The European Commission
Community Research
Energy, Environment
and Sustainable Development

EUROPEAN COMMISSION
5th RTD Framework Programme
Contract N° EVK4 – CT – 2002 – 00104

SHE
SUSTAINABLE HOUSING IN EUROPE
www.she.coop

ECONOMIC AND SOCIAL ISSUES TOWARDS SUSTAINABLE HOUSINGS

February 2009

WP 11.9

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SUMMARY

OVERALL CONTEXT

1 - THE SUSTAINABLE DEVELOPMENT CONCEPT AT THE BUILDING SCALE

We do not go back to the sustainable development concept but we focus here on sustainable construction or sustainable buildings. In 1998, the CIB W82[1] proposed the following definition of sustainable construction: « *The creation and responsible management of a healthy built environment based on resource-efficient and ecological principles* ».

Many researchers and professionals think today that this definition is not sufficient insofar as social and economic aspects are completely forgotten (in the objectives as well as in the analysis). The report entitled « An Agenda for Sustainable Construction in Europe »[2] produced by the European Construction Energy Federation (FIEC) on behalf of the European Commission recommended in 2001 to each Member State to work out and to publish an action plan for sustainable construction. In 2002, Finland, Germany, Ireland, Luxembourg, the Netherlands and United Kingdom had already worked out such a document whereas French public authorities supported the HQE® approach and labelling[3].

At the end of 2002, a new working group was created thanks to the DG Enterprise in order to produce a guidebook and recommendations about the Life Cycle Cost (LCC) methodology, applied to each construction phase so as to go towards sustainability: the **Whole Life Costing (WLC).** It is indeed necessary to analyse all the life cycle phases of a building; however this working group has included different models based on the Net Present Value (NPV) of economic and environmental factors whereas social aspects were not taken into account.

The HQE^{2}R project[4] and approach proposed in 2004 the use of sustainable development (SD) **objectives and targets** for European cities and buildings. 5 objectives (and 21 targets) have been defined which can be applied to sustainable construction:

- **to preserve and enhance heritage and to conserve resources**, i.e. human resources, constructed or natural heritage, natural resources (energy, water, space), whether local or global, biodiversity, etc.;
- **to improve the quality of the local environment,** for the residents and users;
- **to ensure diversity:** diversity of population, habitat, human activities, space;
- **to improve integration**: integration of the inhabitants in the city, in order to make everyone feel both an inhabitant of the city and with a role to play in the city; integration of neighbourhoods in the city, with reference to the multi-centres city[5];
- **to reinforce social life** through local governance, relationships of social cohesion and actions of social equity.

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1 Construction International Board (CIB), Working Group W82 about sustainable construction

2 J. Goodall and all, for the DG Enterprise (EC) and the FIEC, "Competitiveness of the Construction Industry - An Agenda for Sustainable Construction in Europe", 2001

3 HQE as High Quality in Environment is an approach structured on 14 targets among which 3 have to be selected. A management plan has also to be set by quantitative objectives but it is not required to reach any performance targets.

4 European Commission 5th Framework Programme, www.suden.org

5 Jean Pierre Sueur, « Changer la ville », *Odile Jacob publisher*, p.66 and following, 1999

The 21 targets of the HQE²R approach are detailed below and can support the definition of new sustainable buildings:

The European Commission Community Research Energy, Environment and Sustainable Development

THE 5 OBJECTIVES AND 21 TARGETS FOR SUSTAINABLE NEIGHBOURHOODS AND BUILDINGS

TO PRESERVE AND ENHANCE HERITAGE AND CONSERVE RESOURCES

1 - To reduce energy consumption and improve energy management
2 - To improve water resource management and quality
3 - To avoid land consumption and improve land management
4 - To reduce the consumption of materials and improve their management
5 - To preserve and enhance the built and natural heritage

TO IMPROVE THE QUALITY OF THE LOCAL ENVIRONMENT

6 - To preserve and enhance the landscape and visual comfort
7 - To improve housing and building quality
8 - To improve cleanliness, hygiene and health
9 - To improve safety and risk management
10 - To improve air quality
11 - To reduce noise pollution
12 - To minimise waste

TO ENSURE DIVERSITY

13 - To ensure the diversity of the population
14 - To ensure the diversity of functions
15 - To ensure the diversity of housing supply

TO IMPROVE INTEGRATION

16 - To increase the levels of education and job qualification
17 - To improve access for all residents to employment, to services and to facilities
18 - To improve the attractivity of the neighbourhood by creating living and meeting places for all the inhabitants of the city
19 - To avoid unwanted mobility and to improve the environmentally sound mobility infrastructure (public transport, bicycles and walking)

TO REINFORCE SOCIAL LIFE

20 - To reinforce local governance
21 - To improve social networks and social capital

Source: HQE²R project, www.suden.org

The construction of new buildings in existing neighbourhoods has indeed to meet sustainable development's objectives, in regards with the buildings themselves or with their role and their integration into the neighbourhood: building's mix of use, impact on social and urban diversity, on local movements, on customer areas, etc.

It is also a matter of going beyond technical issues and of integrating the "Reinforce the social link" objective, even if this objective includes different notions or criteria according to the standard of living and to local living conditions. In the same way, to take into account inhabitants' needs requires an analysis of the different functions of a building and thus to anticipate / foresee spaces or places for communal living (meetings/play spaces, green spaces …). These spaces are directly linked to **buildings' use** and have to be integrated into "sustainable" (in the sense of sustainable development) construction projects.

It is thus a matter of designing, building and retrofitting so that sustainable buildings are:

- **Adaptable and flexible according to uses, future needs and new technologies:** indeed, buildings have to be able to evolve according to occupants' needs and opportunities in the neighbourhood. A sustainable building has to integrate the evolution of households' sizes, occupants' ages, and the possibility of use change… In the same way, a building must be able to adapt to technological changes: these will be numerous in the 80 years of a building's life with the advent of fuel cells, home automation…
- **Economically profitable for the community** (economic efficiency principle), who are on the one hand users (tenants and residents) and main stakeholders (owners), on the other hand the entire community.
- **Integrating the buildings' users and inhabitants in the neighbourhood:** the various issues linked to the neighbourhood's land planning has to be assessed: quality of life in the neighbourhood, accessibility of services and facilities, presence or absence of public transport (and the demand resulting from the project)… are criteria to be taken into account at the time of the project's implementation. In the same way, participation of inhabitants and users is an essential key to the success of a project, by making them aware of their needs and their respective expectations.
- **Optimising space's use and real density** (expressed in terms of use and human occupation of space): multi-use is preferred to building's unique use (for example unique use as sport facility).
- **Maximising local asset creation** in buildings and residential spaces: common spaces (common sauna in Finland for example), local production of compost for nearby family gardens integrated to public spaces, creation of local jobs…
- **Participating in the environment quality, and in education and training** for workers and inhabitants.
- **Using efficiently natural resources:** energy efficiency, water resources efficient management, reduction of materials consumption and recycling improvement…
- **…**

Last, as sustainable development is defined with three interlinked pillars (Environment, Economy and Social), we use this structure in the SHE project and so in the following chapters.

2 – THE ECONOMIC PILLAR INSIDE A SUSTAINABLE DEVELOPMENT APPROACH OF A BUILDING PROJECT AND THE LIFE CYCLE COST ANALYSIS

We tried within the list below to set out the different **economic dimensions** of a sustainable construction or land planning project (organised according to Sustainable Development principles).

Economic efficiency of projects: the needed requirements in a Sustainable development approach are:

- to respect the market rules but to include all the **social, human and environmental external costs** (market prices reflect a non-sustainable economy…),
- **to promote the emergence of local productive systems, the creation of local value chains, the synergy of companies**, the development of competencies and people, source of productivity and innovation,
- to take into account the evolution of property income and the evolution of resources' prices.

Social equity:

- **to fix prices** (price scale, rents…) according to incomes and to social redistribution policies,

- **to take social clauses into account in public tenders**,
- to promote services to people, activities of social and solidarity economy which are complementary to free market.

Environmental quality:

- to take into account **resources' prices (energy, water) and the evolution of their scarcity,**
- to take into account the **costs of getting rid of pollution or damages and risks,**
- to take into account the **costs of demolition and retrofitting.**
- to take into account **resources costs**
- to take into account **the choice of available materials and techniques**

Long-term principle:

- to take into account **long-term evolution of costs and prices (energy prices)**

Governance principle:

- to take into account the **costs and benefits of participation and training**
- **to integrate non-market economy** (household work, voluntary help…)

In the previous list, the dimensions integrated in the overall life cycle cost analysis are in bold and we can so observe that this method is indeed really relevant for developing/assessing a project respecting the sustainable development principles: economic efficiency of projects, social equity, environmental quality, long-term principle, governance principle.

The life cycle cost analysis raises indeed the sustainable development questions about present choices' long-term consequences (long-term principle), and about both social and environmental effects. Thinking ahead encourages moreover discussion and mutual consultation between the stakeholders as future consequences of a decision will depend a lot on their behaviour (Governance principle).

However, the purpose of life cycle costing is not to give a market value to everything. Some elements have thus to be included in the prospective and interdisciplinary thinking (sustainable development processes have to evolve in time and in relation to interdependencies).

3– REMINDER ON THE SOCIAL PILLAR

For a building construction/retrofitting project, it is necessary to consider:

1. *Resident/tenants' satisfaction :*

- **Social redistribution**: it concerns the level of the housing's sale price or rent and charges. Housing corresponds generally to an important part of the inhabitants' revenues and the aim of a sustainable building is also to contribute to the reduction of this part. This can be done thanks to many actions like the choice of high efficient and joint equipment and services.

- **Welfare**: it directly concerns the quality of life and the comfort the residents benefit from, and depends on the quality of housing, of open spaces…

- **Social capital**: social capital is a factor that measures the quality of the social relationships between the residents. This factor can be partly measured thanks to an assessment of the solidarity actions between the residents.

- **Accessibility**: accessibility of buildings especially concerns old people and disabled persons who require specific equipments for their well-being.

2. *Buildings integration in the neighbourhood*

- **Integration**: a building continuously interacts with its neighbourhood and the neighbourhood itself interacts with its surroundings. These interactions create a feeling of belonging, and this feeling could be positive if the inhabitants consider that their area is not excluded from development. This feeling of "permeability" depends on many elements: the existence of an efficient public transport system, the presence of public services…

- **Urban diversity**: the existence of different functions contributes to the dynamism of the neighbourhood and also to the inhabitants'quality of life. Small trades, leisure, cultural and sportive facilities are usually welcomed by the residents of any neighbourhood.

3. *the building construction phase:*

- **The workers**: it concerns the training from which they have benefited during the building works and consequently the improvement of their quality of work as well as the reduction of accidents and of building's defaults.

- **The neighbours** living in the surroundings: the social dimension deals with the reduction of nuisances for the neighbours during the building works in terms of noise, air pollution, spatial occupation…

4. *social aspects when the buildings are finished and so during the using phase of the buildings.*

- **Dwellings**: the social dimension deals with various aspects: the number of persons in regards to the number of rooms, the number of children per room, etc.

- **The neighbourhood**: the social dimension deals also with reducing the nuisances for the neighbours: noise, air pollution, spatial occupation, parking…

4 – REMINDER ON THE ENVIRONMENTAL PILLAR

The future building construction/retrofitting has to:

- reduce energy consumption and to improve energy management
- improve water resources management and quality
- minimise land consumption
- reduce the consumption of building materials
- preserve and enhance the built and natural heritage
- preserve and enhance the landscape and visual comfort and to be of good design
- reduce pollutants' emissions

This pillar is described in other SHE thematic reports, for example in regards to energy and water management.

5 – GOVERNANCE AND PARTICIPATION

Governance is considered also as one of the sustainable development pillar and the SHE project is also focussing on participation and partnership.

6 – THE OBJECTIVES OF THIS SPECIFIC SHE REPORT

The objectives of this SHE report are:

- to work out and to apply a new specific methodology for analysing and assessing the economic, social and environmental impacts of the SHE projects by comparison with traditional (reference) buildings. The method used is Overall Life Cycle Costing (including externalities) thanks to the working out of the SET-SHE model (Part 1)
- to look at social aspects towards sustainability in the SHE projects (Part 2)

PART 1 – A SUSTAINABLE ECONOMIC TOOL SET FOR THE SHE PROJECT

CHAPTER 1 – SUSTAINABLE ECONOMY AND LIFE CYCLE COSTING INCLUDING EXTERNALITIES

An integrated sustainable development approach means that each sustainable project has to link and to deal **simultaneously** with the three pillars: environment, economy and social aspects. The project's stakeholders have to take into account the (immediate and postponed) project's impacts on economy, environment and society and they have to try to create a synergy between these 3 fields (by finding win-win-win solutions).

In this perspective, an "economic sustainable project" has to be analysed **not only for its financial benefit and cost but also for its contribution to collective wealth**, in other words for its collective value for all the stakeholders. For a construction/retrofitting project, this means not to consider only the owner's benefit but also financial and non monetary benefits and costs for the other stakeholders: for the residents/tenants (a comfortable and affordable house), for society (pollution reduction), for national and local authorities. This requires at least considering the immediate and postponed costs and benefits, that is to say, considering the whole building's life cycle, from its design and construction to its maintenance and demolition.

The **Overall Life Cycle Cost** (OLCC) analysis tries precisely to assess the collective value of a product and service. The OLCC aims indeed at giving information to the market stakeholders about the real costs of equipments and services by an analysis of their whole life cycle on the one hand and of their externalities and induced impacts on the other hand.

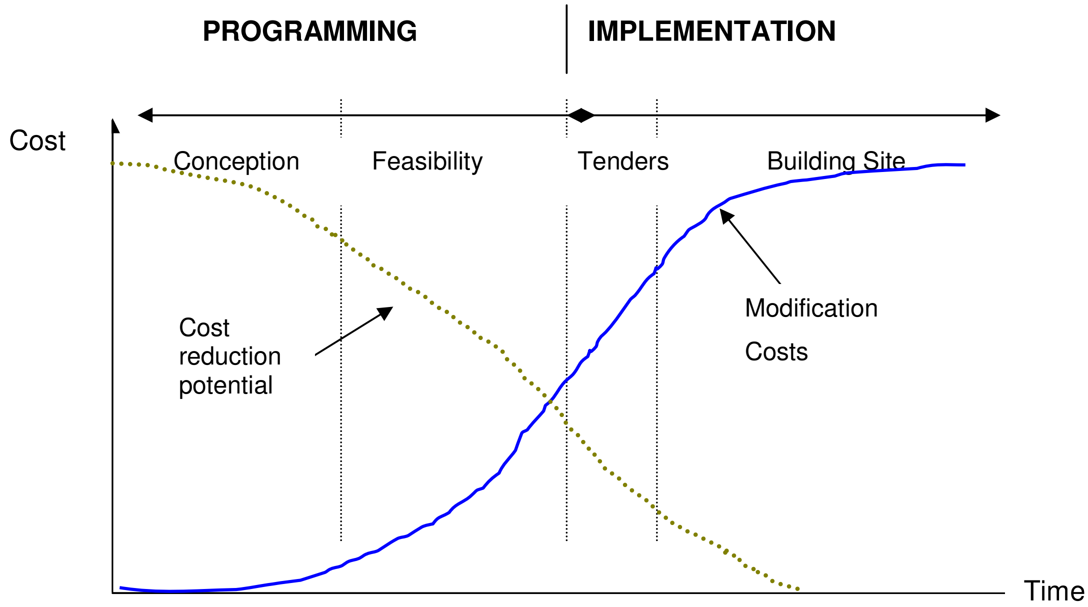
OLCC can thus be considered as a really relevant and adapted tool for developing sustainable housing.

OLCC is not only a technical tool, a calculation of the sum of capital costs at the building's life span scale, running costs (management, operation and maintenance cost), demolition/retrofitting costs and induced impacts costs. It requires cooperation between the stakeholders – owner, builder, architect and user – to define these costs for the various buildings elements. This cooperation is also necessary to give a monetary value to externalities, environment and social impacts (for pollutant and CO_2 emissions, noise nuisances, health and comfort impacts etc.), and to allocate this value to the various stakeholders.

The OLCC analysis, if used after a building's project conception, is an assessment and monitoring tool. It can then be used for the information of residents/tenants or to ask for grants. However, if it's used from the early stages of the construction process, it can be a capital decision-aid tool (the more upstream the better**)** *(see the figure on the next page).*

However, in this SHE study, the projects were already partly decided: the SET-SHE model has thus been built for assessing the OLCC of the projects by comparison with reference buildings (cf. chapter 3.1.).

Opportunities for an Overall Life Cycle Cost analysis



Source : Michael Clift, "Life-cycle costing in the construction sector in UNEP Industry and Environment", April – September 2003

CHAPTER 2 – EUROPEAN STATE OF THE ART ON THE LIFE CYCLE COST (LCC) ANALYSIS

2.1 – STATE OF THE ART OF THE PRESENT OBSTACLES TO LCC USE IN THE CONSTRUCTION SECTOR

In the construction sector, Life Cycle Costing (LCC) is a well-known concept. Numerous construction economists have proposed approaches aiming at integrating postponed costs for the maintenance and end of life of materials, products or equipments. The more recent sustainable building approach has enhanced the attractiveness of this LCC concept, as in the construction sector the reduction of the postponed costs and the investment overcost are to be foreseen by the owner.

It is admitted that sustainable construction approaches generate a supplementary cost of investment of 5 up to 10 %. An economic assessment of sustainable buildings based only on investment cost and purchase prices does thus make it impossible to reach an economic balance whatever is the social housing operation, or to generate enough profitability for a private developer, insofar as the rents have legal maximum values and market prices do not take into account the sustainability aspects of the construction. Strategies including subsidies and financial engineering are in these cases a necessity. Life cycle costing can have an important role to play in this strategy, which would thus be supported by a communication policy showing the future gains.

LCC has indeed become nowadays a priority for sustainable buildings supporters. For example, the French Architect College wished to develop a LCC tool:

« The College must take the initiative to propose a « theoretical framework » for a LCC analysis which will make it possible to go beyond the low-cost logic in order to take into account sustainable development concerns. This definition work must be able to promote applied studies and to support the creation of an ad hoc tool that can be used and accepted in the upstream discussions with the owners and in works assessments. If they get simple and clear concepts, making it possible to take into account the work life cycle, architects will be more easily able to prescribe recommendations and to discuss with their clients about issues beyond short-term constraints".

However, public and private owners are always very unwilling, as shown by numerous comments held at the PUCA workshop in Paris ("Plan Urbanisme Construction and Architecture", 22 and 23 November 2004): " it is a difficult question…", "we do not know what we measure…", " part of the costs are not managed…".

In the public sector and more particularly in the social housing sector, one of the main obstacles to any LCC analysis or to the definition of a LCC tool is the necessity to modify management rules, which should accept the concept of operation deficit, which is not in accordance with present public accounting practice. Indeed, unless subsidies are available to balance the investment, an overcost implies a deficit which might only be reimbursed by future charges savings.

In the private sector, LCC methodology generally concerns at least two stakeholders whose interests are opposed: the builder and the owner (manager). If the project has an overcost which is not reflected in the market price, the builder has no interest in implementing a project with an overcost. Knowledge of the LCC within a clear framework could justify an overcost which would be reflected in the market price and would be acceptable to the client. A contract should be concluded in which a LCC analysis would be the focal point. We should say at last that any public support or subsidy should be justified by a LCC analysis (instead of by a theoretical overcost calculated by the owner itself, as it is done for example in France).

It is thus still important to demonstrate how Life Cycle Costing could help to get sustainable construction.

2.2 – State of the art of Life Cycle Costing as an element towards sustainable construction

2.2.1 – The life cycle cost various methods

The life cycle costing concept

The life cycle costing concept is a very often quoted concept but its definition is far from being always the same one. As many people can see, the life cycle costing amounts to the sum of purchase and maintenance costs. We define it as direct life cycle cost or DLCC.

The overall life cycle cost concept including externalities

An overall life cycle costing is an economic tool which is both more complex and less technical and which tends to take into account projects' costs and social and environmental benefits. It tries to define a project's overall value in time and space. Therefore, an overall life cycle cost analysis takes into account:

- **All the various project's costs** throughout lifetime (from conception to destruction) => ***direct life cycle cost.***
- **All the various environmental and social projects impacts** which correspond to non market project's effects or which are borne by actors external to the project. The microeconomic stake of the life cycle cost analysis (concerning owner and user) is coupled with a macro-economic stake relative to indirect and consequential effects: for example, selective building site's waste sale enables an interesting benefit for construction companies as well as the organisation of a local waste valorisation cluster, which would then provide sorting standards…; use of wood and energy saving will reduce the amount of potential future taxes on carbon ; acoustic comfort (of the building site, and for users and residents) and air quality (in buildings) can save health care costs, … => ***impacts' assessment: indirect effects and externalities***.

