurement

Description	Public procurement can be an important key for innovation. As procurement procedures are often very precise in detailing all building requirements, it rules out innovations (Bosch et al., 2013)
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Change in public procurement' provides a qualitative measure and is rated on a five-point Linkert scale: Has the project inspired new forms of public procurement procedures? (No impact on public procurement procedures - 1 - 2 - 3 - 4 - 5 - High impact on public procurement procedures). Guidelines for 'Change in public procurement' 1. No impact: the project used a new procurement procedure but this is not known to the outside world.

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	2. Little impact: the project used a new procurement procedure but is hardly known for this. 3. Some impact: the project developed and used a new procurement procedure and has received some professional attention because of this. 4. Notable impact: the project developed and used a new procurement procedure and has attracted a lot of professional attention because of this which has led to a few further experiments with the new public procurement procedure. 5. High impact: the project developed and used a new procurement procedure and has attracted a lot of public and professional attention because of this which has led to several further experiments with the new public procurement procedure.

b) Changing rules & regulations

Description	The realization of projects will often involve the alteration or different interpretations of regulations and rules. The fact that the development is 'on the edge' often means that it is innovative and that it can fulfil an important signalling function for new developments: here are the obstacles for the solutions of the future. As existing rules and regulations are based upon old systems (centralizes energy networks, traditional building processes), true innovations often break the rules (Bosch et al., 2013)).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Changing rules & regulations' provides a qualitative measure and is rated on a five-point Linkert scale: Has the project contributed to, or inspired, changes in rules & regulations (at local -city planning, zoning- or national-, -spatial law, energy laws-level)? (No impact on rules & regulation - 1 - 2 - 3 - 4 - 5 - High impact on rules & regulations). Guidelines for 'Changing rules & regulations' 1. No impact: the project has not, at any level, inspired changes in rules and regulations 2. Little impact: the project has led to a localized discussion about the suitability of the current rules and regulations. 3. Some impact: the project has led to a public discussion, leading to a change in rules and regulations. 4. Notable impact: the project has led to a public discussion, leading to a change in rules and regulations. This in its turn has sparked a discussion amongst other administrations about the suitability of the current rules and regulations.

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	5. High impact: the project has led to a public discussion, leading to a change in rules and regulations. This in turn has inspired other administrations to reconsider their rules and regulations.

5.5 MIMETIC PROCESSES

a) Diffusion to other locations

Description	A sustainable concept might be reproduced by other cities or regions. This can encompass both the innovations within the project (e.g., technology, new product) as the institutional aspects of the project (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Diffusion to other locations' provides a qualitative measure and is rated on a five-point Linkert scale: Is the project copied in other cities and regions? (Not copied in other locations - 1 - 2 - 3 - 4 - 5 - Very much copied in other locations). Guidelines for 'Diffusion to other locations' 1. The innovation is not copied in other locations. 2. The innovation has been copied once in another location within the same city/region. 3. The innovation has been copied several times within the same city/region. 4. The innovation has been copied in projects within the same city/region, as well as projects outside the original city/region. 5. The innovation has been copied in its country of origin, as well as internationally.

b) Diffusion to other actors

Description	The innovations inside the project can be copied by other companies, or regarding the case of study - other universities, and the adoption of technologies can be copied by others, for instance end users. Companies will generally follow the leading companies and adopt technologies for which the leaders set the standard (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)

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Guidelines	The indicator 'Diffusion to other actors' provides a qualitative measure and is rated on a five-point Linkert scale: Are the new technologies, principles and/ or practices in this project copied by other commercial parties (e.g. developers or builders)? (Not copied by commercial parties - 1 - 2 - 3 - 4 - 5 - Very much copied by commercial parties). Guidelines for 'Diffusion to other actors' 1. The innovation is not at all copied/adopted by other commercial parties. The newly applied technologies, principles and/or practices remain exclusive to the initial parties involved. 2. The innovation has been copied/adopted by one other commercial party who aims to apply, or has applied, the new technologies, principles and/or practices in other projects. 3. The innovation is copied by several other commercial parties. 4. The innovation is copied by many other commercial parties. 5. The innovation has become the new guideline for commercial parties, most have copied it.