Both of these dimensions have to be successively integrated and implemented in order to work out a complete operational tool that we will call Life Cycle Cost Assessment (with reference to LCA, Life Cycle Assessment).

We consider that the overall life cycle costing assessment includes:

- the direct life cycle cost assessment
- the externalities' assessment
- the indirect effects' assessment

Finally this approach has to be completed with a breakdown of costs and profits between the stakeholders concerned by the project, hence the term of "shared life cycle costing".

2.2.2 – The life cycle costing methods applied to the construction sector

In numerous North-European and Anglo-Saxon countries (but also in Italy), the sustainable buildings' approach relies on the Green Building Challenge (GBC) method.

Green Building Challenge (GBC) is an international cooperation's project which aims to develop a tool for sustainable building assessment presenting the different and sometimes contradictory aspects of a building's performances. One of the GBC objectives is also the further integration of these results into tools and methods for different partner countries.

GBC provides an assessment scale in which several elements refer to the life cycle costing assessment. The life cycle costing has two dimensions:

- **the environmental assessment of life cycle costing** (or Life Cycle Assessment, LCA) assesses the environmental impact of a product or an equipment, from its manufacturing to its life end;
- **the economic assessment** (Life Cycle Costing, LCC, or Whole Life Costing, WLC) assesses the economic impacts of products or equipments, from their manufacturing to the end of the assessment period / time (LCC) or to their life ends (WLC).

This assessment concerns the whole construction process and has an extremely broad definition. Indeed, the economic assessment of Life Cycle Costing (LCC) includes not only the initial capital cost and future building operation and maintenance costs but may also include factors which are relative to occupation, location, as well as to environmental and social factors.

The following equation sums up the LCC method :

Total LCC = Acquisition (a total of all initial capital costs)

+ NPV of the Building (operation + maintenance + repair + refurbishment + disposal – residual value)

+ Occupation (occupational LCA factors)

+ Mobility (location LCA factors)

+ Environment (environmental LCA factors)

+ Society (societal LCA factors)

where :

"NPV" stands for Net Present Value of the accumulated future costs over a certain period of time, e.g. 30 years, at an agreed discount rate, e.g. 2.5%, depending on prevailing interest and inflation rates.

"Building (operating + maintenance + repair + refurbishment + disposal – residual value)" refers to the future costs of all the different activities necessary to run the building or other constructed facility during a certain period of time, e.g. 30 years.

"Occupational factors" refer to health, comfort, productivity, safety and security of a building (e.g. office).

"Mobility", hence location factors refer to the location of a (industrial, commercial, office, school, etc.) building. We should calculate LCC not solely for the building but also as regarding its location in relation to incoming materials' and outgoing products' flows as well as to employees' daily commuting or children's daily commuting to school, that is to say the pattern of movements the building's location is causing.

"Environmental factors" refer to different environmental impacts linked to the building or to its use.

Source: Olavi Tupamäki MSc, Total LCC and Sustainable Construction, in Sustainable Buildings, 2002

The LCC method has been used in numerous construction projects in Finland, Denmark, Netherlands… and beyond the calculations, is able to lead to relevant questions about the project. The following aspects are indeed likely to be debated :

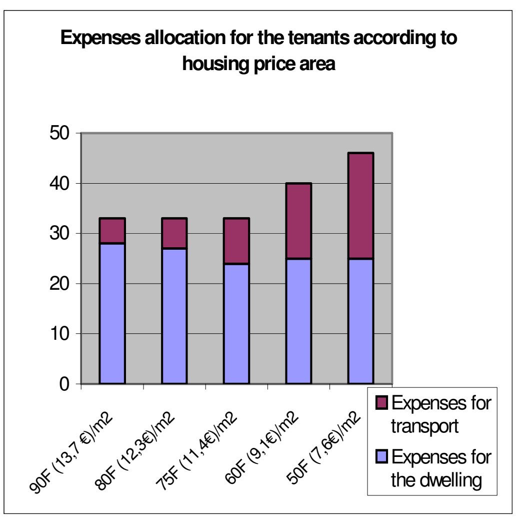
- **The building's or equipment's lifespan**: in particular, how to make the adaptability of buildings and their facilities easier in relation to the evolution of needs, behaviours, technologies, prices…?

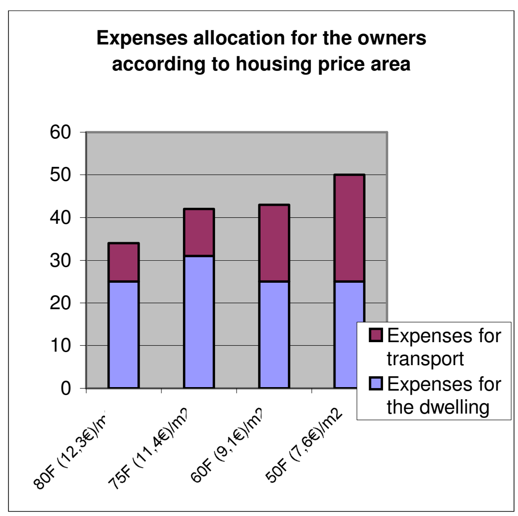
  Building's adaptability is an element which defines a sustainable construction and which has to be taken into account in the LCC method, even if the economic evaluation is difficult.

  This adaptability involves choices such as the existence of chimney pipes, the maintenance of space for lift shafts, the future space availability for cables and networks, the apartments' adaptability in order to enable the modification of their size, their rooms quantity, their use (particularly on the ground floor…), etc.
- **The property's calculation time and resale value**. Sustainable buildings' construction may lead to a resale value which is higher than a traditional building's one. This estate value gain can be included in the life cycle costing. It may be linked to a better maintenance, a choice of more sustainable materials, or an image improvement which enhances neighbourhood's or property' s value.
- **The building components' lifespan** as well as times when considerable retrofitting would be necessary. These parameters have a serious impact on the financial balance of a project and are at the same time difficult to assess. They are also linked to maintenance costs.
- **The building's location**. Does this location imply transport expenses that users cannot cut down? For example, it is not appropriate to build a "sustainable building" far from public transport, schools, shops. By including this variable in the cost, we better understand the real building's and land planning's impact on households' (or users') purchasing power and income, as well as on energy expenses.

  An illustration is given by a research made in the Ile-de-France Region (the region including Paris and its surroundings) about the share of family income spent in the couple "housing + transport", according to the housing price zone.

The share of the family income devoted to housing does not vary a lot (26% for tenants and 28% for owners).On the contrary, the share of family income which is devoted to transport is less than 10% in dense urban areas whereas it reaches 25% for tenants and 30% for those who become owners in remote areas: in other words, the part spent in transport explodes in areas with low rent…





Source : JP. Orfeuil, Revue La Jaune et la Rouge, 1998

- **Future costs' assessment:** the LCC method enables a better knowledge and a better mastery of future costs and their implications: the risk factor and the uncertainty have to be included in the project's economic assessment, and flexibility and reversibility of choices have to be favoured.

LCC is an answer to owners who criticise the life cycle costing method on the pretext that we do not know how to anticipate…

This question about the future is admittedly not obvious and may challenge some habits: the financial risk which concerns for the moment only construction should also concern long-term risks…

2.3 – EUROPEAN OVERVIEW

This state of the art is based on a bibliographic analysis of articles or documents which present researches and methodologies developed in Europe, followed by an overall assessment of existing methods and tools (cf. 2.3.8) and a synthesis summarising the interest of the life cycle costing for developing a sustainable development approach, in comparison with existing tools (cf. 2.3.9).

2.3.1 - Assessing the economic consequences of environmental decisions [6]

This is a summary of the results of a Danish research.

Aim of the study

The objective of the research was to assess the economic consequences of environmental decisions on three caseworks with distinct environmental profiles by using a life cycle costing analysis.

Definitions

Life cycle costs are the sum of capital costs and running costs (costs of management, operation, and maintenance).

Capital costs cover construction costs, land purchase cost, as well as the residual value of the property.

Taxes, insurance, and administration costs are included in management costs. Operational costs are composed of costs for operating, cleaning and for energy. The maintenance costs include continuous maintenance, periodic maintenance and replacements.

Methodology

Three single-family houses were selected, each representing a different environmental profile:

- A **conventional** house built with aerated concrete and bricks;
- An **environmental** house in wood;
- An **ecological** house built with straw bales.

The LCC method was used for the study of the economic consequences.

The life cycle costs were thus calculated as follows. first step is to discount the capital costs and the running costs to a specific time (typically the time when the use of the buildings begins). The second step is to annualise the costs. The annualised costs of two or more alternatives can now be compared.

Results

The following table shows the annualised costs of the three single-family houses:

Cost in euro/m^2	Conventional house	Environmental house	Ecological house
Capital	67	70	53
Management	26	23	24
Operation	19	11	12
Maintenance	15	31	13
Total	**127**	**135**	**102**

[6] Kim Haugbolle (PhD at the Danish Building and Urban Research), "Assessing the Economic Consequences of Environmental Decisions", in *Sustainable Buildings*, Oslo, 2002

Conclusion of the research

Kim Haugbolle suggests that:

- The capital costs of the conventional house and the environmental house are within the same order of magnitude, whereas the capital costs of the ecological house are a little lower.
- The running costs of the conventional house and of the environmental house are within the same order of magnitude, whereas the running costs of the ecological house are significantly lower.
- The life cycle costs of the conventional house and the environmental house are within the same order of magnitude, whereas the life cycle costs of the ecological house are significantly lower.

However, the quality of the calculations depends on the validity of the data used:

- The validity of data for the conventional house was high.
- The validity of data for the environmental house was fair, but not good.
- The validity of date for the ecological house was poor.

Moreover, the conclusions depends on some conditions:

- Incorporating the resale price in the calculation will especially benefit the conventional house, thus reducing the difference between the three houses.
- Changing the real discount rate does not change the benchmarking of the three houses.
- The lifespan of the construction is critical. If the lifespan of the ecological house and the environmental house only reaches 15-30 years, then the life cycle costing will be favourable to the conventional house.
- Savings on life cycle costs does not necessarily reflect more sustainable choices, but rather that taxation is avoided and/or that the owner carries out much of the work himself.

Finally, the environmental life cycle assessment revealed that the Danish rules are not respected for the ecological house, particularly in terms of thermal losses, that is why the author concludes that the ecological house is the most economical without being the most sustainable.

2.3.2 - Test and assessment of LCA and LCC for buildings [7]

The development of methods like LCA or LCC in the construction field has its origin in the requests or needs of architects, designers and researchers.

An important research which was supported by authorities and the main professional stakeholders was carried out in Finland. Some Dutch researchers were associated with this research in order to broaden the experience field.

Aim of the study

The objective was to clarify the needs of the builder and to test several LCC and LCA tools in order to develop an assessment tool that is easy to use, transparent (in its calculation of the building's environmental impact), usable in all European countries, and is an aid for decision at each stage of the construction.

Methodology

The first stage consists in identifying the customer needs. This means to define selection criteria for assessing LCA and LCC tools. These selection criteria could be: the tool easiness of using, the energy calculation procedure, the potential for international use, etc.

The second phase consists in testing a selection of potential LCC and LCA tools in order to assess the tool suitability for the customer needs and for an international application. The buildings chosen for the test represent typical buildings corresponding to specific customer groups (commercial, public and private sector).

The tested LCC tools are :

- Kiinteustötieto v 2000.0.207,

[7] Chiel Boonstra (DHV Accomodatuib and Real Estate, The Netherlands), Petri Tossavainen (Pohjois-Savo Polytechnic School of Engineering, Finland), Reetta Hurri, Juha Parviainen, Nicole Schaffroth, "Testing and Evaluation of LCA and LCC Tools for Buildings", in Sustainable Buildings, Oslo, 2002

- Kostenreferentiemodel v1.35a,
- Arskostnadsanalyse v 2.0.

The tested LCA tools are :

- BEAT 2000,
- Eco-Quantum,
- Envest,
- Green-Calc,
- Okoprofil.

The LCA and LCC tools are :

- LAGOE,
- OGIP,
- TAKE.

Conclusion of the chapter

For the majority of customers, the use of LCC tools has priority above LCA tools, as it is still unclear what LCA tools offer. None of the tested tools is suitable for Finland. Customers complain moreover of a lack of transparency (black box calculation) and criticise the fact that building typologies (at least building descriptions) and environmental profiles are strongly related to national situations.

A prerequisite for the development of LCA and LCC tools is further European and national research with the aim of developing a common framework for building data, building structures and environmental data. In parallel to this harmonisation process, the development of profiles is recommended (national profiles, energy profiles, specific supply-chain profiles) which might ease data-input and interpretation.

Finally, the collection of data, their use and their interpretation is consuming far too much time to be both realistic and justified or profitable. Furthermore, most of the software used are incompatible and would require too many adaptations to become compatible.

The majority of existing tools lack transparency and are very much influenced by the national culture of their designers. Many recommendations or requests are formulated by owners or deciders even to LCA tools which are much more numerous than LCC tools: to provide assessment indicators or a grading out of 10, to identify the necessary data as well as the impacts by category or by type of impact (greenhouse effect gas, effect on the ozone layer, etc.).

The development of LCA and LCC tools is therefore an important issue for European and national research with the objective of reaching a common methodological framework for building's data, the analysis of buildings' structures and environmental data. In parallel to this harmonisation of process and methods, the development of buildings' profiles is recommended (national profile for reference buildings, energy profiles, profiles for specific construction value chains…), as it would make data's research and interpretation easier.

2.3.3 - Projects assessment

The assessment of projects is a crucial step in the sustainable construction process as regards the objectives we have set ourselves for the different targets. A lot of software and calculation tools were developed and we would just here remind ourselves of their existence.

The table located on the following page presents succinctly the main models relative to the buildings' life cycle analysis. It shows that the environmental approaches which are at the root of the sustainable process focus so far on the most operational targets, that is to say targets relative to the buildings' performance, more particularly on the management and maintenance performance (which includes among others energy and water consumption targets). More than 80% of models study these targets whereas less than 60% of models are concerned with the construction and demolition stages.

As for targets on services offered by buildings in operational stage and on replacement of equipments, they are only present in less than 40% of models.

2.3.4 - LCC and sustainable construction [8]

Aim of the study

The objective was to examine the best way of including sustainable development in construction using LCC and LCA together.

Definition

In advanced European vocabulary, "construction" is a word that covers the entire chain of design, manufacture, construction, maintenance, repair, recycling/destruction of any infrastructure or building. To qualify this value chain, the word CREC – Construction and Real Estate Cluster – is used.

Life cycle costing (LCC) is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and in terms of future operational costs.

LCA is for assessing all the environmental impacts associated with a product's manufacture, use and disposal and with all actions in relation to the construction and use of a building or of other built facilities. LCA does not address the economic or social aspects.

Methodology

The idea is to use LCA and LCC together in order to cover not only the initial capital and future cost of a building but also occupational, location, environmental and societal factors.

Conclusion of the research

LCC is a very useful[9] concept but to become widely accepted, concerns about uncertainties in forecasting the following elements must be overcome: performance of building; products and systems' costs; occupational, location, environmental and societal factors.

[8] Olavi Tupamäki MSc for Villa Real Ltd, "Total LCC and Sustainable Construction", in Sustainable Buildings, Oslo, 2002

[9] on the same idea: Nordic Innovation, the Nordic LCC-project, Reykjavik, 2004

The elements of the numerous buildings' life cycle analysis models

Phase	Step	Green Housing A-Z (J)	ECDG (J)	BRI – LCA (J)	LEEDTM (USA)	Energy 10 (USA)	GBA (USA)	BEES (USA)	Energy certification (FIN)	BEE 1.0 (FIN)	OKOPROFILE (NOR)	SBI's LCA – Tool (DEN)	Eco-Quantum (NL)	Eco – Instal (NL)	EQUER (F)	TEAM (F)	ESCALE (F)	PAPOOSE (F)	ECOEFFECT (S)	ECOPRO (GER)	LAGOE (GER)	BREEAM (UK)	EPCMCB (UK)	TOOLKIT (UK)	E 2000 (CH)	OGIP (CH)	SIA 123 (CH)	OPTIMIZE (CAN)	
Studies	Preliminary steps	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X		X			X	X	X	81 %
	Construction systems	X	X	X	X		X	X		X		X	X	X	X	X		X			X	X	X		X			X	67 %
	Technical systems	X	X		X	X	X						X	X		X		X			X	X							41 %
Design	Design			X									X	X							X								15 %
Construction	Construction	X	X	X	X		X			X		X	X	X	X	X				X	X				X	X			56 %
Operation	Operation	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X		X	X		X		81 %
	Maintenance	X	X		X	X	X	X		X	X	X	X	X		X	X	X		X	X	X	X	X		X	X	X	81 %
	Services					X	X	X			X	X						X			X	X		X				X	37 %
	Use				X		X				X	X	X	X				X	X	X	X	X	X						44 %
	Demolition	X	X	X	X		X					X	X	X	X			X	X	X	X		X			X	X		59 %
Demolition	Waste management	X	X		X		X					X	X	X	X	X		X	X	X	X	X	X			X	X		63 %

Source : Eco-Quantum.com

2.3.5 - EUROLIFEFORM: a LCCP (Performance) model for buildings and public works[10]

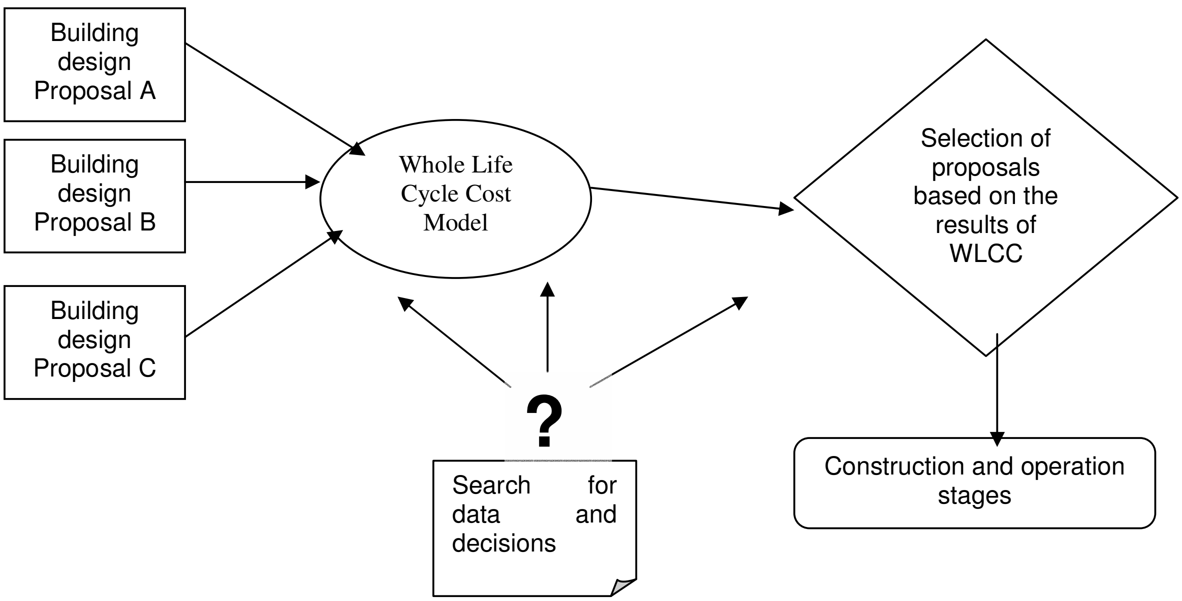
This important European research project (called) EuroLifeForm[11] was coordinated by Taylor Woodrow, with Villa Real Ltd (F1) as main partner. Taylor Woodrow has associated scientists and professionals from 8 European countries to work out a model which associates LCC and performance (LCCP) in the form of a software for the use of homebuilders, property developers, owners and designers.

This project is the continuation of a Finnish research work and of the group WLCC (Whole Life Cycle Costing) created by the DG Enterprise of the European Commission and it corresponds to a request of private industrial sector[12].

Aim of the study

The objective was to develop an operational tool for helping decision making at the design stages and on the choice of techniques and buildings facilities. This model should work for the majority of public sector projects as well as for private sector projects and Public-Private Partnership (PPP) projects.

The difficulties of the approach



This WLCC model [13] is sustained by a model of degradation simulation, a model of risk probability and a model for helping decision-making ("Logbook").

This Logbook is composed of 5 distinct / separate parts :

- the specifications
- the design stage
- the construction stage

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[10] Richard J. Kirkham (School of Industrial and Manufacturing Science, Cranfield University, UK), Muthena Alisa (Taylor Woodrow Construction, UK), Antonio pimento da Silva ("Faculdade de Enenharia da universidade do Porto", P), Tim Grindley (Centre of Whole Life Performance, Building Research Establishment, UK) and Jakob Brondsted (Danish Technology Institute, DK), "EUROLIFEFORM: An integrated probabilistic whole life cycle cost and performance model for buildings and civil infrastructure", *International Construction and Building Research Conference of the Royal Institution of Chartered Surveyors*, Leeds, 7 and 8 September 2004.