5.6 ABILITY TO BRING ABOUT CHANGE

a) Diffusion sustainable construction site

Description	This indicator has as main goal to show how new technologies, principles and/ or practices used inside the sustainable construction site are copied to the others construction sites. The indicator measures the diffusion of these practices in different scales, local, national and international.
Nature	Qualitative
Source	Based in Travis (2003)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Diffusion of sustainable construction site' provides a qualitative measure and is rated on a five-point Linkert scale: Are the new technologies, principles and/ or practices in this sustainable construction site copied to the others construction sites? (Not copied at all - 1 - 2 - 3 - 4 - 5 - Very much copied). Guidelines for 'Diffusion of sustainable construction site' 1. The new technologies, principles and/ or practices are not copied in other construction sites. 2. The new technologies, principles and/ or practices has been copied once in another construction sites.

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	3. The new technologies, principles and/ or practice has been copied in construction sites several times within the same city/region. 4. The new technologies, principles and/ or practice has been copied in construction sites within the same city/region, as well as in construction sites outside the original city/region. 5. The new technologies, principles and/ or practice has been copied in national and even international construction sites.

5.7 INNOVATION CHARACTERISTICS

a) Trialability

Description	The indicator 'trialability' is perceived as "t*he degree to which an innovation may be experimented with on a limited basis"* (Rogers, Diffusion of Innovations 1995, pg.16) An innovation that can be experimented with, will represent less uncertainty for the future users (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Trialability' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent can the innovation be experimented with on a limited basis in the local context before full implementation? (No possibility for experimentation - 1 - 2 - 3 - 4 - 5 - High possibilities for experimentation). Guidelines for 'Trialability' 1. The innovation cannot be experimented with on a limited basis in the local context. Implementation on a limited basis is either technically unfeasible or would require too much extra resources (time, money, expertise). 2. The innovation has very low opportunities for experimentation at the local level, as it would be very difficult to implement the innovation on a limited basis only, or would require substantial extra resources (time, money, expertise). 3. The innovation has a moderate opportunity for experimentation at the local level. It would be difficult to implement the innovation on a limited basis only but would be possible with some extra resources (time, money, expertise). 4. The innovation has a high opportunity as it can be quite easily implemented on a limited basis at the local context, with limited resources (time, money, expertise). 5. The innovation can easily be experimented with on a limited basis at the local context, without requiring extra resources (time, money, expertise).

b) Current market demand for the solution

Description	This indicator aims to measure the rate of adoption of innovation considering that the innovation should meet the needs of its potential adopters. It is possible that innovation might have a distinctive connection to generic problems in European cities, but that the demand for a solution is relatively low (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 →1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Current market demand for the solution' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent is there a general demand for the offered solution? (No demand - 1 - 2 - 3 - 4 - 5 - High general demand). Guidelines for 'Current market demand for the solution' 1. There is no discernible market demand for the offered solution. 2. There is little market demand for the offered solution. 3. There is some market demand for the offered solution. 4. There is a large market demand for the offered solution. 5. There is a widespread market demand for the offered solution.

c) Technical compatibility of Innovation

Description	This indicator provides an indication of the technical compatibility of the innovation, meaning the extent to which the innovation fits with existent practices, administrative and existing technological standards/infrastructures (Bosch et al., 2013).
Nature	Qualitative
Source	Bosch et al. (2013)
Unity	Linkert scale
Normalisation	1 to 10 according to the Likert scale (1 → 1; 2 → 3; 3 → 5; 4 → 7; 5 → 10)
Guidelines	The indicator 'Technical compatibility of Innovation' provides a qualitative measure and is rated on a five-point Linkert scale: To what extent does the project's innovation fit with current practices, existing technological standards and infrastructures? (No technical compatibility - 1 - 2 - 3 - 4 - 5 - High technical compatibility). Guidelines for 'Technical compatibility of Innovation'

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	1. No technical compatibility: the innovation needs many and major adjustments to current (infra)structures and/or practices for its implementation. 2. Low compatibility: the innovation requires some major adjustments to current (infra)structures and/or practices for its implementation. 3. Moderate: some adjustments to current (infra)structures and/or practices are necessary to implement the innovation. 4. High: only minor adjustments (think of a different way of plug, a specific internet connection, etc.) are needed to implement the innovation. 5. Very high: no adjustments to current (infra)structures and/or practices are needed, the innovation can immediately be implemented.

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RÉSUMÉ SUBSTANTIEL

Titre : L'évaluation de la durabilité des bâtiments universitaires : une application d'un outil multi-critères et participatif pour soutenir le processus de prise de décision

Mots clés : Bâtiments universitaires ; Durabilité ; Délibération ; Participation ; Prise de décision

L'estimation de la croissance démographique contenue dans le rapport « World Population Prospects » des Nations Unies (Melorose et al., 2015) indique que, d'ici 2050, la population humaine atteindrait 9,7 milliards de personnes et, d'ici 2100, 11,2 milliards. L'urbanisation rapide suite à cette augmentation de la population entraînera plusieurs défis dans la répartition spatiale des individus et des ressources, ainsi que dans l'utilisation et l'exploitation des terres (ONU-HABITAT, 2017).

Une conséquence de l'augmentation de la population urbaine est que la construction de nouveaux bâtiments nécessitera un apport important de ressources; plus d'énergie, de matériaux et de consommation d'eau. De plus, de nouvelles constructions produiront des quantités importantes de déchets, d'émissions de GES et d'impacts environnementaux, affectant directement la santé humaine et le bien-être.

Actuellement, le secteur de la construction est le plus grand secteur consommant d'énergie à l'échelle mondiale. Dans les pays développés, les bâtiments consomment en moyenne un tiers de la consommation totale d'énergie primaire (Álvarez et al., 2009). L'énergie requise par l'industrie pourrait augmenter de 50 % d'ici 2050 si la société entretient sa consommation d'énergie dans ce secteur. Dans ce cas-ci, l'accord de Paris tente de limiter une augmentation de la température mondiale de 2 ° C et recommande une réduction de 77 % des émissions totales de $CO2$ dans le secteur des bâtiments (UN, 2016, UNFCCC, 2015).

Cela rendrait les villes de demain plus sûres et résilientes, des villes durables favorisant le développement social et économique grâce à une gestion environnementale et à une gouvernance urbaine. De plus, l'adoption des principes de développement durable (p. Ex., l'équité inter-générationnelle et intra-générationnelle, la protection de l'environnement, le partenariat, la transparence, la responsabilité et les principes de décentralisation) pourrait aider les villes dans ce processus de « nouvelle urbanisation ».

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La mise en œuvre des principes du développement durable reste un défi, mais aussi une occasion de décélérer les effets du changement climatique. Christiana Figueres (2016) fut interrogé si un accord climatique global ne serait jamais possible. Elle a répondu que *« l'impossible n'est pas un fait, est une attitude ».* Changer l'attitude à propos du changement climatique consiste à modifier les modèles de comportement et la victoire ne peut être atteinte sans l'optimisme. L'optimisme transformationnel devrait être la croyance fondamentale adoptée par la communauté globale pour adapter nos économies carbonisées face à notre environnement difficile. Par exemple :

- L'augmentation des investissements dans les technologies propres, telles que les panneaux solaires qui pourraient fournir de l'énergie à des villes entières et peuvent créer des effets positifs sur la mobilité et les bâtiments verts;
- Le changement dans l'équation économique qui peut expliquer les coûts du changement climatique et rechercher des avantages économiques et des avantages intrinsèques dans la nouvelle situation;
- L'augmentation de la participation active de tous les secteurs de l'économie;
- Une direction commune des défis sociaux assurés par les Objectifs du Développement Durable (ONU, 2012), qui établissent une priorité nationale pour la mobilisation des parties prenantes et des ressources vers un objectif commun.