[11] 3,8 MEUR, 2001-2004, 5th Framework Programme, Contract n0 GIRD-CT-2001-00497

[12] Cf. Chapter on LCC and sustainable construction (1.4.3). See also RICS (BRE), "Whole Life costing", 2004

[13] Kirkham and al "Rethinking whole life Cycle cost based design decision-making", in *Proc of the 20th Annual Conference of the Association of Researchers in Construction Management at Heriot-Watt University*, Edinburgh, 2004

- the monitoring
- the environmental impact assessment

Conclusion of the research

The first tests of the model on roads construction have underlined the model's complexity and the necessity to go on with research on the subject.

2.3.6 - A conventional method for the calculation of buildings' life cycle energy costing[14]

Definition

Life cycle energy costing was defined as all the investment and exploitation costs that can be foreseen for the building's space and sanitary hot water heating, ventilation and air conditioning (when it's a building feature) and for the building components which are linked to the energy system choice.

Aim of the study

To spread the knowledge and the use of a conventional French methodology and tool for calculating the building' life cycle energy costing in terms of heating, hot water and ventilation with the taking into account of the building specificities.

Methodology

This method can only be applied to new housing. It is designed for all the types of energy: electricity, gas… as well as for renewable energies.

Various data are necessary for this model:

- The financial and economic context of the building project, especially the discount rate;
- Elements about occupation and comfort;
- The description of the energy system (for space and sanitary hot water heating, for ventilation);
- The description of the building components linked to the choice of the energy system;
- The energy consumptions for space and sanitary hot water heating and for ventilation;
- The expenses for the planned energy system;
- The expenses for the planned building components linked to the chosen energy system.

The building must moreover respect the country's legislation (in France it would be especially the 2000 thermal legislation and the air legislation).

After the collection of all these elements, the method compares different energy solutions for the building. Each option is studied in terms of investment cost and energy consumption. Then the life cycle energy cost is calculated.

Conclusion of the research

The objective of this method was to give a good visibility on the expenses of its energy system:

- for himself: investment, major repairs and replacement;
- for his tenants: energy consumptions, yearly maintenance.

But the complexity of the calculation methodology makes it very difficult the practice of this tool.

The life cycle costing criteria are only economic, it seems thus necessary to integrate in this method others indicators such as thermal comfort, management, financing, so as to obtain more extended information on the project.

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[14] AICVF, CARDONNEL Ingénierie, Centre Français de l'Electricité, CHAUFFAGE FIOUL, COSTIC, CSTB, EDF, FFIE, FG3E, Gaz de France, GFCC, PERIGEE, POUGET Consultants, TEC, UCI/FFB, UMGO/FFB, UNTEC, « Méthode conventionnelle de calcul du coût global énergétique des bâtiments », in *Le Moniteur*, *Cahier détachable n°2* , 6 September 2002

2.3.7 – An Overall Life Cycle Costing of social housing operations, the French CGP model [15]

The municipality of Dunkirk wanted to know more about the impact of French High Environmental Quality (HQE®) approach and thus required a life cycle costing tool. This tool can be however used for any residential building.

Definitions

The French High Environmental Quality (HQE®) approach associates the major stakeholders of an operation of construction or renovation to the improvement of the construction and the building use environmental quality. The life cycle costing is defined as the acquisition cost, the running cost, the maintenance cost, the modification cost and the demolition cost. The sharing out of life cycle costing between all the stakeholders can be called "shared life cycle costing".

Aim

The objective was to present and test assessment tools for the HQE buildings integrating economic, environmental and social dimensions and distinguishing by stakeholders the costs and benefits of the HQE approach.

Methodology

The shared life cycle costing model distinguishes two phases (construction and use) and allocates all the costs and benefits between the stakeholders and per year. The stakeholders are the inhabitants, the social owner, local authorities and the state.

The calculation has been realised for a fifty-year period for new buildings and a thirty-year one for retrofitting. The discount rate was fixed at 2%.

The model enables to take into account the evolution of prices for the various components of the running cost (energy, water…) as well as for the rents. The life cycle costing of the projects can be broken out either in absolute or in relative value.

Three HQE projects (which were then not labellised as they were only at the first labellisation phase) have been tested thanks to the model:

- The construction of 10 new buildings in Dunkirk with an overcost[16] of 10%.
- The rehabilitation of 104 housings in Courghain (near Dunkirk) with an overcost of 30%.
- An experimental carrying out with 64 housings in Verberie with an overcost of 5%.

Conclusion of the research

The shared life cycle costing model can serve:

- To calculate a provisional estimation of the costs (economic calculation) with the help of simulations according to the sensitivity to the different hypothesis as regarding prices, financing…
- To the monitoring of the real costs.

The integration of the induced effects and of the externalities has a limited interest for such small projects. The smaller projects have to be included in bigger construction or retrofitting projects.

2.3.8 - Another example of a tool for helping decision-making by the various stakeholders concerned: to demolish or to retrofit? [17]

Aim of the study

The objective of this study was to assess the impacts of not-demolishing social housing on the housing stock management of social owners and of local authorities when taking into account all the impacts for and in the neighbourhood.

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[15] cf. Philippe Outrequin (La Calade) for Communauté Urbaine de Dunkerque, « Le coût global partagé d'opérations HQE en logements sociaux », 2001 and Catherine Charlot-Valdieu and Philippe Outrequin, « Les enjeux HQE en Ile de France à l'horizon 2010 », in *Cahier du CSTB*, 2002

[16] This overcost was calculated by the social owner because the level of funding from the French Agency for Environment and Energy Management is calculated with it.

[17] Catherine Charlot-Valdieu and Philippe Outrequin (CSTB – La Calade) for OPAC du Rhône, « Etude sur la non-démolition d'un quartier de logements sociaux de l'OPAC du Rhône », 2002.

Methodology

The aim of the methodology is to:

- Furnish to the "OPAC du Rhône" a tool for evaluating the expense accounts and the life cycle costs, taking into account along the whole building's life cycle the options of construction, demolition, not-demolition and rehabilitation as well as integrating the calculation of the indirect effects relative to the neighbourhood social management.
- Enable the translation of the strategies into provisional benefits and expenses for each stakeholder, contributing to a better knowledge of various options' costs and advantages for urban regeneration.
- Propose a decision-aid tool for major operations' policy makers.

Two models have been worked out: a quantitative one and a qualitative one.

The quantitative model assess the provisional accounts for the various partners involved in an operation of demolition or not-demolition. The model also calculates the life cycle cost of each operation, shared between all the stakeholders. The stakeholders are the social owner, the inhabitants, the municipality, the State and the other founders.

The model functions on the basis of scenarios of demolition or not demolition with theirs different options. The evaluation of scenario provisional accounts gives the absolute values of the benefits and the expenses. But the scenarios can also be compared so as to show the differences between them of the various costs and expenses and of the financial transfers between the stakeholders.

The various scenarios of the social owner and his partners are:

- The "not-demolition" scenario, accompanied of no rehabilitation, little rehabilitation or major rehabilitation;
- The demolition scenario followed or not by construction works with different possibilities: allocation of the plot to other possible uses (others than housing) and families' relocation on the site, in the neighbourhood or elsewhere.

These options are based on complementary hypotheses such as:

- The relocation cost for the social owner or for the municipality;
- The removal costs for the social owner or for the municipality;
- The impact of the demolition on the vacancy of other housings for the social owner or for other social owners;
- The impact of the reconstruction on the rotation of housing between the families (evolution of rent and charges);
- The relation between the strategies of the social owners and the municipality in terms of social accompaniment.

The qualitative model reinforces the quantitative one. The analysis of the various scenarios is completed thanks to qualitative indicators chosen according to the neighbourhood's development objectives. Five sustainable development objectives have been selected (which are those of the HQE^{2}R project[18]):

- To ensure diversity;
- To improve integration;
- To preserve and enhance heritage and conserve resources;
- To improve the quality of the local environment;
- To reinforce social life.

The indicators are then defined and the potential impact of the scenarios is assessed for each indicator. Finally the desirable evolution is defined for each indicator according to the sustainable development objectives so as to benchmark the impact of each scenario.

Conclusion of the research

The model provides orders of magnitude representative of the various scenarios and enables the choice of a scenario according to a sustainable development objective.

[18] Cf. www.suden.org

2.3.9 - Synthesis of the European LCC studies

The life cycle costing analysis is a recommendation of the European Commission in one of its communications of 1997: "The Competitiveness of the Construction Industry". **The European Commission report "An Agenda for Sustainable Construction in Europe" [19] recommends the use of the life cycle costing analysis in order to improve the sustainability of the built environment**.

A working group named "Economically Most Advantageous Tender (EMAT)" was created in 2001 to work out a methodology including[20]::

- the relation between quality (of construction, of the building, of life…), life cycle costs and construction costs,
- the definition of quality's selection criteria including quality and life cycle costs,
- the definition of thresholds.

The EuroLifeForm project was the European project in charge of this task…with the difficulties mentioned (cf. chapter 2.3.4).

The main difficulty is to create a model of cost simulation which integrates all the various data necessary to the construction of a building. There are indeed a multitude of factors which influence in detail the building's life cycle and the behaviour of its users. It seems extremely complicated to integrate all these parameters in a single model.

It is naturally easier to work in simulation at the construction stage and to use the life cycle costing at the level of building's options. Of course there may eventually be *in fine* some errors insofar as the building will not react like the sum of the different options which would have been selected. The building's optimum is certainly not the sum of different components' optima. Nevertheless, we can think of approaching this optimum step by step, option after option, component after component, as the uncertainties about the future are certainly as important as the gap between our approach and the absolute optimum.

The difficulties encountered at the European level for an integrated approach encourage us to work in this way.

Based on simulation approaches, our work will be able to be a tool with a double vocation : being a **tool for helping decision-making** on the one hand and being **an assessment tool** on the other hand.

The objective of European projects is to work out a tool for helping decision-making but rather than focusing on an excessively complicated integrated tool, **we have accepted the idea that s simulation model has to be developed for each construction stage.**

Moreover, the European tools make considerable references to external factors or externalities but their taking into account is still very limited. We will note in particular that the externalities are studied on a case by case basis, without trying to take into consideration values which are susceptible of general application. This is all the more surprising as the European Commission launched a vast programme of externalities assessment as far back as 1992 (ExternE programme).

In the same way, some induced effects of building more sustainable housing are not yet taken into account in LCC analyses like those raised by the following questions: what would be purchased with the money spared from energy expenses, how many jobs would be created locally in the renewable energy business; as well as macroeconomic induced effects as: lower needs of importing energy from abroad or of strengthening the electricity grid, etc. The life cycle costing analyses are indeed presently limited to the internal life cycle process and thus don't consider the interaction with the rest of the economy.

Finally, the life cycle costing analysis has just started and we already feel the necessity of launching a **collective work on the values of externalities**, followed by a work on their use in economic calculations, as well as by a work on the relation between the costs of the construction, the quality and the life cycle…

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[19] Available on the site: www.europa.eu.int/comm/entreprise/construction/index.htm

[20] Michael Clift (UNEP Industry and Environment), "Life cycle costing in the construction sector", April – September 2003

CHAPTER 3 – THE SET-SHE MODEL

3.1 – INTRODUCTION TO THE SET-SHE MODEL AND ITS OBJECTIVES

The SET-SHE model was worked out by La Calade in partnership with Confcooperative Federhabitazione, OPAC 38 (France), COPES Consortium, CONSEDI Consortium, COPALC Consortium, COIPES Consortium, CCICASA Consortium (Italy), RINGGAARDEN (Denmark) and NORBICETA (Portugal) **. The SET-SHE model uses the Overall Life Cycle Costing approach as a decision aid tool for builders to analyse and assess the economic, social and environmental costs of different construction options at the design stage so as to promote sustainable housing.**

The SET-SHE model uses the software MS Excel. Its structure is set out and detailed in the following paragraphs. There are slight differences of structure between Italia on the one hand and France and Portugal on the other hand (Denmark is completing the data). One of the differences is that social buildings in France are rented whether they are sold in Italia and Portugal. However, the overall framework is the same, with parallel calculation of life cycle costs for a reference building and for the SHE project: the costs data for reference buildings and sustainable buildings stem from either ratios commonly used by builders or specific cost by cost calculation based on the market prices or on quotes for equipments, as well as on forecasted or real saving of operating costs. The specific cost by cost calculation is better but not always possible or convenient (which underlines the necessity to capitalise these data).

For social cooperatives (or social owners in France), the SET-SHE model enables to analyse how to reduce the cost of housing for future residents or tenants through a reduction of charges. For property developers including for social owners/cooperatives, the life cycle costs calculated by the model could constitute an argument for sale. For a local authority, the SET-SHE model enables to justify the investment overcost for a sustainable building as well as the relevance of grants to cover this overcost.

We can summarise the overall objectives of SET-SHE Model (beyond the framework of the SHE project) as following:

- to be an economic tool in order to support decision,
- to widen the microeconomic approach by introducing several environmental impacts (externalities),
- to give not only the owner point of view but also to take into account the inhabitants' and the society's benefits and costs (to share the costs and benefits between the stakeholders),
- to be not only in the present time,
- To analyse incertitude in order to reduce the economic risks.

In the framework of the SHE project, the SET-SHE model enables to analyse and assess the economic, social and environmental costs of the 9 SHE projects in comparison with traditional (reference) buildings for two calculation periods, 30 and 60 years.

3.2 – Direct Life Cycle Costing (without externalities)

The SET-SHE model defines a project OLCC by two steps. The first step is the **direct life cycle costing or DLCC** and corresponds to the total cost of a project, including the initial or investment costs and the expected postponed or running costs.

The direct life cycle costing includes indeed the following elements :

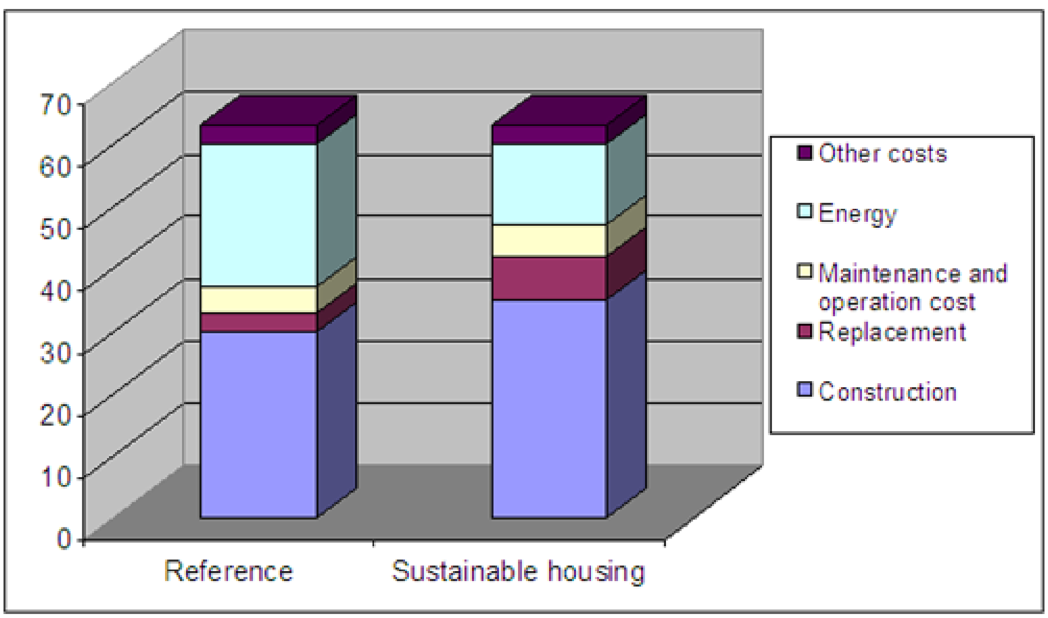
1 – Initial costs

- Acquisition of the ground
- Demolition
- Construction distinguishing structural works, finishing, sustainable equipment and others
- Contribution to the implementation of open spaces and technical networks ("secondary urbanisation")
- Contribution to urbanisation ("primary urbanisation")
- Technical abilities
- Financing costs

2 – Postponed/Running costs

- Running maintenance and repair
- Operation costs

Direct Life Cycle Costing of a project (in €/m²/year)



Source: La Calade for SHE

Initial or investment costs

The investment costs are analysed component by component, from specific construction element to technical studies (cf. Table 2 of the chapter 3.5. for the nomenclature). It requires to have each component's investment cost, completed for the construction elements by their specific lifespan. This lifespan is assessed according to the nature and the type of products or materials (cf. Table 5 of the chapter 3.5.).

As life cycle costing is calculated with the net present value of investment costs, the net present value of each component has to be calculated. The discount rate is 2.5 % for a 30-year-calculation period and 1.5% for a 60-year-calculation period (cf. Annex 1 for more details on these rates). The calculation period duration has thus an influence on the discount rate and therefore on the amount of the net present value.

For the construction elements, this net present value is calculated relatively to their lifespan or, if the lifespan is longer than the calculation period, relatively to the calculation period. The calculation of net present values enables thus to take into account the components renewal and the renewal dates.

Operation costs

Operation costs include the various utilities as well as specific maintenance costs :

- heating
- sanitary hot water (SHW)
- self-production of electricity
- self-production of thermal energy
- electricity consumption for common and open spaces
- electricity consumption in dwellings
- sanitary water
- water consumption for common and open spaces
- specific maintenance

These operation costs are calculated for a reference year. Then, the model proposes to include the evolution of prices, particularly energy and water prices which can change quite differently than the inflation rate.

Residual value of the building

If the calculation period is smaller than the building lifespan, there is at the end of the period a residual value for the project. However, the questions raised by the taking into account of the building's residential value in the DLCC are quite complicated to answer: what is the value of the buildings at the end of the calculation period, i.e. 60 years? Will sustainable buildings (SHE buildings) have a longer lifespan than a traditional building? Will SHE buildings have an higher resale value than a traditional building's one?

This is indeed not easy to give the future value of any building built now. The property value is often responsible of the major part of the evolution. The technical impacts are still more difficult to assess.

We have thus decided not to take into account the residual value in the SET-SHE model, but it could always remain as an element of discussion for a construction project.

The DLCC analysis as a first step for discussing about construction options

The DLCC analysis opens naturally a discussion about the economic, environmental and social assessment of each construction project element taken into account into its calculation, for example:

- **The building and equipments lifespan:** particularly how to favour the adaptability of the building in regards to the evolution of needs, behaviours, technologies and prices?
- **The components' lifespan:** and the date in the life of the building when retrofitting would be necessary: how to optimise these life spans without increasing too much the investment cost?

- **The calculation period and the residential value:** what calculation period to choose so as to correspond in the best way to the building lifespan if the residential value is not taken into account?
- **The postponed/running costs:** what investment would induce a greater decrease of the running costs, so as to result among others in a DLCC reduction?

The DLCC analysis favours thus already a new and sustainable way of thinking which associates the short term (construction phase) and the long term (building management and use).

3.3 – EXTERNALITIES ANALYSIS

3.3.1 – Definitions and valuation methods

In a sustainable development perspective, a construction project must be analysed for its contribution to the collective wealth. The SET-SHE model proposes to define the overall value of a project. In this way, the satisfaction of needs (need of a comfortable and affordable housing) has to be included and constitutes the counterpart of costs for the stakeholders.

These stakeholders can be the users and inhabitants (who pay the provided service) but also national or local authorities (in the framework of an Housing Policy for example), the owners who invest and look for profitability, and the society which can benefit or withstand different indirect impacts (or falls out): jobs, pollution…

In other words, the measure of the wealth linked to a project must take into account the costs and revenues of the project during its whole life time for the various stakeholders and has also to take into account the non monetary impacts of the project which can be borne by other stakeholders.

The project analysis according to the different sustainable development targets shows that a project has impacts on numerous parameters. A part of them are directly translated on the market: energy or water expenditures, management costs…

Other elements are measurable in an indirect way and not immediately: it is for example the evolution of the property value of the project. Other elements also are measurable for their physical impact (air pollution, noise) but the transformation of these data in social or environmental costs is more difficult.

As a consequence, we have to take into account the externalities which stem from a construction plan because they affect not only the costs and revenues of the main stakeholders (social owners, residents…) but they affect also the collective wealth, spreading into space and/or time. For example, let's consider the case of pollution that we are going to analyse with more scrutiny later: air pollution emissions may have an impact on health and at the same time (through CO_2 emissions) may enhance climate change.