L'éducation a un rôle majeur dans la transformation de la société, car elle est devenue une stratégie de promotion du développement durable (Sauvé et al., 2007). Les activités de formation et de recherche ont la capacité d'apporter des changements dans le comportement et les modes de vie de la société, mais sont également essentielles pour la diffusion des connaissances (UNESCO, 1997).

Les universités fournissent un leadership à la société en façonnant la réflexion et la formation des décideurs. Les établissements d'enseignement supérieur sont conscients que les décisions de ces leaders engagent l'avenir de l'humanité sur les aspects écologiques, économiques et sociaux (CPU, 2012).

Les contributions au SD peuvent être divisées en trois domaines principaux:

(1) par leur mission, englobant les activités d'enseignement et de recherche ;

(2) par l’ancrage social, par des activités, par la création de partenariats et l'esprit d'entreprise et la dynamique urbaine, par l'engagement dans la communauté locale et les contributions du milieu de vie ;

(3) par leurs opérations internes, qui englobe les responsabilités sociales et environnementales liées à la qualité de vie, aux conditions de travail au sein du campus et à la gouvernance avec la participation, la consultation et la direction responsable (Bouckaert, 2016).

À travers leur structure de campus, les universités pourraient fournir les meilleures conditions de vie et de travail possibles. En outre, les universités devraient assumer les responsabilités sociales et environnementales qui découlent de leur existence en tant qu'institution sociale. Les universités contribuent activement à la société, elles doivent participer à la durabilité de leur développement environnemental au risque de compromettre leur avenir (Ibid., 2016).

La structure physique du campus universitaire est un fragment de la ville. Par conséquent, les terrains de stationnement, les espaces verts et les bâtiments sont des éléments urbains primaires qui composent les campus. La nouvelle architecture universitaire est conçue comme un maillage de liens tridimensionnels entre les enseignants, les étudiants et les chercheurs pour diffuser, produire et partager des connaissances à l'intérieur et à l'extérieur du bâtiment (Compain Gajac, 2014). De nombreuses universités récentes ont transformé leur campus en construisant de nouveaux bâtiments à faible consommation d'énergie pour obtenir des certifications environnementales (p. Ex., LEEDS, HQE). Cependant, ils négligent souvent le potentiel d’économie d'énergie de la rénovation des bâtiments existants qui favorise en même temps leur valeur écologique, économique, historique et culturelle.

L'arrivée massive de nouveaux étudiants associés à la démocratisation de l'enseignement supérieur, après la Seconde Guerre mondiale, a motivé la construction de nouveaux bâtiments. De nos jours, ces bâtiments datent des années 1960 et 1970, correspondant à 40 % de l'actif universitaire en France, ce qui représente 18 millions de m² (CPU, 2014).

L'architecture moderne a fortement influencé ces bâtiments du fait d'une construction accélérée à partir de structures préfabriquées à faible coût. Cette architecture favorisant le *fonctionnel* a su répondre à la demande et aux contraintes de l'époque. Son héritage représente aujourd'hui un patrimoine historique significatif.

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Avec le temps, l'état générale des bâtiments s'est degradé par manque de maintenance contribuant à l'augmentation de consommation d'énergie (CPU, 2014) et remettant ansi en cause la responsabilité environnementale et sociale des universités concernées.