Besides, beyond the ethical aspect, externalities represent a major economic and social concern because, by definition, positives externalities are going to be under-produced while negatives ones are going to be over-produced: "*the essential being of such a phenomenon is that a person A while giving a given service to a person B for which he/she receives a payment, creates advantages or drawbacks such that those who benefit from it cannot be taxed and those who suffer from it cannot receive a compensation*[21]*.*"

So we have two main objectives in this chapter: firstly, we would like to present and assess the main externalities linked to a construction plan. Secondly we would like to include externalities in the overall life cycle costing.

To our mind, the development of such valuation tools is absolutely necessary:

- first, they could be used as an European basis for assessing the quality of different buildings,
- secondly, their development might give to stakeholders the opportunity to anticipate the costs and revenues that stem from a construction plan, considered in its whole life cycle.

Thus, the integration *ex ante* of externalities should not only improve the information's quality available to investors but it would also enable them to arbitrate between a plan initially more costly but in an overall life cycling costing perspective more profitable for the investor himself and/or to the whole

[21] Pigou A.C., "Economics on Welfare", *MacMillan publisher,* London, 1920.

society, and a less expensive construction plan which would have a greater overall life cycling cost. In this way, a shared cost analysis makes the difference because it will enable to identify the stakeholders who are going to support the (positives or negatives) costs resulting from the externalities as well as those who benefit from them. We will thus have now the means to influence the decision-making process by encouraging people to choose investments that are not always rational from their sole economic point of view but that are optimal (and rational) from a social point of view.

If such an approach necessarily needs to stand on a consensus, the main stake of our work is to give a value to externalities so as to take them into account in the SET-SHE model. This externalities' valuation will have to be reliable enough for economic calculation.

The valuation of externalities in monetary terms is a difficult task. Indeed, for externalities such as greenhouse effect gas emissions or air pollution and their damages on health, we already get some measure of their impact expressed in physical terms. In this case, the stake will be to translate these quantitative effects into monetary values. In return, some externalities such as the value given to landscape or the value given to time spent in travelling due to the building location seem to depend more on qualitative criteria. In this case the monetary valuation will be more complicated. However, different methods were pointed out by the literature concerning the issue and we would like to make a brief survey of these valuation methods before proceeding to a detailed analysis of externalities.

The literature particularly used **five methods** to give a monetary value to these effects of human activity which, due to their nature, don't have a market value:

1. the hedonist price method
2. the travel cost method
3. the contingent valuation method
4. the method of the market of tradable emissions permits
5. the damage costs method

Of course, the utility of these methods will vary according to the externality.

1. The hedonist price method

The hedonist price technique "consists in seeking for a substitution market in which environmental characteristics are attributes of goods or factors trade in a real market.[22]". Intuitively, quality of water features, air and landscape affect houses price because they are taken into account as attributes in the price making process. So this method aims at assessing the respective part of each of these main factors in the attractiveness of a residence place and therefore the amount that consumers have been willing to pay for it. Such a way of reasoning bears upon the idea that the value that people give to landscape attributes may be assessed on the basis of the monetary amount that people spend so as to purchase goods including these same environmental characteristics. In this way, the real estate market is often used for implementing the method which stands on the following principle: the "environment variable" must be separated, so that the price difference between two identical houses is only due to their environmental attributes (quality of water features, air, landscape...). As a consequence, one is able to assess the amount of money people spend in order to benefit from environmental attributes. Thus, the hedonist price method enables to reveal the shadow price given to environmental attributes. More formally, the build-up of the hedonist price function consists in establishing a functional link between the real estate price and its characteristics (size of plot, location, environmental attributes), a relation which also depends on socio-economic characteristics of buyers or tenants.

If the method is based on strong assumptions (perfect information of the buyer, pure and perfect competition on the real estate market) which seem very far from the real market, there are also other limitations. The first issue is the implementation: indeed, this method needs a very large number of data at which one must have access, as regards the real estate on the one hand, and about the quality of environment on the other hand. It requires therefore to be able to build indicators that describe the quality of these environmental factors, taking into account threshold effects. Secondly, there are

[22] Redeis quoted by Anne Siriex (Université de Limoges), Thesis « Le paysage agricole : un essai d'évaluation », 2003

limitations relative to the methodology: this method gives indeed a range of values for a specific externality quantity or quality (as an externality is not valued uniformly by people) while the ability to identify a demand curve (obtained by taking the inverse of the prices function) requires an unique value. Finally, with this method, one can achieve to define a shadow price but we must keep in mind that this price is influenced by local environment. Indeed, a same attribute won't be valorised in the same way when it is a common good in the surroundings and when it is a scarce one. This last remark suggests that the generalisation of such a method to a European level would not be relevant. However, as we will see it, we achieved to gather numerous studies that enable to propose average values which could be used as an European basis.

2. The travel cost method

The basic idea consists in "assessing the amount that agents are willing to pay for the planning of recreational sites, in function of time and money that they spend to go to the site[23]." Indeed one can reasonably postulate that agents show the intensity of their use demand through the total of amount they spend to go to a recreational place. The principle of the method is to consider that these expenditures, which include travel costs, fees, and opportunity cost of time, reflect the price that people are willing to pay. More formally, the question is to build-up a demand curve that we suppose decreasing: as for any quantity demanded, frequent visits to a site decrease with the price, here assimilated with travel costs (that take into account all the expenditures). The first stage of building this demand curve is to try to anticipate how a change in the price of travelling would affect the rate of visits. Then, in a second stage, the question is to derivate this demand function, which is aggregated under the hypothesis that persons coming from different areas would visit at the same rate if they were charged with the same travel costs. We could thus get the net value of the resource.

However, this method has also limitations. First, it is based on the hypothesis that a decrease in a number of visits is only due to a rise in the price of travel costs while one's have to take into account substitutes, even imperfects ones. Secondly, if on the one hand, gathering all the information available is costly, on the other hand the rate of frequent visits can be raised artificially by the repeated presence of regular visitors. Thirdly, the variable "travel costs", which is the main one in such a model, can be affected by an exogenous shock, which would also introduce a bias in the results. Finally, this method only enables to take into account the direct beneficiaries of a recreational site. It neglects the values procured to people living in the surroundings. As a consequence, with this method, a landscape with only few visits has no value. Thus, the travel costs method as the hedonist price one enable to reveal the economic behaviour of consumers and finally to point out the preponderant role of the market in the process of revealing preferences. However, none of those two methods enable to take into account non-use values, and in this sense the following method appears more exhaustive.

3. The contingent valuation method (or willingness to pay method)

The contingent valuation method consists in making people reveal their preferences through a questionnaire. They express thus directly their willingness to pay so as to see an asset improved. Thanks to the mechanism of direct interrogations, one is able to anticipate how a modification of the environment will affect the welfare of a person. In other words, the contingent valuation method is "a method of self revelation of preferences, when behaviours cannot be observed directly on a market. It allows, via a questionnaire, to assess directly measures of welfare variation".[24]

The implementation of this technique, while full of promise, is a difficult task. First, as market for these goods is quasi non-existent, people have difficulty by lack of references to express their preferences. Secondly, as the income is constant, the value has to correspond to an opportunity cost. Finally, as behaviours are not directly observed on a market, the results depend on the information available to persons and on their opinions, which is a drawback for some economists. In return, in spite of these

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[23] Pearce quoted by Anne Siriex (Université de Limoges), Thesis « Le paysage agricole : un essai d'évaluation », 2003

[24] Desaigues and Lesgards,(1992), quoted by Anne Siriex (Université de Limoges), Thesis « Le paysage agricole: un essai d'évaluation », 2003

drawbacks, the willingness to pay (WTP) method enables to include benefits linked to non-use values: the shared consumption value (persons could in the present time benefit from the asset), the option value (the person itself can benefit from it later), the bequest value (future generations could benefit from it). Nevertheless, it is usually admitted that results coming from this contingent valuation method are largely influenced by the payment's technique and mean. Without going into details, different techniques can be used to collect the willingness to pay: an open question, a close question, a rising or decreasing system of bid. Undeniably, the selected technique is going to affect the treatment of data and to introduce an instrumental bias which will necessarily influence the results.

4. **The market prices or the method of the market of tradable emissions permits**

The hypothesis advanced is that in the economic calculation, we retain the price market of an element which could be tradable on a market, even if it is not tradable in our project. Nowadays greenhouse effect gas emissions are concerned by such a market. Indeed, since the first January 2005, the European System of Tradable Quotas has come into operation following an European Directive[25]. This market concerns certain types of installations designated by this Directive which aims at reducing by 8% the amount of greenhouse effect emissions into the European Union by the end of 2012.

The market comprises thus 12000 installations representing 2 million tons of CO_2.

The idea is to use the price resulting from this market as a basic value for all the stakeholders who are not subject to this market but concerned (directly or not) by the issue of greenhouse effect gas emissions.

5. **The damage costs method**

Externalities can also be valued on the basis of the costs of the activities engaged to avoid damages (method known as the prevention principle) or on the basis of the expected costs of damages. It could be average costs or marginal costs if we focus on the money spent so as not to create an additional "unity" of damages or on the cost of an additional "unity" of damages. This method is particularly useful for giving a monetary value to climate change.

In spite of their limitations, we choose to use each of these methods[26] in the following externalities valuation: indeed, the juxtaposition of these different modes of estimations could enable to increase the amount of data available for valuing externalities. Besides, it would be a mean to check the relevance of our results.

The externalities taken into account in the SET-SHE model are:

- The emissions of greenhouse effect gas
- The emissions of atmospheric pollutants
- The costs relative to noise pollution
- The value of the time wasted in travelling due to the location of the building and the induced cost of travels by car
- The landscape value
- Other externalities are suggested but not introduced in the model (the opportunity costs of public funds, the depletion of resources)

3.3.2 – Greenhouse effect gas emissions

The warming up of atmosphere has been since the ratification of the Convention on Climate Change[27] recognized by the quasi-totality of countries as one of the great challenges of the 21st century. Indeed, greenhouse effect gas emissions linked to human activities tend to accelerate climate change. However,

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[25] Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the community

[26] For more details about the different valuation methods, see also: Barde J-P, « Economie et politique de l'environnement », in *l'économiste*, puf, 1992.

[27] United Nations Framework Convention on Climate Change (UNFCCC), New York, 9 May 1992

with the ratification of the Kyoto protocol[28], several countries are committing themselves to reach emission's reduction targets. The achievement of such objectives requires a collective awareness awakening in a short term: we cannot anymore express the life cycle cost of a construction project without taking into account the costs linked to greenhouse effect gas emissions. However the main problem is that the integration of external costs linked to the additional greenhouse effect requires to define the price of one ton of carbon emitted[29].

Our aim in this part is thus to assess the monetary value of one ton of carbon with the help of studies already carried out on the subject and gathered here by valuation method.

3.3.2.1. The market price

On the 1st January 2005, the European Union implemented a market of carbon which took the shape of a market of greenhouse gas emission allowances reserved to certain types of installations designated by an European directive[30] : the starting prices were about 20 to 23 €/ ton of CO_2.

In 2006, after a maximum spot price around 29.5€, the exchange price dropped significantly while the barrel price rose a lot. This decrease, after a slack period between May and September 2006, has continued steadily until the spot price has been reduced to a mere 0.26€/ ton at the end of May 2007.

Spot prices for 2005-2007 and future prices for 2008-2012 of one ton of CO_2

Source: « Powerment Carbon », Caisse des Dépôts et Consignations

However, a new market period will be opened in 2008 with new national allocation plans (one for each European country). The price of the ton of CO_2 is foreseen (previsions at the end of may 2007) to be **23 €** in December 2008. Another important factor to determine the price for the new period is the price of each CO_2 ton in case of non compliance: **100 €**[31]

3.3.2.2. The Damage costs

Another way for assessing the carbon price is to evaluate the cost of the damage caused by a rising concentration of greenhouse effect gas.

[28] United Nations Framework Convention on Climate Change (UNFCCC),. "Kyoto Protocol to the United Nations Framework Convention on Climate Change", 1997

[29] The CO_2 contributes to 70% of French emissions linked to human activity (Source: MEDD, French Department of Environment).

[30] The European directive aims at reducing by 8% the European Union greenhouse effect gas emissions by 2012.

[31] *European Directive 2003/87/CE*

Numerous authors have thus tried to evaluate **globally** the costs of damage linked to an increase of carbon emissions (globally because the damages are calculated on the basis of global average of benefits and losses[32].).

According to a study by Nordhaus and Boyer[33], an increase by 2.5 °C in the temperature of the globe would diminish the GDP by 2.5% per year for the countries of the European Union, that is to say by 625 € per year and per inhabitant. The economist Sir Nicholas Stern in its review to the UK Prime Minister ("The Economics of climate change"), has estimated the cost **to 5% of global GDP** (in a wider perspective, up to 20%).

In the European Commission "ExternE" programme, the damages caused by energy production systems are assessed with four extremely different levels of damage's intensity relative to CO_2 emissions: the value varies thus between 1 and 37.9 € per carbon ton e.g. **0.27 to 10.2 €/tCO_2**.

Moreover, the 2005 IPCC Special Report on Carbon dioxide Capture and Storage (CCS) indicates that with greenhouse gas emission limits imposed, CCS systems will be competitive with other large-scale mitigation options, such as nuclear power and renewable energy technologies. Most energy and economic modelling worked out to date suggest that the deployment of CCS systems starts to be significant when carbon prices begin to reach approximately 25–30 $/t$CO_2$ (**30-37**€ in price of 2005). The US Department of Energy consider that currently the price of CO_2 capture by current technologies is 150$ (204€)/ton.

An examination of the studies[34] which deal with the value of one avoided carbon ton tends to show that this value is in the 70–215 dollar range per carbon ton, that is to say, with the conditions of 2005, between **15 and 47 €** per CO_2 ton avoided.

National estimations have also been made on the marginal costs of reducing emissions if these reductions had to take place within the country. The IEPE[35] assessed that the French value was about 195 $ per carbon ton in prices of 1990, which is about 220 € per carbon ton in prices of 2006 (that is to say 60 € / t CO_2). The average cost would be 136 $1990/t C. The international marginal cost for reducing emissions would also be equal to 136 $ 1990/t C while it is about **40 €/t CO_2 for the European Union**.

These studies show also that numerous parameters affect the value of one avoided ton of carbon. At first, the carbon value depends on the importance of the carbon market in a framework of a system of tradable emission permits, which itself depends on the ambition of the reduction targets and on the geographic area concerned. Thus if currently costs of avoided carbon can be lower in Developing Countries, in the years after Kyoto, that is to say after 2012, the carbon value will depend on the definite emission objectives and on the number of countries signatories of the future protocol.

In a study in France by the "Commissariat Général du Plan", authors also point out that high prices of petroleum and gas affect the carbon price by two ways: on the one hand, this evolution is in favour of energy saving and substitutions towards sources with a lower content in carbon. On the other hand, it would release constraints on the carbon market. As a consequence, a high price of petroleum tends to reduce the cost of avoided carbon[36].

Finally, studies also show that this value rises obviously with the reduction objective and with the number of stakeholders subjected to this objective. In the same time, the opening of the transferable permits market to other countries might cut by 2 to 2.5 the value of this marginal cost.

[32] Richard Tol, Thomas Downing, Samuel Fankhauser, Richard Richels, Joël B. Smith*,* « Progrès dans l'estimation des coûts des dommages des émissions des gaz à effet de serre »*,* 2001.

[33] W.D. Nordhaus and J.G. Boyer*,* "Warming the World: Economic Models of Global Warming"*,* 1999

[34] Odile Blanchard and Patrick Criqui*,* « Le concept de valeur du carbone, évaluation et applications dans les politiques de lutte contre le changement climatique »*, in rapport au Commissariat général du Plan*, June 1999.

[35] Institut d'Economie et de Politique de l'Energie (University of Grenoble).

[36] Commissariat général du Plan*,* « Transports: choix des investissements et coûts des nuisance*s* », ibid. p.32.

3.2.2.3. Proposition of a cost for a dioxide of carbon ton

This brief survey of the literature reveals a variability in the estimations of the carbon value. Besides, due to the multiplicity of the factors that affect carbon value, there is a big uncertainty about its future evolution. Nevertheless, studies based on worldwide energy models enable us to fix a price **hypothesis**: we propose to apply in our economic calculation an average price of 50 **€ per CO_2 ton** (assumptions taken in 2006, during the SHE projects analysis phase; these assumptions could be modified if the assessment were done end 2008, following the recent works of the European Commission).

However, the integration of this externality in the life cycle costing calculation also requires getting data on the potential evolution of the carbon value. We will set the hypothesis of an annual evolution of 1%.

3.2.2.4. CO_2 emissions of building

The emission of CO_2 are calculated on the basis of the quantity and type of energy used. We have set the following values of emissions by source of energy (for more details, cf. Annex 1).

Factors of CO_2 emission (gCO_2 / kWh)

Heating fuel	304
Natural gas	224
Wood and wood waste	10
Electricity	
French average	180 for heating use, 40 for other uses
Italian average	500
Portuguese Average	231 for heating use, 143 for other uses
Danish Average	517

Source: La Calade for SHE

The storage of CO_2 in wood used as a building material of the sustainable building is also taken into account in the SET-SHE model. Each wood cube meter corresponds thus to an avoided cost of 1.8 euro.

3.3.3 – Atmospheric pollutants

The air pollution linked to human activity creates numerous damages on human beings and on their health, as well as on ecosystems and on buildings.

This pollution stems from the energy consumption of transport, buildings, industry (some come also from the evaporation of solvents and from the addiction to smoking…). The impacts are local (car exhaust like NOx emissions and the results of its photodegradation, the ozone, as well as dusts produced by diesel combustion) but also regional (acid pollution with SO_2, volatile organic compounds…).

Health impacts of atmospheric pollutants

Primary pollutants	Secondary pollutants	Effects
Particles (BS, PM10, PM2.5)		**Cardiopulmonary morbidity** (admissions to the hospital for cerebrovascular troubles, congestive cardiac insufficiency, chronic bronchitis, chronic cough among children, symptoms on the inferior respiratory tracts, cough among asthmatics), **Mortality :** reduction of life expectancy caused by short term and long term exposure
SO_2		**Cardiopulmonary morbidity** *(hospitalisation, asthma, sick leave, reduced activity)* **Mortality**
SO2	sulphates	Same effects than the particles
NOx		**Morbidity** (respiratory, ocular irritation)
NOx	nitrates	Same effects than the particles
NOx+VOC	Ozone	**Morbidity** (admissions to hospital for respiratory troubles, reduced activity days, attacks of asthma, symptoms days), **Mortality**
PAH (Polycyclic Aromatic Hydrocarbons) Soot of diesel oil, benzene, 1,3,-butadiene		**Cancers**
CO		**Morbidity** (cardiovascular) **Mortality** (congestive cardiac insufficiency)
Dioxins		**Cancer**
As, Cd, Cr, Ni		**Cancer, other morbidity**
Hg, Pb		**Morbidity** (neurotoxic)

Source : Rainer Friedrich, Ari Rabl and Joseph V. Spadaro, December 2001[37]

If the urban atmospheric pollution is easily perceived as a nuisance and if the sanitary impact is quite real, its extent is still not well known.

Epidemiological studies show the existence of sanitary impacts on the short run in relation to the pollution picks. Generally, the risk of premature death increases when the pollution is higher of about 2 to 5% in the case of a cardiovascular disease, and of 1 to 6% in the case of a respiratory disease (these values are significantly different from zero) [38]. The number of deaths would be 265 per year according to a study on 9 French conglomerations (corresponding to 10 millions of inhabitants).

This sanitary impact also exists on the long run even if it is more difficult to measure it: the risks of death caused by pulmonary cancer or chronic respiratory disease seem to increase for the populations living permanently in more polluted areas. A study carried out in 2000 indicates 31 700 deaths per year in France because of long term exposition to pollution[39].

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[37] Rainer Friedrich, Ari Rabl and Joseph V. Spadaro, « Quantification des coûts de la pollution atmosphérique : le projet ExternE de la Communauté Européenne », in *Pollution Atmosphérique*, December 2001

[38] Dr Sylvia Medina and al., « Analyse des liens à court terme entre pollution atmosphérique et santé », in *Erpurs*, 1998.

[39] Nino Kunzli and al., "Public health impact of outdoor and traffic-related pollution : an European assessment", in *The Lancet, volume 356*, p.799, 2 September 2000.

A recent study by the European Commission also shows that in 2000, in the twenty-five countries of the European Union, more than 288 000 deaths were caused by emissions of particles forming a deposit, because the nose and the throat are not able to filter it... (quoted from *Le Monde*, 2 May 2005).

On the contrary, the French "Académie des Sciences" puts into perspective the impact of the atmospheric pollution which is representing only 1.2% of the lifetime lost by people because of their behaviour (against 55% for the smoking addiction and 40% for the road accidents) [40]. Nevertheless, the authors precise that if the individual risk is limited, it is much more significant if we consider the whole population[41]…

The entire atmospheric pollution represents a cost estimated between 0.3 and 2% of the GDP(Gross Domestic Product), 8 studies analysed by the French Environment Department giving a average cost of 0.6% of the GDP, i.e. 150 € per year and per inhabitant. Finally, a bibliographic analysis made by Emile Quinet[42] gave an average of 0.47% of the GDP (as shown in the next table):

Evaluation of the cost of damages caused by atmospheric pollution

Study	**Country**	**Year**	**Health damages**	**Material degradations**	**Vegetation damages**	**% of GNP**
Gunnarson et Leeksell	Sweden	1986	0.02-0.06	0.00-0.03	0.00-0.02	0.03-0.11
Bouladon	UK	1991				0.15-0.35
Planco	Germany	1990	0.07-0.18	0.05-0.09	0.13-0.21	0.25-0.48
Grupp	Germany	1986	0.11-0.42	0.05-0.06	0.03-0.15	0.19-0.63
EcoPlan	Switzerland	1992	0.14	0,13	0.15	0.42
Infras	Switzerland	1992	0.01-0.03	0.07-0.16	0.16-0.45	0.24-0.64
Himanen et *alii*	Finland	1989				0.23-0.7
Deakin	USA	1990				0.48
VROM	Netherlands	1985	0.16-0.29	0.08-0.13	0.14-0.18	0.38-0.6
Pillet	Switzerland	1988	0.02-0.06	0.21	0.18-0.41	0.41-0.68
Mautynen	Finland	1988				0.2-1.2
UPI	Germany	1991	0.59	0.07	0.26-0.41	0.92-1.05

Source: Emile Quinet 1993

In the cost of atmospheric pollution, the cost linked to buildings degradation can be estimated to about 15%, i.e. 22 € per year and per inhabitant.

The European Commission ExternE project has highly contributed to improve the knowledge on the impacts and costs generated. The calculated costs correspond to the damage caused by pollutants as a whole, including thus damages on ecosystems, materials, human health and harvests. According to the results of the study carried out by Vito (Vlaamse Instelling voor Technologisch Onderzoek) in the framework of the DIEM project (5th RTD Programme Framework), these costs are estimated to the following values (European average):

SO_2: 4.3 € / kg

NO_x: 4 €/ kg

For France, the proposed values are the following

SO_2: 6.3 € / kg

NO_x: 4.4 €/ kg

[40] Académie des Sciences, « Pollution atmosphérique due aux transports et santé publique ».

[41] Annette Peulsvat-Bergeal for the French parliament, « Rapport d'information n° 3088 sur la pollution de l'air », presentation of 23 May 2001

[42] Quinet E, « Les coûts sociaux des transports: évaluation et liens avec les politiques d'internalisation des effets externes », *working document n° 1 of the « OCDE / CEMT » Seminar on external transport costs internalisation*, Paris, 1993.

The ExternE project evaluate the damage costs for (cf. table on the next page)::

SO_2,: between 1.5 and 18 €/kg (according to the hypothesis and the contexts),

NO_2: between 0.2 and 30 €/kg (via nitrates) and between 0.08 and 2 €/kg (via ozone),

VOC (Volatile Organic Compounds): between 0.05 and 1.2 €/kg.

The costs quoted previously are indeed within these ranges.

We will thus retain the following values relative to atmospheric pollutants emissions:

SO_2: 6.3 € / kg

NOx: 4.4 €/ kg

VOC: 0.4 €/kg

From the unitary emissions of the different kinds of energy, we can thus estimate the external cost of a MWh of gas, fuel or electricity:

SET-SHE model cost of atmospheric pollution by energy source

	Emission factor in g /MWh[43]			Impact in €/MWh
	SO_2	**NOx**	**VOC**	
Natural gas and LPG	2	181	9	0.81
Fuel oil	517	181	36	4.07
Electricity	0 (direct) + generation cycle			0.84 (F) 3.71 (I) 5.86 (Pt) 7.51(DK)
Wood	0	290	2 897	2.43
Coal (for elec. impact)	2 326	181	163	

Source : La Calade for SHE

The Institute of Stuttgart (IER) gives moreover the following external costs (energies used for the production of electricity in Germany) [44] :

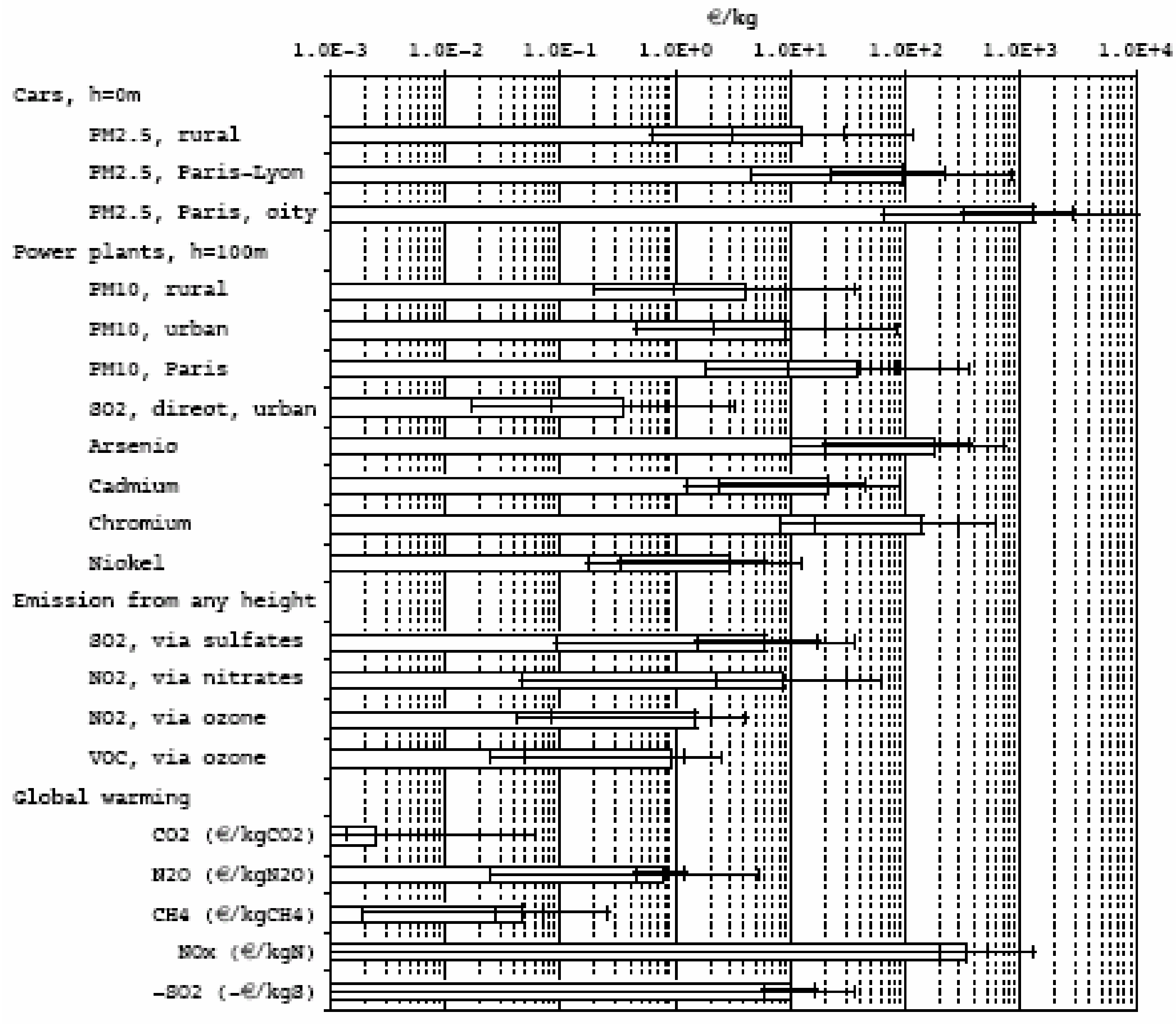
- for natural gas: 1 €/MWh (to compare with the value retained in the SET-SHE model)
- for heavy oil: 12 €/MWh
- for coal: 4 €/MWh

The impact cost of electricity depends on the weighting of these three types of energy in the national electricity production profile, since hydraulics, wind and nuclear energy don't emit any of the atmospheric pollutants studied. The weightings retained for each country stem from the energy statistics of the International Energy Agency.

[43] For the factors of emission, the source is: La Calade, « Plan de protection de l'atmosphère de l'agglomération bordelaise », DRIRE Aquitaine, December 2003.

[44] Rainer Friedrich (University of Stuttgart), "Advances on the ExternE methodology", Workshop on External costs of energy and transport.

Cost of damages per kg of emitted pollutant in France



Source : Rainer Friedrich and all., ibid, December 2001

3.3.4 – The landscape value

An attractive environment (presence of green areas, water features, open spaces) is likely to influence houses prices. In this way, landscape, which was defined as "a tract of country which meet observer's eyes"[45] has to be included into externalities analysis. In the case of landscape, externality means two things:

- On the one hand, it can be seen as an externality of production when the building offers an attractive view to its inhabitants.
- On the other hand, the implantation of a new building is going itself to alter the surroundings. In this case, it must be analysed as an externality of consumption.

Obviously, these two aspects will influence landscape value but in our perspective of overall life cycle costing, we will focus particularly on the first one: indeed, when it comes to assess a construction plan, the geographic site for building is generally already chosen and, unless the site is a "natural site", it will have only a marginal impact on landscape.

[45] Merlin et Choay, « Dictionnaire de l'urbanisme et de l'aménagement », published in *collection PUF*, 1996.

In this part, our aim is to assess in monetary terms the welfare created by the opportunity to live in attractive places, without dealing with the potentially negative aspects of a landscape (presence of motorway, railway...).

Various studies try to assess the landscape value. We will thus firstly make a state of the art of the literature by presenting the different studies with regard to the method used. Secondly, we will explain the method and values that we use in the SET-SHE model. Finally, we will present a synthesis of our calculation mode.

3.3.4.1. Overall presentation of the existing methods for assessing the landscape value

1. In our view, the more complete study is the one by Joke Luttik[46]: nearly 3000 house transactions were studied to estimate, via **the hedonist price method**, the effect of environmental attributes on transaction prices in eight towns or regions of the Netherlands. The analysis was performed in two stages. First, the house price due to structural housing attributes was estimated with a linear regression analysis. Then, assuming that the difference between this value and the actual transaction price could be mainly ascribed to differences in location, the location indicator was linked in a second linear regression to location's variables (environmental amenities, traffic noise, presence of school and view from the building...). In order to take into account the range of existing types of housing and the influence of surroundings in house prices, the study was segmented into eight geographic groups. Since the variance between cases was low, it was judged that taking average values would not affect the relevance of the results:

- a view from a building's flat quotes an average premium on house prices - when statistically significant- of 8% for a lake, 4.5% for a green strip and 7.5% for a park.
- the presence in the vicinity of a park raises price by 9%, by 7.5% for a lake and 10% for open spaces.
- in this study, the quality of landscape has also an impact on houses price.

An interesting remark is that when several environmental amenities are significant, the effects are additional. Consequently, if a house has a garden bordering water, this implies a view of a lake, which in turn implies that there is a lake in the vicinity. This means that, due to landscape attributes, the price of a house can be 20 % higher than the price of a house lacking in these attributes. Undoubtedly, it is difficult to know if buyers are willing to pay a premium for the attractive environmental setting or for the high social status image. But, as there is a large number of observations in the study, results are statistically robust.

Similar studies were carried out in rural areas in the United States and in Great Britain, where it was established that, due to agricultural and forested amenities, the premium on houses price could fluctuate between 7% and 30%.

In Switzerland[47], a study conducted on 510 apartments in the Valais Alps clearly showed that landscape had a decisive influence on rents.

Finally, a study in Quebec carried out on 761 individual houses enabled to assess the influence of the nearby presence of mature trees (at least 30 years old) on houses' price: it can rise the price by 0.4%. Conversely, when there are not mature trees in the vicinity, the price of houses can decrease by 6%. Another study, using the same sample, concludes that a positive differential of wooded land cover between the property and its vicinity increases the value of a house of 0.2% for each percentage point, while the density of vegetation has a negative impact on houses prices when it represents more than the average. These last remarks show that the main difficulty in assessing the value of landscape is due to threshold effects because houses prices are affected in a non-linear way.

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[46] Joke Luttik, "The value of trees, water and open space as reflected by houses price in the Netherlands", in *Landscape and Urban Planning*, 48, p.161-167, 2001.

[47] Prof. Dr. Nils Soguel (IDHEAP, Lausanne), « La valeur du paysage du point de vue des habitants et des touristes : prix implicites et stratégies de compensation ».

2. Landscape quality may also be assessed on the basis of the time and the money that agents are willing to pay to have access to a site and benefit from it. However, such a method cannot be applied easily because **travel costs** are not the only parameters that determine accessibility to a site.

3. Another method consists in assessing the **willingness to pay** (WTP) so as to preserve or improve the quality of a given landscape amenity. An opinion poll was used to assess how much tourists were willing to pay so as to support a public plan aiming at preserving a Mediterranean landscape (in the national park of Cilento in Southern Italy)[48]. This WTP fluctuates from 100 up to 130 euro by hectare of cultivated land.

Similar estimations were conducted in Great Britain and Finland: authors tried to assess the landscape value of public spaces and wooded areas via the contingent valuation method in an urban fringe.

In France, a study[49] was carried out on the preservation of the "plateau des Millevaches "in Limousin. The willingness to pay of inhabitants was estimated at 14-15 euro per year and per hectare which corresponds to 6 or 7% of the average local housing tax.

A study of Hanley and Knight conducted on the preservation of an urban open space (in the surroundings of Chester, UK) obtains a conservation cost of 889£ per year and per hectare. But since environmental benefits are not included in this measure, this estimation is undervalued.

Some studies which use the "willingness to pay" method were summarized according to the way people benefit from landscape amenities: recreational use (R), landscape use (L), ecological use (E), rest use (R):

Results of studies using the willingness to pay method

	Date	**Country**	**Externality**	**Population**	**Value (£/ha/year)**
Benett et al.	1995	GB	R	Visitor	503
Tyrvainen	2001	Finland	R	Resident	1101-4357
Maxwell	1994	GB	R, L	Resident,	1946-2954
Bateman et al.	1996	GB	R	Resident	1346-4276
Bishop	1992	GB	R, P, E	Visitor	1875-2102
Hanley et Knight	1992	GB	R, P, E	Resident	889

Source: www.odpm.gov.uk

The main problem with the contingent valuation method is that the answers largely vary according to the way of the questions are asked. Indeed when people were asked firstly about their willingness to pay to avoid an oil slick, the answer was an average amount of money of 85$. They were then asked to answer a series of questions about environmental concerns classified by themes and in this case the willingness to pay for the same objective was only 0.29 $.

With the support of such a survey, it seems problematical to fix an unique and general value for landscape. However, in the SET-SHE model, we have chosen two indicators and we are able to provide some key data which can be used as a European basis and fitted according to construction plans.

[48] Gianni Cicia (University of Napoli), « Bonne volonté de payer la conservation rurale du paysage : une étude de cas dans l'agriculture méditerrannéenne »

[49] Anne Siriex (University of Limoges), Thesis « Le paysage agricole : un essai d'évaluation », 2003.

3.3.4.2. The monetary valuation method for landscape in the SET-SHE model

First indicator : accessibility and quality of open or wooded spaces

This indicator, made of two criteria (accessibility and quality), takes into account different types of open spaces as well as water features. It appeared to us that a resident would give a positive value to landscape attributes only when the two conditions are fulfilled.

Indeed, if people cannot reach an open space easily (because it is private or too far), they won't value it. So accessibility takes into account two criteria: proximity and accessibility's quality.

In the same way, an open space which is accessible but in poor quality (not maintained or even dangerous) cannot have a positive value. This indicator of quality also consists in two criteria: the attractiveness of the open space and the ways in which it can be used.

The main difficulty here stands in the fact that if residents give a positive value to accessible open spaces with high quality, the impact on houses price varies according to the distance and in a non-linear way: on the one hand, a house too far or too near of such a space will sometimes be not as much worth than a house located within an intermediary distance[50]. On the other hand, Thornes[51]shows that houses with a direct access to forests are worth 20% to 25 % more and that this extra value disappears when there is a road to cross so as to reach the forest.

At last, researchers find that, when proximity to an open space is significant, the effect on prices becomes substantial when distance varies between 0 and a few dozen of meters. By European agreement, we will consider that an open space is accessible when it is located within a radius of 300 m and when one can go there without crossing urban "barriers"[52]. We thus provide in the SET-SHE model a set of questions that enable to take into account this indicator[53].

Second indicator: quality of landscape visible from the apartment

We saw previously that residents gave a positive value to an attractive view. But some nuances have to be introduced. Indeed, Cavailhès and al[54] find that in a radius of 70 meters around a house, a view is an amenity while an exposure to other's view is a nuisance (even if 64% of houses give a larger view from the building than the inhabitant is exposed to the view). However, in their study which was conducted on 2520 house transactions in the Dijon's region, the view of a landscape beyond a distance of 70 m doesn't really appear statistically significant. The first explanation may be that, as in this region the attractiveness of landscape is common, it is not easy to distinguish the different attributes beyond 70 metres. The second explication given by the author that makes up to him this result transferable, is that people close usually their garden so as to protect their intimacy, thus limiting the view from the house. However, as in our project plan a minority of flats are on the ground floor, this result will not hamper our analysis.

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[50] Bolitzer and Netusil, "The urban impact of open spaces on property value in Portland, Oregon", in *Journal of environmental management, 59,* p185-193, 2000.

[51] Thornes, "The value of suburban forest preserve: estimates from sales of vacant residential buildings lots," in *Land Economics, 78,* p624-641, 2002.

[52] The effect of a urban "barrier" appears as soon as the land to build is cut from the rest of the city or from public services and facilities indispensable for life in the neighbourhood. Urban barriers can be natural (water features) or result from circulation ways. A street is a barrier for pedestrians if the car traffic reaches more than an average of 10km/hour, and if there are no sidewalks of at least 0.80 m wide, or protected crossing every 100 metres. For cyclists, a street is a urban barrier if the car traffic reaches more than an average of 30km/hour and if there is not a well-built cycle track for a great number of cyclists. For the disabled, fitting of sidewalks as well as sound devices for the blinds have to be added. Source: Frédéric Héran (Ifrési-CNRS), « Evaluation de l'effet des coupures urbaines sur les déplacements des piétons et des cyclistes », PREDIT II, 1999.

[53] cf. synthesis at the end of the chapter

[54] Cavailhès and al, "The landscape from house: seeing and being seen. A GIS-based hedonic price valuation", 2005.

Other results are surprising:

- In their sample, the presence of forests and cultivated lands in the vicinity affect houses prices only when they can be seen.
- The view of water features has a negative impact on prices even if the house is not liable to flooding. If this result confirms the one found by Paterson and Boyle[55]which explain it by the presence of wetlands, the majority of studies in the literature conclude that water features positively affect houses prices[56].

Last, using a quality of life index which enables to weight different environmental attributes, the authors assess that the landscape in sight from the building is on average worth 2.4% of an house price, all types merged.

In the light of these studies, the valuation of landscape in view from the building seems to depend on some factors particularly linked with the building's surroundings (which introduces threshold effects) and with the socio-economic characteristics of the residents (which may reverse the positive influence of an attribute).

However, we judged that by proposing four qualitative criteria to qualify landscape, we were able to take into account these nuances and to establish some value (based on the reviewed literature) that could be used as an European basis. Let's note that, due to threshold effects, this indicator will take positive monetary values in only on and after a definite point of attractiveness[57].

<u>The SET-SHE calculation mode</u>

We will now explain the monetary valuation method used in the SET-SHE model. We have to express, for each indicator, the value (in % of real estate value) of a landscape attribute in function of the references values built with the support of the literature presented previously: an accessible and high quality open space costs on average a premium of 9% and up to 12% on houses price and an attractive view seen from the building can rise houses price by on average 6.5% and up to 12%.

Once values are expressed in % of the real estate value, we have to do the sum of it. For the moment, we don't introduce weighting between the two indicators. Indeed any weighting depends particularly on subjective criteria that we suppose as intrinsically influenced by the quality of indicators. Furthermore, to a certain extent, we introduce weights by using different values for the two indicators.

Then, we have to multiply the % by an average cost of reference and by the usable area, and then to discount and express the results in euro.

Before giving a synthesis of the monetary valuation method, we would like to note that if in our estimation we only used the hedonist price method, the contingent valuation method could be a way of checking the consistency of our results by comparing the results.