Une étude de la Direction générale de l'enseignement supérieur a conclu que 15**%** des bâtiments universitaires français ne sont pas adéquats pour les activités de recherche et d'enseignement (Campus Responsables, 2013). Ces bâtiments ne peuvent pas faire face aux nouveaux défis de la conception pédagogique numérique et ni de la transition écologique. La consommation d'énergie et les émissions de CO_2 de ces bâtiments sont, respectivement, trois fois et deux fois plus élevées que les limites établies par la loi Grenelle Environment (Caisse de Dépôts et CPU, 2010).

La rénovation de ces bâtiments existants réduirait non seulement les effets indesirables de la consommation d'énergie et des émissions de GES, mais pourrait aussi servir à améliorer la qualité de l'air intérieur et le bien-être général des étudiants et des autres acteurs qui utilisent le campus. C'est avant tout une occasion pour les universités d'affirmer leur position en tant qu'institution sociale importante qui s'attaque non seulement aux responsabilités sociales et environnementales locales, mais aussi qu'elle contribue à l'échelle mondiale comme un acteur fort pour un changement sociétal.

La revue de la littérature présente de nombreux résultats bénéfiques pour améliorer la performance de la durabilité des bâtiments universitaires (par exemple, les avantages environnementaux, économiques et sanitaires et communautaires). Cependant, elle souligne de nombreux obstacles, tels que le manque d'expérience et d'information, la sensibilisation, la coopération entre les parties prenantes du projet et les risques inhérents à la technologie (Gan et al., 2015; Häkkinen et Belloni, 2011).

Les bâtiments existants sont des éléments cruciaux d'un campus universitaire parce qu'ils accueillent des activités de recherche et d'enseignement. Le processus de rénovation de ces bâtiments pourrait contribuer à la réduction de la consommation de ressources naturelles, de la production de déchets et de la pollution, tout en favorisant la santé et le bien-être de ses occupants. Néanmoins, compte tenu des obstacles existants, il est possible de conclure qu'il est nécessaire d'établir une approche pour soutenir et de clarifier processus de prise de décision de la rénovation du bâtiment universitaire.

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Notre hypothèse ici est qu'un processus d'évaluation peut être utile pour analyser les actions passées, en détaillant les résultats obtenus et en identifiant les déficiences pour corriger ainsi et tirer des leçons potentiellement utiles pour les projets futurs. En d'autres termes, il peut être avantageux d'aider les décideurs (par exemple, les concepteurs, les propriétaires, les investisseurs) à prendre des décisions plus éclairées.

Actuellement, l'évaluation de la durabilité environnementale des bâtiments (par exemple, LEED, HQE, BREEAM, CASBEE et autres) ont de nombreuses limitations. Ils favorisent une approche « axée sur le bâtiment » qui considère uniquement l'environnement bâti comme un objet d'évaluation, plutôt que d'évaluer et d'examiner la complexité de la construction des relations urbaines en tant qu'élément nécessaire en faveur de la durabilité (Mateus et Bragança, 2011, Richardson et Cashmore, 2011).

De plus, les systèmes existants, évaluent les bâtiments par leurs professionnels responsables pour suivre la certification et n'engagent pas des autres acteurs. Cela limite l'évaluation globale du bâtiment aux indicateurs purement quantitatifs et néglige l'expérience humaine.

Le défi majeur d'un projet de rénovation concerne l'incertitude et le risque du fait du manque d'information. Par conséquent, les outils d'aide à la décision doivent fournir suffisamment d'informations. Nous suggérons qu'un outil multi-critère convient de fournir toutes les informations pour fournir autant de certitudes que cela est possible. Cette thèse vise à répondre à la problèmatique suivante : « Quelle méthode favorise le développement durable dans la construction et la rénovation d'un campus universitaire ? »

Un outil participatif d'aide à la décision sera développé et testé pour mesurer la performance des stratégies de la rénovation du bâtiment Aile Sud de la Bergerie Nationale et des solutions pour améliorer sa performance seront suggérées dans une approche d'amélioration continue.

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