[55]Paterson and Boyle, "Out of sight, out of mind? Using GIS to incorporate visibility in hedonic property value models", in *Land Economics, 78,* p.417-425, 2002.

[56]Earnhart and al., "Combining revealed and stated preferences method to value environmental amenities at residential locations", in *Land Economics*, *77,* p.12-29, 2001.

[57] We remind that all the values proposed by studies are given "when significant": it means that in some cases, lanscape has no impact on houses price, in others words, people feel unconcerned by it.

3.3.4.3. Synthesis

Assessment of the indicator : accessibility and quality of wooded or open spaces

Nature of criteria	Detail of questions
Proximity (P)	Proximity: Are there open spaces in the vicinity: less than 300 m from the house?
Way (W)	Does a comfortable footpath exist?
	Does a comfortable way for bikes exist?
Dimension (D)	Is the dimension more or equal to 1 hectare?
	Is it an open space of city or agglomeration?
Attractiveness (A)	Cleanliness and quality of maintenance?
	Family use, adapted to children use?
	Multi-purposes: jogging, rest, recreational uses?
	Security inside the open space?

Source: La Calade for SHE

Assessment of landscape seen from the building

Nature of landscape seen from the building
Exceptional landscape
Attractive landscape
Common landscape
Poor landscape

Source: La Calade for SHE

In this part, with the help of numerous studies concerned by the issue, we achieved to build a basis for the monetary valuation of positive externalities linked to landscape. Including this externality is a progress: it should enhance the taking into account in construction plans of the welfare generated by landscape, but it also shows that there is a premium on the real estate value when the building provide an attractive place to live (that is to say investment return).

3.3.5 – Acoustic pollution

Noise is a very complicated phenomenon that could not be restricted to its measure in decibel as its perception as a nuisance depends a lot on its frequency, duration and usualness, as well as on the background noise and the personal circumstances as the tiredness, … The noise can create a disturbance which was defined as « a perceptive and affective feeling considered as negative by the persons who heard noise »[58].

One of the first consequences of noise is that ones get into intolerance with regard to noise. When it results in intolerance with regard to neighbours, it becomes an impediment to life in society. To manage noise in housings, rules have to be implemented but actions cannot be restricted to series of interdictions.

The management of noise may be done in term of time, for example in function of the hours of the day, but it particularly must be done in term of space so as to better separate spaces aimed at transports and collective life from those reserved to apartments and private life.[59]

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[58] M. Mouret and J. Vallet, Ministère des affaires sociales, de la santé et de la ville, « Les effets du bruit sur la santé », p.12, 1995.

[59] Jean Marie Rapin, Dominique Aubrée et Béatrice Bouchet (CSTB for ARENE Ile de France), « Gérer et Construire l'Environnement Sonore », in *cahier n° 6 of CSTB*, 1997.

However, for low levels of noise, that is to say under than 65 dB (A), the experts agree on the idea that the impact of traffic noise, prevalent in the everyday life, cannot be reduced to physical measures [60]. Indeed, when the level of noise is slopping down, the notion of disturbance threshold is going to depend more on individual sensitiveness than on the real acoustic level". Thus for levels lower than 65 dB (A), the effects of noise will be dependant on other effects linked to people's ways of living and will be adding to a situation of stress. In this case, the noise is used as a vector for expressing a more general dissatisfaction with the urban environment.

The **origins of noise** may be classified according to the type of disturbance that they produce:

- The sources which are considered as the **normal consequence** of life in society and which are shared by a great number of persons (the "scratching"). The noise coming from transports is one of them.
- The sources which are the consequences of individual behaviours (domestic noise) or of specific location near noisy professional activities (such as industries and shops, noisy leisure, noise linked to building sites). Only few persons are concerned by this source of noise, so it is known under the general term of **neighbourhood noise**.

Detailed data on noise disturbance perception are quite limited. However, a study conducted by IAURIF in 1996 on multifamily buildings gives a general idea about how inhabitants appreciate the soundproofing in regard with the noise stemming from immediate vicinity (inside or outside the building). We have reproduced some of these results:

Number of persons who complain about noise

	Number of persons who complain (%)			
	RECENT HOUSING (< 10 YEARS)		**existing housing**	
TYPE OF HOUSING	interior noise	exterior noise	interior noise	exterior noise
Social Collective	15 %	5 %	23 %	11 %
Private Collective	5 %	15 %	11 %	23 %
Individual Housing	5 %		11 %	

Source : IAURIF, 1996

Moreover, according to a study carried out in Ile de France region[61] on air conditioning in offices, more than **40 % of salaried worker complain about interior noise.**

For France as a whole, the study published by INSEE showed that 40 % of French feel disturb by noise in general, the noise linked to transports being the first cause of noise with 25 % of disturbed persons[62].

3.3.5.1. Overall presentation of the existing methods assessing the cost of noise

There are numerous assessments of the noise cost in Belgium, Switzerland and in countries of the North of Europe. In France, the "Commissariat Général au Plan" estimated in 1994 that acoustic pollution represented 0.3 % of the GNP. Another study carrying out on in six European countries estimated that the noise related to transport generates damage equal to 0.2 % of the GNP (assessment going from 0.02 % up to 0.4 % of the GNP)[63].

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[60] ARENE Ile de France, ibid. p.13.

[61] Dr F.Squinazi (Laboratoire d'Hygiène de la ville de Paris), « L'air intérieur dans l'habitat domestique et le tertiaire », *Study by self-questionnaire in Ile de France in the framework of a study for the FFB Ile de France*, 1994.

[62] INSEE, « Enquête permanente sur les conditions de vie des ménages », 1999.

[63] Emile Quinet, « Le coût des nuisances des transports : méthode d'évaluation et usage des résultats obtenus », *Synthesis work,* quoted in ENTPE working document 98/02 of Jean Pierre Nicolas.

In Europe, studies give estimations of costs based on three calculation modes[64]:

- the value of noise pollution is estimated according to the inhabitants' willingness to pay (WTP) in order to reduce this pollution,
- the value is estimated by observing the real estate market prices (thanks to the hedonist method which aims at distinguishing the various factors explaining the real estate's price differences),
- the cost of created damages.

1. The Hedonist method

Studies using the hedonist method aim at showing the impact of an exposure to noise on the level of rents. A study carried out in Zurich, Bale and Neufchatel in Switzerland and Brisbane in Australia shows that the level of rent decreases on average of 1% per dB.

In Neufchatel, a deep analysis shows that the dwelling rent level can decrease of 0.4 to 1.2 % per dB. Above a specified threshold, this depreciation is of 0.8 to 1%.

In Belgium, a study of 1994 showed a depreciation of 0.4 to 0.5 % of the dwelling price per dB(A) above 50 dB[65].

A study by CADAS (cf. endnote 62) shows that the depreciation ratio is more important in more recent studies, as if population's awareness of acoustic pollution was growing with time.

The limitation of setting a depreciation value per dB for a building is that it is reliable only if levels of noise evolve a little or weakly or if there is a continuous progression in the level of noise. The value is thus meaningless when noise evolves brutally and drastically (for example in the case of a nearby building site). Moreover, the studies show that it is not possible to define a level of noise above which there is a depreciation of the building value, and that the depreciation of the building value does not increase in proportion with the level of noise[66].

If we consider the link between the percentage of disturbed persons and the sound level[67], the Boiteux report[68] (which describe data back to 1979) shows that 30 % of persons feel disturbed by a degree of noise inferior to the Laeq of day threshold of 60 dB (A), which is still the prescribed threshold for new infrastructures. It means that moderated depreciations can be retained for thresholds lower than 60 dB (A), which is confirmed by other studies.

We have also to distinguish daylight noise from night noise. In many European countries (Italy, Germany, Austria, Switzerland, Netherlands, Portugal), the difference between these thresholds is about 10 dB (A).

Finally, for the depreciation of real estate value in function of degrees of exposure to noise, we will retain the following values[69].

Emile Quinet, « Les coûts sociaux des transports : évaluation et liens avec les politiques d'internalisation des effets externes », *working document n° 1 of the « OCDE/CEMT » Seminar on external transport costs' internalisation*, Paris, 1993.

[64] J-M Kail, J. Lambert et E. Quinet (CADAS, Comité des Applications de l'Académie des Sciences), « Evaluer les effets des transports sur l'environnement : le cas de nuisances sonores », in *CADAS rapport n° 16*, Paris, November 1999.

[65] Mayères quoted by Alain Counet, Colloque AGIR, in *cahier du ME*, November 1994

[66] Commissariat Général du Plan, « Transports : choix des investissements et coûts des nuisances », March 2001.

[67] J. Lambert, F. Simonnet, « Les comportements dans l'habitat soumis au bruit de circulation », in *rapport IRT*, December 1979.

[68] Commissariat Général du Plan, « Transports: choix des investissements et coûts des nuisances », sous la présidence de Marcel Boiteux, p.183, 2001.

[69] The Laeq of day values are identical with the ones advocated by the Boiteux report. Concerning the Laeq of night, there is a slight difference in the threshold of 5 dB (A).

Depreciation of real estate values in function of the degree of exposure to noise

Laeq for daylight in dB(A)	< 60	60 - 65	65 - 70	70 - 75	> 75
Laeq for night in dB (A)	< 50	50 - 55	55 - 60	60 - 65	> 65
% depreciation / decibel	0.4 %	0.8 %	0.9 %	1 %	1.1 %

The depreciation's value could be chosen according to the maximum value between Laeq of day and Laeq of night.

2. The Willingness to pay (or contingent valuation) method

This method aims at asking directly to inhabitants their willingness to pay (WTP) so as to reduce or eliminate acoustic nuisance.

According to a study carried out by the "Centre d'Etudes Economiques et Sociales de l'Environnement de l'ULB" in Brussels, inhabitants of streets subject to a level of noise superior to 55 dB (A) would accept to pay 34 € per year.

A similar study conducted in Oslo and Akershus in Norway in 1994 gives results of a willingness to pay comprised between 400 et 800 € per household so as to reduce by 50 % acoustic nuisances. Norwegian would also accept to pay from 350 to 700 € per household so as to reduce dust by 50 %, from 500 to 1000 € so as to reduce CO_2 emissions by 50% and from 1100 to 2200 € so as to reduce local atmospheric pollution[70]by 50%.

The IER Institute of Stuttgart carried out a census of 11 studies performed in 7 European countries. The WTP varies between the studies of 7 to 99 € per dB, per inhabitant and per year, with an average of 32 € and a median value of 23.5 € (in euro of 2001)[71].This great variability complicates any generalization.

As the willingness to pay is varying a lot in function of households according to their notion of disturbance and of their own experience related to noise, the **use of such criteria is impossible besides the carrying of a specific investigation.**

3. The effect on health – Damage costs

It is established that noise affects health but existing studies don't enable to define its damage cost on health, except to a certain extent for noise linked to transport and air traffic. The impact is demonstrated for noises above 65 – 70 dB (A) in clear field, that is to say **above 68 – 73 dB (A) in frontage**. In this case, **hedonist costs can be raised by 30%**.

4. Avoidance costs

The avoidance cost is the cost of actions of prevention and protection that would be necessary to reduce the noise. National estimations vary greatly, according to the time, to the location, but also according to the objective of protection (maximum of noise).

Emile Quinet[72] made a synthesis of 10 studies conducted in 6 countries and reached a median rate of 0.3 % of GNP.

In France, the study by Cetur – Sofretu – Systra gave a ratio of 0.36 % of GNP for a protection level equal to 65 dB (A). In Germany, a study by Planco[73] gave a ratio of 0.15 % of GNP for a protection level equal to 55 dB (A) which rises to 0.9 % for a protection equal to 45 dB (A).

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[70] K. Saelensminde et F. Hammer, Oslo, 1994, quoted by Jacques Lambert (INRETS) et Sylvie RAMBEAU (SETRA / MELTT), « Evaluation monétaire des impacts des transports sur l'environnement », *13ème Congrès mondial de la fédération routière internationale*, Toronto, 1997.

[71] *the two Swiss studies result in an average WTP of 82 €/dB-inhabitant-year, that the average of 4 Norwegians studies is 30 € and that the Swedish study gives a ratio of 28 €. In France, the study by Lambert and al. gives a ratio of 7 € per dB, per inhabitant and per year*

[72] Emile Quinet, « Les coûts sociaux des transports : évaluation et liens avec les politiques d'internalisation des effets externes », *working document n° 1 of the « OCDE / CEMT » Seminar on external transport costs' internalisation*, Paris, 1993.

According to a study by E. Quinet, damage costs are about of 75 euro per year and per inhabitant and vary between 40 and 225 euro.

Our main concern however is about the noise related to apartments (inside the building) and in this case we have to distinguish new constructions from others:

- **in case of new constructions,** noise must be considered ex ante, and the construction project could include a reduction of the disturbance caused by acoustic nuisance. For example, the architectural organization of partition walls between apartments may avoid almost totally the neighbourhood noise. Such measures represent 0,3 to 6 % of construction costs [74].
- **in case of existing constructions,** and particularly social ones, measures and thus avoidance costs would differ according to the noise sources:
    - for external noise: from the setting of double glazing windows and soundproofing of ventilations to the soundproofing of front and the setting of acoustic shields (which is about 150 to 400 € per m^2 of shield),
    - for noise coming from common parts : the installation of soundproof doors can reduce this noise,
    - for noise coming from technical shaft (heating, ventilation…) : the problem has not been solved, but might it be ?
    - for noise coming from ceilings and dividing walls: the setting of "false ceiling" or of soundproof floor can be a solution.

In France, the National HLM organisations Federations Union "USH" started an experimental program of soundproofing concerning 1000 apartments built between 1949 and 1974, using thin acoustic doubling. The costs of the material and of the installation, that were judged acceptable, were about 2 300 € (VAT included) by apartment, that is to say an investment of 160 € per dB. The expected gain was 14 dB(A) for noise related to air traffic and joint ownership and was about 18 dB(A) for impacts[75]noise. The effects on rents was lower than 150 € per year.

3.3.5.2. The monetary valuation method for noise in the SET-SHE model

In the SET-SHE model we retained the following values that we got thanks to the hedonist price method, with the inclusion of the damage costs method results.

Depreciation of real estate values in function of the degree of exposure to noise

Laeq of daylight in dB(A)	< 60	60 - 65	65 - 68	68 - 70	70 - 75	> 75
Laeq of night in dB (A)	< 50	50 - 55	55 - 58	58 - 60	60 - 65	> 65
% depreciation /decibel	0.4 %	0.8 %	0.9 %	1.1 %	1.3 %	1.4 %

Source: La Calade for SHE

In the case of a lack of information on existing acoustic nuisances in the SHE projects, we will take an average value of depreciation equal to 1 % by additional decibel and, reciprocally, a gain of 1 % by decibel avoided thanks to a particular protection.

3.3.6 – The Time value

3.3.6.1. The value of time spent in travel induced by the building location

This chapter deals with assessing the value of time spent in travelling due to building location. Intuitively, a household who lives in a place where there are some services in the vicinity (schools,

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[73] Planco Consulting, « Externe Kosten des Verkerhrs : Shierre, Strasse, Binenschiffart, Essen », *Report for the Deutsche Bank*, 1990.

[74] Lionelle Nugon – Baudon, « Maisons toxiques », *published by Flammarion*, p. 141, 1999.

[75] Source : USH « Logements : doublage mince pour améliorer l'acoustique, in *Cahier Technique du Bâtiment,* p. 44-45, September 2000 and Isabelle Duffaure-Gallais, « Réhabilitation acoustique de 80 logement », in *CSTB magazine,* July-August 2000.

shops) needs to do fewer travels in its everyday life than a household who would live far away from them. As a consequence, the first household benefits in comparison from a saving of time that would have otherwise been spent in travelling. This time saving corresponds to a positive externality that has to be valorised.

At the time of its first introduction[76] into economic analysis, the time value stems from the scarcity of the "time goods". Thus, when a reduction of the time spent in travelling enables to save one hour, it is as much time won for consumption and the utility of the consumer rises by this same value. In this case, the time value for a given person and at a given time is single and independent of the activity on which time is spent.

Such a conception is however not sufficient: the perception of "wasted time" varies indeed according to people's tastes and to the nature of activities. De Serpa[77] proposes thus models in which there are as many time constraints as consumption activities (he doesn't take into account travels related to professional activities). By allowing the time value to vary according to circumstances, this conception seems more relevant[78] to us than the first one and we would consequently rather use it. In fact, even if our concern is to give a value to time spent in travelling, we are aware of the necessity to take into account various parameters.

State of the art of existing European studies

The greatest part of studies carried out in Europe[79]on the estimation of time value distinguishes in the first place the various motives for travelling. For professional motives, time value was assessed at about 70% to 80% of the hourly wage cost, knowing that for commuting, time value is about 50 to 60% of this cost. For "other motives", it is about 20 to 30 % of the hourly wage cost. Let's note that when time is devoted to leisure activities, for example to a walk, time takes a value of zero.

However, there are other parameters that affect time value. Time value is also influenced by the quality of travels, which varies according to transport modes. There is indeed an increasing time value function of travel's duration and of travel's painfulness. Moreover, the value could indeed be doubled when taking into account the time spent in connection or in walking.

At last, studies have shown that time value seems to rise with income, but less quickly than it.

Time value is often expressed in function of an hourly wage cost. In this case, time and money are seen as perfect substitute. Thus, when time is devoted to a « pure leisure activity » then the time value is 0. Such an hypothesis is undeniably exposed to critics. Moreover, McKean and al.[80] did remark that due to the fact that a great part of the population does not have the status of a salaried worker, many persons (retired, students, unemployed) are with this valuation method simply not taken into account. It is thus commonly said that average hourly wage is a reference for the determination of time value although it may differ from it for some reasons: for example, if travels are linked to a constraining activity or to a laborious activity, the opportunity cost of time is worthier than usually:

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[76] Becker, "A theory of the Allocation Time", in *Economic Journal, 75*, p.493-517, 1965.

[77] De Serpa, "A theory of the economics of time", *in Economic Journal*, *81*, p.828-846, 1971.

[78] For more information about the differences between the De Serpa and Becker theories, see also: Truong and Henshe, "Measurement of travel time values and opportunity cost from a discrete-choice model", in *The Economic Journal*, p.438-451, 1985.

[79] Commissariat Général du Plan, « Transports: choix des investissements et coûts des nuisances, sous la présidence de Marcel Boiteux », p.183, 2001. We advise the reader to refer to this study for more details : the main part of the information that we gathered in this chapter are coming from it. However all the assumptions and calculations are under our liability.

[80] McKean, Johnson and Walsh, "Valuing Time in Travel Cost Demand Analysis: An Empirical Investigation", in *Land Economics*, (71), p.96-105, 1995.

Example of time value in different European studies

	Travel	Mode	Date	Value in €/hour/person
Average of 9 countries	Personal	Car	1997	3.5
Average of 11 countries	Personal	Train	1990	2.7
Average of 12 countries	Professional	Car	1995	17
Average of 10 countries	Professional	Train	1990	13

Source: *McKean, Johnson and Walsh, 1995*

If we update these values, we obtain the following ones for travels by car:

- Professional travels:
  - during the work: 20 €/ hour = 10 % of travelling
  - commuting:18 €/hour (which is seen as equal to 90 % of the value linked to professional travels) = 30 % of travelling
- Personal travels: 4 €/ hour = 60 % of travelling

The average time value would be about 10 € / hour. In average, it is rising with the income level and according to the kind of travel: time value is lower for urban travel than for non urban ones.

State of art of existing French studies

In France, various models (MATISSE, IDRAC, SETRA) calculate the time value.

According to MATISSE model, time value is worth 10 € per hour and per person for travels by car under 30 km but takes the value of 12.5 € for travels beyond 80 km. Time value follows the same evolutions as those pointed out by European studies. The only new characteristic is that time value, while also rising with time, rises less quickly than the growth rate of consumption.

The IDRAC and SETRA models propose a lower value: 6.6 € per hour and per passenger, but this value is considered to be underestimated.

Another study on the willingness to pay (WTP) related to the opening of the Prado – Carénage tunnel in Marseille gives a WTP of 7 to 8.2 € per hour and per person[81].

At last, the "Commission for transports" assumes that time value would correspond to 61% of hourly wage costs for professional travels, to 55 % for commuting and to 30% for other motives. By and large, time value would be equal to 42 % of gross hourly wage cost.

The Time value in the SET-SHE model

Our approach deals with time wasted because of the building's remoteness from schools, and from public and collective facilities as well as from the workplace but with less importance stressed on this last factor. In other words, the not-commuting travels are the main concern of our study and we won't really take into account "pure professional travels". We will thus consider the household structure of travels, which is in France the following one:

- Commuting : 20 %
- Other motives : 80 %

If we go by these ratios, we propose for the SET-SHE model a time value equal to 55 % x 20 % + 30 % x 80 % **= 35 % of the average hourly wage cost**

[81] F. Leurent (French Direction of Forecasting), « Transports urbains et calcul économique », *working document*, *N° 97-1*, 1997

The Time value for the SET-SHE model

Country	**Average hourly cost of labour (in euro)**[82]	**% of Wage and treatments**	**Average hourly wage cost**[83]	**Time value (in €/hour)**
France	28.20 €	72. 4%	20.4 €	7.1 €
Italy	21.39 €	75 % (t)	16 €	5.6 €
Portugal	9.56 €	80. 7 %	7.7 €	2.7 €
Denmark	30.7 €	92 %	28.2 €	9.9 €

(t): temporary

Source: La Calade for SHE

3.3.6.2. The costs of travels by car caused by the building location

A sustainable building must contribute to generally minimise travels expenditures as well as polluting emissions related to motorised travels.

It is however not easy to anticipate the future household travels linked to the location of their apartment. Buildings which are a long way from schools, shops or public transports will often cause such motorised travels.

As fuel expenditure corresponds to a reduction in the purchasing power of the persons travelling by car, it could usefully be taken into account in economic calculation of travels expenditures linked to the building location.

In order to assess the economic cost of travels by car, we have thus to be able to determine the average price of fuel, expressed in euro per km.

We have indeed some key data available concerning fuels used in cars:

	Consumption in fuel expressed in g/km for an average speed of 25 km/hour	**Percentage of use of each of these fuels (for the French car fleet)**	**Price of fuel in € / litre**
Gazoline	92.6 g/km	60%	1.3 €/litre
Diesel Fuel	85.5 g/km	40%	1.1€/litre

Source : La Calade according to Ademe Data[84]

After calculation, the marginal cost of travels by car is (on average) 0.14€ per km.

Let's note that the energy cost of travels by cars is here undervalued: indeed, to get the average value of 0.14 euro per km, we used the average consumptions of fuels for a hot engine. It was however estimated[85] that on the three first kilometres covered by cars, as the motor is cold, consumption could rise by 30 % on average with regard to the one of a hot engine. As this average value depends on the exterior temperature, on the kind of fuel used, on time passed between each travel..., we judged that it would be too difficult to include such a nuance in the model. Besides, the value of 0.14 corresponds effectively with the third of the average overall cost of a car per km and per year, which is in favour of the relevance of our estimation.

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[82] http://epp.eurostat.ec.europa.eu

[83] http://epp.eurostat.ec.europa.eu

[84] ADEME, « Emissions de polluants et consommations liées à la circulation routière », 1998.

[85] La Calade, « Inventaire et analyse des émissions de polluants liées à l'énergie sur le Grand Lyon », POLYEN97, 1999.

3.3.6.3. Indicators retained in the model

First indicator: facilities and services in the vicinity

The issue is to determine, via a questionnaire, the whole facilities and services which are in the vicinity (within a radius of 300m around home). This first indicator aims indeed at checking the presence of school services (from nursery to elementary school), of grocers and supermarkets, of basic leisure facilities (sports, bars...), and of medical services. It also takes into account some services directly provided by municipalities, post offices, banks... The question is then to determine at which distance are these facilities from the place of residence. The basic idea is to valorise buildings which are in vicinity of these services. However to do that, we have to take into account two parameters expressed in function of a national average: first, the probability of presence, secondly, the probability of using. Once taken into account, we have the means to calculate the distance in km between services and home and to get the annual distance covered by inhabitants due to the location of the building, expressed in km per inhabitant.

Let's note that there is a rising bias in this method. Indeed, in the SET-SHE model, we are going to sum the number of km covered for going to the spot of each of these services. However, some of these facilities can be situated in only one location. So, an inhabitant might, without doing more km, go to the supermarket, buy bread, send his letters. This bias is in part compensated by another one which results in an under-evaluation of the number of km covered by inhabitants. Indeed, in the SET-SHE model, the kilometres covered so as to go to a service in the vicinity (in a radius of 300 metres) are not taken into account, whereas when two close facilities are in opposite directions, the distance covered can be superior to 300 metres. Thus, in spite of these limitations, our method appears as a good approximation.

Detail of the indicator (European and French values)

Nature of service	Probability of presence (1)	Probability of using (2)	Explanations of columns: (1) or/and (2)
Day nursery	57%	2%	(1): (*Source: « L'accueil collectif et en crèches familiales des enfants de moins de six ans en 2003, Enquête annuelle auprès des services de PMI », Séries Statistiques, n°79, March 2005*)
Nursery school	57%	10%	(1): Database coming from the DG Environment on a sample of 24 European cities. (*Source: European Commission, European Common Indicators, 2003*) (2): 2.5 million of children at school in France for 24 millions of households
Primary school	57%	15%	(1): Database coming from the DG Environment on a sample of 27 European cities. (*Source: European Commission, European Common Indicators, 2003*) (2): 4 millions of pupils in France for 24 millions of households
Shops of proximity (greengroceries, bakeries)	72%	66%	(1) and (2): Data coming from a study carried out by INSEE on the living conditions of French households.
Supermarket Hypermarket	85%	26%	(1) and (2): Data coming from a study by INSEE on the living standards of French households.
Public transports station	85%	9%	(1): Data base coming from the DG Environment on a sample of 23 European cities. (*Source: European Commission, European Common Indicators, 2003*) (2) :Share of travels in public transports: 8.6%. (*Source: CERTU, « La mobilité urbaine en France: les années 90 », 2002*)
Sport basic facilities or swimming-pool	60%	16%	(*Estimation : La Calade*)
Open spaces	65%	80%	(1): Average of 22 cities in Europe. (*Source: European Commission, European Common Indicators, 2003*)
Municipality, public and social services	50%	95%	(*Estimation: La Calade*)
Post office	5%	60%	(1): 17 200 post offices in France. (*Source: la Poste*)
Cash points	10%	90%	(1): 43 714 cash points that is to say 0.7 per 1000 inhabitants. (*Source: Mastercard)*
Hall, theatre	60%	10%	(1) and (2): study carried out by INSEE on the living conditions of French households.
Cyber coffee	10%	5%	(*Estimation : La Calade*)
Chemist	8% (average)	100%	(1): national average : 0,37 per 1000 inhabitants : Hypercenter : 100% ; suburban : 5% ; City : 15 % ; Peri-urban : 0,5% - Average : 8%
Health services, doctors	32%	100%	(1):3.16 doctors for 1000 inhabitants with 1.58 general practitioner and 1.58 specialist. On average, there is a chemist for 4 doctors, so the probability of presence is 4 times as big. The probability in hyper-centres is 100%. NB: on a sample of 27 European cities, the DG Environment has assessed that the probability of presence of doctors is 52%. (*Source: European Commission, European Common Indicators, 2003*)
Restaurants, cafés	80 %	15%	Average between restaurants and cafés, made with the support of a study carried out by INSEE on the living conditions of French households.

Source: La Calade for SHE

Second indicator: the mode of transport used

The analysis presented previously was more focused on motorised transports while our analysis must include all the transport modes including travels by foot and by cycle.

We achieved to establish a more detailed nomenclature[86] :

- Walk: 26.4 %
- Bicycle: 2.1 %
- Two wheeled vehicle (motorized): 1.3 %
- Public transport: 8.6 %
- Cars: 60.8 %

Thanks to this nomenclature, we have references ratios that enable to calculate **the distance covered according to the modes of transport** used. However, in order to facilitate the calculation, we retained the following values in the SET-SHE model:

Modes of transports used*:*
Cars : 60%
Public transport: 10%
Others : 30%

Third indicator : number of hours spent in travelling

The time spent in travelling according to the mode of transport used can be obtained by dividing the distance covered with each mode by the average speed of these transports, that is to say: 25km/h for cars, 18km/h for public transport et 6km/h for non motorized transports.

It is important to know the number of hours spent in travelling by mode of transport as the **value of the time spent in travelling** depends to the mode and to the quality of transport. However, as seen previously in the chapter 3.3.6.1. on the value of time spent in travel, it is difficult to collect data and we decided to use in the SET-SHE model an average value per person and per hour spent in travelling, whatever the mode of transport was (the average value retained in the SET-SHE model depends nevertheless on the country).

Finally, thanks to the knowledge of the distance covered by mode of transport, we have the possibility to take into account the cost of travelling. It is however difficult to calculate it: in a first approach, it seems that the costs of travelling by car may be assessed in function of the price of fuel per km while the costs of public transport can be estimated on the basis of the number of travels made by users and of the fare currently applied.

However, thanks to season's tickets or subscription systems, public transport cost is zero at the margin: indeed, as users pay an amount of money which is generally independent of the number of travels, cost of one travel is equal to zero at the margin (in such a case, only the value of time spent in travelling has to be taken into account).

That is why regarding travelling costs, we only took into account the **energy cost of travelling by car** which amounts on average to 0,14€/km.

[86] *Source : La Calade, average of studies carried out on households in France since 1994.*

Synthesis scheme of the whole SET-SHE valuation method[87]

Questionnaire aiming at determining facilities and services in the vicinity of the building
(within a radius of 300m)

⇓

Taking into account the probability of presence of each facility

⇓

Taking into account the probability of using of each facility

⇓

Mode of transport used		
Car : 60%	Public transport : 10%	Others : 30%

⇓

Distance covered in function of transport modes, expressed in km per year and per inhabitant

⇓ ⇓

Number of hours spent in transport get by using the average speed of each mode		
car : 25km/h	Public transports: 18km/h	others : 6 km/h

⇓

With a time value of :
7. 1 € per hour for France, 5.6 for Italy, 2.7 for Portugal, 9.9 for Denmark
(average value retained in the model)

⇓

Total value of the time spent in travelling

Distance covered by car per km per year and per inhabitant

⇓

With a price of fuel of :
0.14 € per km
(average value retained in the model)

⇓

Energy costs of transport by car

We deal thus in the SET-SHE model with two kinds of externalities caused by a building location: the value of time spent in travelling and the energy costs of travelling by car. We are thus now able to assess in monetary terms the costs linked to travels induced by the building location. We would like to point out that costs of travelling by cars are here undervalued. Indeed, we could have gone further: travelling by car also has energy cost in terms of greenhouse effect gas emissions that we could have assessed.

3.3.7 – Other potential externalities

3.3.7.1. Energy resources depletion

According to results stemming from economic models, « in a growth economy, the price of resources available in limited quantities is supposed to rise by an annual rate almost equal to the discount rate. »

The energy resource depletion could thus possibly be introduced in the SET-SHE model. It is however a difficult task for two reasons : on the one hand, by adopting the perspective of the "factor 4" scenario in the SET-SHE model in regards to the calculation of the future prices of carbon and energy, we took into account (to a certain extent) the problem of energy depletion. On the other hand, to our knowledge, figures and calculation modes about this externality are not available.

3.3.7.2. Opportunity costs of public subsidies

When projects receive public funds, these funds come often from taxes which are costly for the socio-economic efficiency. We could so introduce an opportunity cost of public funds. It would take the form of a multiplying coefficient superior to 1 that would be applied to each euro spent by public stakeholders in a project. Each unity of public funding corresponds in fact in a shared cost analysis to a loss of collective wealth:

[87] Apart for the questionnaire that has to be filled by the user, all the data is already integrated in the model.

In brief, for each euro added to taxes, the loss for collective wealth is (1 + ρ) euro.

In Europe, an average rate of 1.13 can be retained[88]. In France, the working group of the "Commissariat Général du Plan"[89] proposes to retain a coefficient of 1.3. This coefficient is in net reduction with regard to the coefficient advocated by the public authorities in the eighties (it was then about 1.5).

3.4 – THE SHARED COST ANALYSIS

The life cycle costing will be very different according to the stakeholder concerned or according to the point of view from which it is considered. A project may indeed have a high profitability for a stakeholder and may imply at the same time for others high economic, social or environmental costs. The main reproach we can raise against life cycle costing analyses carried out until now is that they take only into account a single stakeholder's point of view: for social housing, the resident/tenant, for a product, the industrial company producing it, etc.

The life cycle cost has to be shared between the concerned stakeholders. For a building, as well as for a land use project, there are at least five stakeholders:

- inhabitants, users and occupants of the building;
- the owner or the client who can also be a building's resident;
- the State representing the national authorities;
- local authorities, representing infra-national public authorities, from the city council to the agglomeration, the county and the region;
- the society, representing all the economic stakeholders directly or indirectly concerned by the project.

To calculate the shared life cycle costing, the project has to be analysed with all the monetary and real flows between the stakeholders, as the balance could be positive for some and negative for others.

The shared life cycle costing is calculated as the net present value for each stakeholder of the net expenses and benefits linked to the land purchase, the construction, the building's use, the demolition for a duration corresponding to the building's lifespan or to a longer duration fixed according to the building future's visibility (50 years for example).

So as to calculate the overall life cycle costing, we have drawn up expenses accounts for each stakeholder on the basis of the following table (*Source: La Calade for SHE*):

---

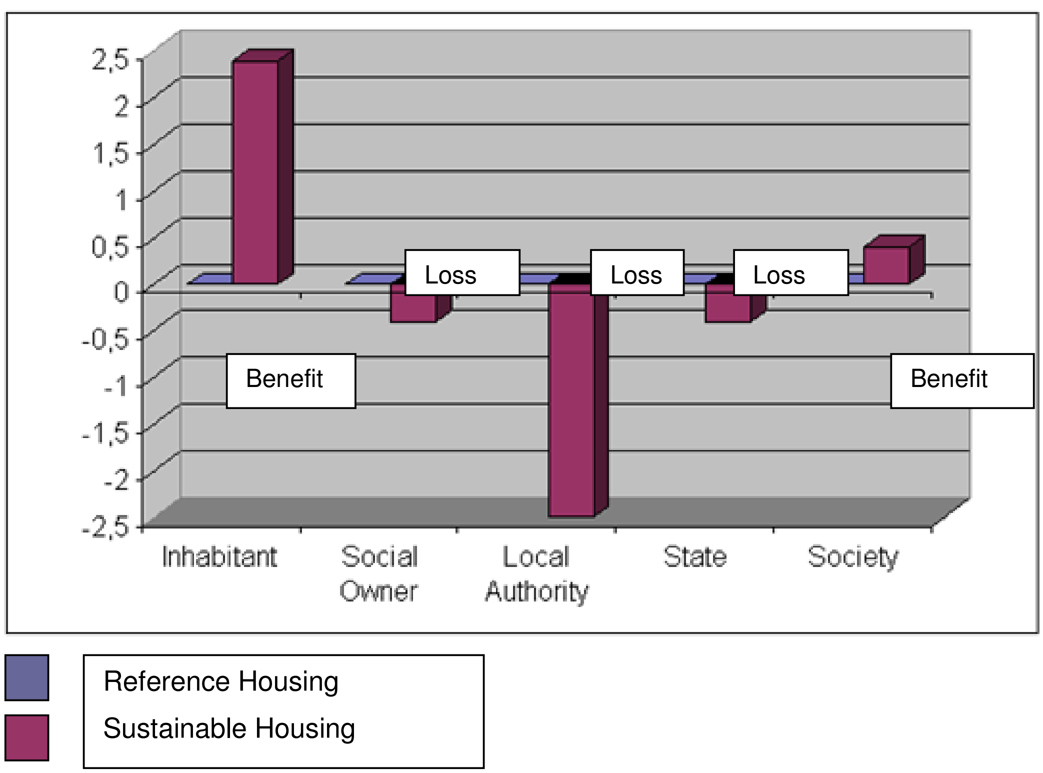
[88] Alain Bernard and Marc Vielle found, with the help of a calculation based on a general equilibrium model, a coefficient of 1.13 for France, a figure comparable to other European countries as well as comparable but superior to the ones of the United States (1.02) and to the ones of Japan (1.03). (Source: A. Bernard and M. Vielle, "Measuring the Welfare Cost of Climate Change Policies: a comparative Assessment based on the computable General Equilibrium model GEMINI-E3", in *Environmental Modelling and Assessment*, *volume 8 n° 3*.

[89] The working group carried out a valuation based on a simple calculation mode: they obtained figures comprised between 1.1 and 1.4. In the scientific litterature, this rate varies for developed countries between 1,15 and 1.5, according to the fiscal system. JJ Laffont gives a range of 1.3 – 1.5 in its article entitled "Competition, Information and Development" (*Annual World bank Conference on Development Economics*, 1998).

(Source: Commissariat Général du Plan, « Réduire le taux d'actualisation des investissements publics », p. 71, January 2005)

	Expenses	Benefits
Household	Charges Rent Home and Waste disposal Tax	% rent + avoided charges % rent helped by subsidies
	Externality landscape Externality noise disturbance Externality wasted time	
Social Owner	% rent + avoided charges Maintenance cost Running cost Home Tax NPV (Net Present Value) of pay back NPV of self-financing	Rent Refundable Charges Not refundable charges NPV (Net Present Value) of the subsidies and grants
State	% rent helped by subsidies NPV of the subsidies and grants	VAT
Local Authorities	Cost of maintenance made by the city NPV of the subsidies and grants Social Help	Home and Waste disposal Tax
Society	Cost of damage caused by greenhouse effect gas Cost for the health system of the air pollution	

The overall life cycle costing analysis could be set out with this following representation:



Source: La Calade for SHE

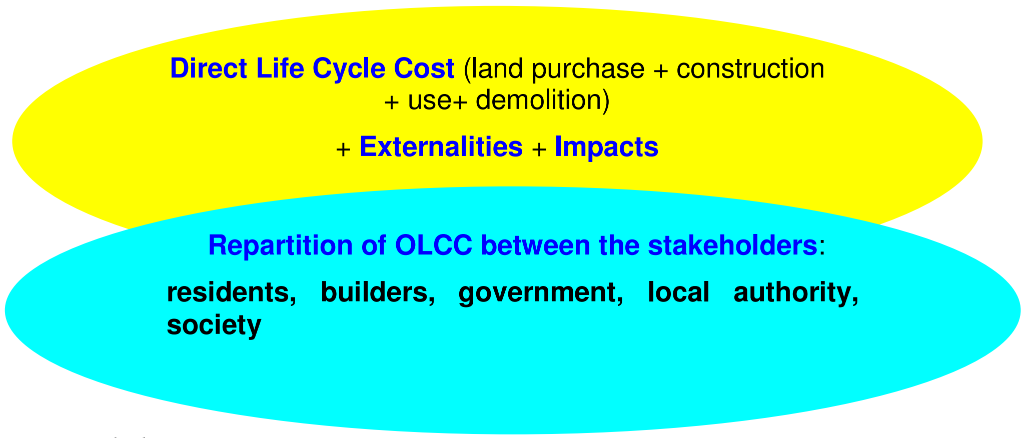
This tool could enable the test of technical simulations so as to assess their economic impacts and to allocate these impacts between the stakeholders.

In this case, the use of the word "cost" could be incorrect as cost for a stakeholder means benefit for an other, and as the overall assessment has to result in a benefit…

From an economic point of view, the objective is effectively a cost reduction, and consequently a greater economic efficiency, with regards to the social and human dimensions. This induces us to set out the method of life cycle costing in three parts:

- Assessment of Direct Life Cycle Cost
- Assessment of externalities and induced effects
- Allocation of the Overall Life Cycle Cost between the stakeholders

General structure of a project's Life Cycle Costing analysis



Source : La Calade

3.5 – The SET-SHE model structure

The SET-SHE model compares the SHE project carried out by the project's partners (social owner or social cooperative) towards more sustainable housing with a reference building, that is to say the project if it were designed traditionally. The model uses MS. Excel.

The SET-SHE model is presented in three versions:

- An Italian version where the construction cooperative (the SHE partner) is in charge of the construction but sells the building to different households who become owners, and where the calculation is made according to the liveable area.
- A French and Danish version where the client is a social owner who rents the housings to tenants and where the calculations is made according to the square meter of usable area. This version is presented in French and in English.
- A Portuguese version where the cooperative sell the units and where the calculation is made according to the square meter of usable area.

This chapter presents firstly the input data sheet of the SET-SHE model, then its endogenous data or hypothesis and at last the SET-SHE results sheets.

3.5.1 – The SET-SHE model input data sheet

The input data sheet contains:

- The description of the construction project
- The initial cost for each investment element, as well as the life span for each construction element

- Operating costs
- Externalities

3.5.1.1. The description of the project

The project is described through general data and main features, e.g. living or usable area, number of flats, total investment cost, financing of the operation (cf. Table 1).

For countries where the social owner rents the dwellings, the financing of the operation is useful to assess the distribution of costs and revenues between the various stakeholders.

The French model version (which should be used for Denmark too) made then calculations with the usable area. The usable area of the operation is not calculated uniformly from a country to another, which makes any comparisons difficult. In France the usable area corresponds to the housing's area to which half of the area of the garages is added (according to a specific national regulation).

In the Italian version, the calculation is done according to the living area, which enables a comparison between countries. It is why in the analysis of the overall results of the paragraph 4.2, we have converted the French and Portuguese results from square meter of usable area into square meter of living area.

Description of the construction project in the SET-SHE Model, example taken from the Bourgoin Jallieu analysis – Table 1

Name of operation and of contracting authority		Diederichs / OPAC 38		
Localisation		Bourgoin Jallieu (Isère)		
Operation nature (brief description)		Construction of 40 flats in 4 buildings, of a rugby training centre and of 25 closed garages		
Total number of flats		number	61	
in collective building		number	61	
in individual houses		number		
Total number of plots		number	0	
Number of garages		number	25	number of individual garages or number of places in a collective garage
Living area		m^2	3 324	calculation of living area
Usable area		m^2	**3 600**	usable area
Common spaces area		m^2	20	area of cycle sheds, common laundry…
Ground area		m^2	3030	
Year of coming into service		year	2004	
		Reference Building	**Sustainable Building**	
Amount of rents forecasted	€	**208 209**	**210 291**	please input the overall annual amount of rents
Reference average cost without VAT	€/m^2	1 100		
OPERATION FINANCING		**Reference Building**	**Sustainable Building**	
Autofinancing	€	0	0	
Loan	€	3 736 409	3 554 076	
Local subsidies, local council, county, region	€	0	316 294	
National subsidies	€	415 157	418 057	
Other subsidies	€	0		

Source: La Calade for SHE

3.5.1.2. Initial Cost by investment component

The SET-SHE model is requiring for each component of the investment to fill in the real cost of the SHE project and the forecasted cost for the reference building. (cf. Table 2 for the nomenclature).

The SET-SHE model proposes an average value for each construction element (cf. chapter 3.5.2 for more details on these average values). However, for some construction element, the lifespan could be modified: for example for floor covering, the value of the model could change between the SHE project and the reference building if the SHE project use tiling instead of carpet.

Nomenclature of the SET-SHE model for the initial costs analysis – Table 2

COST OF GROUND PURCHASE
DEMOLITION COST
Cost of traditional demolition
Cost of selective demolition
Cost of the pre audit for traditional demolition
Cost of the pre audit for selective demolition
Pollution removal
CONSTRUCTION COST
STRUCTURAL WORK
Earthwork
Valorisation of removed earth on the spot and rubble
Structure
Concrete slab
Pebbling
Masonry: external masonry, internal masonry work and partition
Roofing, waterproofing and insulation
FINISHING
Internal and external plasterwork
Floor and wall covering (incl. skirting), stair
Internal joinery (doors)
External joinery (doors and windows)
Exhaust duct
Drain pipe
Cement works (threshold…)
Tinplate work
Blacksmith work
Painting
Green Spaces
Lift's installation
Various works
Supplementary masonry for various installations
External ground covering – Networks' connections
OTHER COSTS
Security
Construction site management : waste disposal cost: collection, sorting, removal…
INSTALLATIONS - TECHNIQUES
Heating
Ventilation
Water supply
Raining water collection
Solar heating
Electrical installations
Solar photovoltaic
SECONDARY URBANISATION COST
PRIMARY URBANISATION COST
TECHNICAL STUDIES AND CONSULTING
Honorary (incl. construction site security)
Complementary studies and sustainable development consulting advice
FINANCIAL COST (social insurance, land registry, joint ownership regulation, other costs)

Source: La Calade for SHE

3.5.1.3. Postponed/running costs

The forecasted (or real if the SHE building is already built) running costs of the SHE and reference buildings have also to be completed in the Input Data Sheet. The running costs comprised the maintenance and repair costs as well as the operating costs (cf. chapter 3.2.).

In the French version, the average annual cost of maintenance and repair without VAT are required for the calculation of the maintenance cost (in € per m^2 and per year). In the Italian version this is already completed in the calculation sheets because the cooperative is not responsible for the maintenance and repair of the buildings.

For both versions, the operating costs are detailed with the following nomenclature:

Nomenclature of the operating costs – Table 3

Heating
Energy used
Heating type : collective, individual, district heating
Sanitary hot water
Mode of supply : centralised, independent
Energy used
Self-production of electricity
Self-production of thermal energy
Type of produced energy
Electricity for common spaces
Electricity for dwellings
Drinkable water
Water in the common spaces
Specific maintenance
Cleaning up
Green areas maintenance
Other costs

Source: La Calade for SHE

Notice :

- The table requires entering energy consumption for heating and another for Sanitary Hot Water (SHW). It is possible that in case of collective heating systems, the allocation of the energy consumption between heating and SHW is not possible. In this case, we enter the energy consumption in the space devoted to the input of heating.
- For the self production of energy, the self production of thermal energy is not set out as it is not necessary for the calculation (as it is taken into account in the subsequent reduction of heating energy), whereas as the self production of electricity is being resold; it needs to be input in the model.
- The electricity consumption for lighting, sanitary hot water, electro domestic appliances have to be assessed so as to be input in the model even if this information is not well known from the cooperatives and social owners. The SET-SHE model proposes different ratios.
- Energy and water prices are assessed including the subscription and consumption costs. The average unitary cost could thus a priori vary if the consumption differs between the SHE project and the traditional construction.

3.5.1.4. Externalities

The input data specific to the externalities are (cf. Table 4 and chapter 3.3):

- the avoided acoustic pollution: what is the reduction of decibel related to a reference situation (in some countries, the reference situation can be given by a national regulation).
- The quantity of wood used in the construction, so as to deduce from the externality cost of producing greenhouse effect gas the CO_2 stored in the wood
- Landscape and open spaces quality: on the one hand, accessibility (by foot and by bicycle) to green and open spaces and quality of these spaces, on the other hand, visual quality of the view from the building.
- The input data necessary to calculate the wasted or won time in travelling (cf. chapter 3.3.6), that is to say: presence or not in a radius of 300 meters of different services or facilities. The calculations are made with the probability of presence and of use of these amenities. These probabilities are given for each country by the model.

The SET-SHE model retains concerning landscape and open spaces quality the same data for the reference building than for the SHE project but the structure enables to input different data.

There are no specific input data on greenhouse effect gases emissions (apart from the wood quantity) and on atmospheric pollutant emissions as the data on emissions of CO2, sulphur dioxide (SO_2), nitrogen oxides (NO_x) and volatil organic compounds (VOC) are calculated with the energy consumptions of the buildings (consumption for heating, sanitary hot water, electric appliances).

Externalities input data in the French version of the SET-SHE model – Table 4

		Reference Building	Sustainable Building
Acoustic pollution			
Avoided acoustic pollution for SB thanks to supplementary acoustic insulation from outside	dB (A)	0	
Open spaces and visual quality			
Proximity: Are there open spaces in the vicinity: less than 300 m from the house?	Yes / No		
Does a comfortable footpath exist?	Yes / No		
Does a comfortable way for bikes exist?	Yes / No		
Is the dimension more or equal to 1 hectare?	Yes / No		
Is it an open space of city or agglomeration?	Yes / No		
Cleanliness and quality of maintenance?	Yes / No		
Family use, adapted to children use?	Yes / No		
Multi-purposes: jogging, rest, recreational uses ?	Yes / No		
Security inside the open space ?	Yes / No		
Nature of landscape seen from the building (input yes in front on the right suggestion)	Exceptionnal		
	Attractive		
	Common		
	Poor		
Wood quantity used in the construction			
Wood quantity used in the construction	dm^3/m^2		
Distance between the project and basic anemities and services			
		Presence in the perimeter	Distance if known
		1 for yes / 0 for no	in meters
Day nursery	The perimeter could be understood as the neighbourhood, the block or a radius of 300 meters around the project	1	
Nursery school		1	
Primary school		1	
Neighbourhood shops (greengroceries, bakeries)		1	
Super/hypermarket		1	
Public transports station		1	
Athletic basic equipments or swimming-pool		1	
Open spaces		0	
Municipality, public and social services		1	
Post office		0	
Cash points		1	
Hall, theatre		1	
Cyber coffee		0	
Chemist's		1	
Health services, doctors		1	
Restaurants, cafés		1	

Source: La Calade for SHE

3.5.2 – The endogenous data of the SET-SHE model

Lifespan of the construction items

The lifespan of the various building's components is an important element of the OLCC methodology, as it would greatly influence the Net Present Value.(NPV) of the component: for example, a component with a cost of 10,000 euro and a lifespan of 30 years has a net present value equal to 525 euro. If the lifespan is only of 15 years, the NPV reaches 839 euro i.e. an overcost of 60 %.

The model usesthe data of the following table to provide a referent lifespan for each construction element:

Lifespan of construction elements used in SET-SHE model – Table 5

	Years		**Years**
Building front HP cleaning	20 – 50	Landing door	30 – 35
Building front renovation with paint	15 – 20	Plumbing – water and gas distribution	50
Building front's waterproofing	20 – 30	Sanitary	30 – 35
Brick Building front	30 – 50	Sink	25 – 30
Joinery in PVC	40	WC, Bathroom, washbasin, bathtub, shower	30 – 35
Wood framed joinery	30	Radiators	50
Aluminium framed joinery	30	Electric Convection Heater	20
PVC Shutters	30	Individual Heating	
Wood Shutters	20	Common Boiler	
Tile, baked clay, concrete Roofing	55	Lift	20
Tin, steel trough, sheet metal, slate Roofing	30	Central Heating Piping	30
Terrace waterproofing	25 – 30	Controlled Mechanical Ventilation	25
Tiling, granite Floor (common)	40	Tiling Floor (dwelling)	50
Rubber floor (common)	15 – 20	Wood Floor (dwelling)	50
Plastic Slab Floor (common)	20 – 25	Plastic Slab Floor (dwelling)	20 – 25
Painted Floor	10 – 15	Carpeted Floor	20
Painted Wall and |Ceiling	8 – 10	Common areas' electricity	20 – 30
Tiling Wall	30	Dwelling's electricity	30 – 35
Wood Ceiling	30	Water distribution and collective sewage disposal	50
Joinery's Paint	8 - 12	Electrical Convectors	20

Source : La Calade with data from various sources

The lifespan of the building elements can be modified if necessary in the model in regards to the technological choices made in the project.

Evolution of utility prices

For the calculation of the DLCC, we need some assumptions on the evolution of utilities prices and particularly of energy.

These assumptions are obviously difficult to define.

When the oil barrel cost was around 18 – 20 $, the forecasts concerning energy by all the major national and international organisations gave a barrel price for 2030 around 30 to 35 $:

- ***International Energy Agency***, "World Energy Perspectives 2004" (report of 26/10/2004): The scenario with the higher oil prices proposes an oil barrel at 35 $ in 2030
- **European Commission "**World Energy, Technology and climate policy outlook (WETO)", 2002: The oil barrel price was forecasted to be of 35 € in 2030 and of 28 € for gas equivalent.
- **French Ministry of Industry** (DGEMP) in a study for energy prospective related to France (carried out by Lepii and Enerdata, February 2005): the main scenario gives an oil barrel price at 30 $ in 2030. The model used in this study to build a factor 4 scenario is based on a barrel price of 35 $.

Otherwise, at the end of 2004, all experts forecasted an oil barrel price which would be about 75 % higher in 2030 than the 2004 price, i.e. an average increase of 2 to 2,5 % per year.

In contradiction of the studies quoted previously, the oil barrel since summer 2005 has had a price superior to 50 $, demonstrating that it is today extremely difficult to forecast any energy price. Experts think however currently that this oil barrel price should be always high. Our proposal is to include in the SET-SHE model an average annual increase of oil price of 2,5 % (with a fixed euro)**.**

Thus, for the price of final products, taking into account the various activities of refining, transport and distribution and also taxes, the assumption of evolution in the SET-SHE model is of **+ 3 % per year (with a fixed euro)**.

Gas price is generally index-linked with the oil price and could have the same evolution. We propose an assumption of price evolution for gas of **3% per year (with a fixed euro)**.

For **electricity**, the price with a fixed euro is increasing less in France than in other European countries. We have thus retained in the model an **evolution of 1% per year for France and of 2% for the other countries** (with a fixed euro).

Water price is also susceptible of varying in an important way. In France, water price increased by 1 % per year (with a fixed euro) between 1991 and 2000.

We propose an average evolution of **1 % per year** for **water price**.

Discount Rate

The discount rate is of 2.5% for a 30-year-calculation period and 1.5% for a 60-year-calculation period. The choice of these hypotheses is explained in Annex I.

Endogenous data for externalities cost calculation

The hypothesis of the SET-SHE model used to calculate externalities are detailed in the chapter 3.3. However, we have repeated some of them in the following tables:

Factors of CO_2 emission (gCO_2 / kWh) – Table 6

Heating fuel	304
Natural gas	224
Wood and wood waste	10
Electricity French average Italian average Portuguese Average Danish Average	 180 for heating use, 40 for other uses 500 231 for heating use, 143 for other uses 517

Source: La Calade for SHE

Reminder of the hypothesis for the cost of atmospheric pollution – Table 7

	Emission factor in g /MWh			Impact in €/MWh
	SO_2	NOx	VOC	
Natural gas and LPG (Liquefied Petroleum Gas)	2	181	9	0.81
Fuel oil	517	181	36	4.07
Electricity	0 (direct) + generation cycle			0.84 (F) 3.71 (I) 5.86 (Po) 7.51(DK)
Wood	0	290	2 897	2.43

Source: La Calade for SHE

Reminder of SET-SHE model time value – Table 8

Country	Average hourly cost of labour (in euro)[90]	% of Wage and treatments	Average hourly wage cost[91]	Time value (in €/hour)
France	28.20 €	72. 4%	20.4 €	7.1 €
Italy	21.39 €	75 % (t)	16 €	5.6 €
Portugal	9.56 €	80. 7 %	7.7 €	2.7 €
Denmark	30.7 €	92 %	28.2 €	9.9 €

Source: La Calade for SHE

SET-SHE Model: data for the calculation of travel needs to basic amenities and services – Table 9

	Presence Probability	Use Probability	Travel (nb/year)
Day nursery	57%	2%	220
Nursery school	57%	10%	220
Primary school	57%	15%	220
Neighbourhood shops (greengroceries, bakeries)	72%	66%	300
Super/hypermarket	85%	26%	50
Public transports station	85%	9%	220
Athletic basic equipments or swimming-pool	60%	16%	50
Open spaces	65%	80%	50
Municipality, public and social services	50%	95%	10
Post office	5%	60%	30
Cash points	10%	90%	50
Hall, theatre	60%	16%	50
Cyber coffee	10%	15%	50
Chemist's	8%	100%	25
Health services, doctors	32%	100%	12
Restaurants, cafés	75%	44%	100

Source: La Calade for SHE

[90] http://epp.eurostat.ec.europa.eu

[91] http://epp.eurostat.ec.europa.eu

Summary

We have gathered in the following table the main hypothesis used in the SET-SHE model, including hypothesis on CO_2 value (set out in the chapter 3.3.2):

Hypothesis of the SET-SHE model – Table 10

	Italy	France	Portugal
Period of calculation	30 and 60 years		
Discount rate	2.5 % (30 years) and 1.5 % (60 years)		
Gas price	0.07 € / kWh	0.057 € / kWh	0.059€ / kWh
Gas price evolution in % per year	3 %	3 %	3 %
Electricity price	0.17 € / kWh	0.12 € / kWh	0.076 € / kWh (0.062 for night)
Electricity price evolution in % per year	2 %	1 %	2 %
Water price	1.1 € / m^3	3.1 € / m^3	1.8 € / m^3
Water price evolution in % per year	1 %	1 %	1 %
PV sale tariff	0.43 € / kWh	0.30 € / kWh	NA
CO_2 ton value	50 €	50 €	50 €
Annual growth rate of the CO_2 ton price	1 %	1 %	1 %

Source: La Calade for SHE (Note: the utilities prices evolution are given without inflation; In current euro, we would have to add the annual inflation rate)

Concerning the calculation of externality brought by the reduction of sound pollution, it depends on the surrounding's level of noise. We have supposed an impact of 1 % of the building value for each decibel under the legal threshold (which corresponds to a daylight Laeq of 70 to 75 dB (A) and a night Laeq of 60 to 65 dB (A), cf. 3.3.5).

3.5.3 - The SET-SHE results sheets

The SET-SHE model results are presented in two parts:

- A first sheet presents the overall life cycle costs of the project including direct costs, postponed/running costs and externalities.
- A second sheet divides the overall cost between the various stakeholders: the tenant/resident, the social owner/cooperative, the society, the State and the local authority.

Each result is given for the SHE project and for the reference building.

Net present values of Direct Life Cycle Costs and externalities – Table 11

Source: SET-SHE model, La Calade for SHE

Life Cycle Costing :

Consorzio COPALC, Bologna

Petiod of calculation in years	30

NET PRESENT VALUE	SHE project in discounted €	SHE project €/m²	SHE project in %	Traditional project in discounted €	Traditional project €/m²	Traditional project in %
COST OF GROUND PURCHASE	21 040	24,05	13,7%	21 040	24,05	13,9%
DEMOLITION COST	0	0,00	0,0%	0	0,00	0,0%
CONSTRUCTION COST	91 583	104,67	59,7%	81 164	92,76	53,7%
Structural work	35 012	40,01	22,8%	33 081	37,81	21,9%
Finishing	44 099	50,40	28,7%	38 875	44,43	25,7%
Other costs	0	0,00	0,0%	0	0,00	0,0%
Installation-techniques	12 472	14,25	8,1%	9 209	10,52	6,1%
SECONDARY URBANISATION COST	850	0,97	0,6%	1 700	1,94	1,1%
PRIMARY URBANISATION COST	5 716	6,53	3,7%	5 716	6,53	3,8%
TECHNICAL STUDIES AND CONSULTING	6 013	6,87	3,9%	4 055	4,63	2,7%
FINANCIAL COST	2 331	2,66	1,5%	2 331	2,66	1,5%
TOTAL COST WITHOUT VAT	**127 532**	**145,75**	83,1%	**116 006**	**132,58**	76,8%
VAT	**6 568**	7,51	4,3%	**5 733**	6,55	3,8%
TOTAL COST WITH VAT	**134 100**	**153,26**	87,4%	**121 739**	**139,13**	80,6%
Maintenance	**3 500**	4,00	2,3%	**3 500**	4,00	2,3%
Heating	6 992	7,99	4,6%	12 419	14,19	8,2%
Sanitary hot water heating	745	0,85	0,5%	3 036	3,47	2,0%
Electricity self-production	-803	-0,92	-0,5%	0	0,00	0,0%
Common areas electricity consumption	1 884	2,15	1,2%	1 441	1,65	1,0%
Flat electricity consumption	6 400	7,31	4,2%	7 758	8,87	5,1%
Flat water consumption	627	0,72	0,4%	1 183	1,35	0,8%
Common areas water consumption	0	0,00	0,0%	0	0,00	0,0%
Total of operating costs wit VAT	**15 844**	**18,11**	10,3%	**25 837**	**29,53**	17,1%
Total of running/postponed costs	**19 344**	**22,11**	12,6%	**29 337**	**33,53**	19,4%
Direct Life Cycle Cost	**153 444**	**175,37**		**151 076**	**172,66**	
EXTERNALITY						
Greenhouse gas emisssion	2 320	2,65		3 055	3,49	
Atmospheric pollutant emission	139	0,16		273	0,31	
Avoided acoustic pollution	-5 674	-6,48		0	0,00	
Landscape value	-12 085	-13,81		-12 085	-13,81	
Time value	-306	-0,35		-306	-0,35	
Travel induced	-58	-0,07		-58	-0,07	
TOTAL OF EXTERNALITIES	**-15 663**	**-17,90**		**-9 120**	**-10,42**	
DIRECT LIFE CYCLE COST+EXTERNALITIES	**137 781**	**157,46**		**141 956**	**162,24**	

Overall Life Cycle Cost share between the stakeholders – Table 12

OVERALL LIFE CYCLE COST — in Euro per m^2 of living area — Consorzio COPALC, Bologna — **SHE project**

	Cooperative		Resident		Local authorities		State		Society	
	benefit	loss	benefit	loss	benefit	loss	benefit	loss	benefit	loss
Construction cost	0,00	145,75							72,88	
VAT		7,51					7,51			
Purchase/sale of the building	155,83			155,83						
Property taxes				2,06			2,06			
Maintenance				4,00			0,36		1,82	
Heating				7,99			0,73		2,18	
Sanitary hot water heating				0,85			0,08		0,23	
Electricity self-production				-0,92			-0,08		-0,42	
Common areas electricity consumption				2,15			0,20		0,78	
Flat electricity consumption				7,31			0,66		2,66	
Flat water consumption				0,72			0,07		0,33	
Common areas water consumption				0,00			0,00		0,00	
OLCC	155,83	153,26	0,00	179,99	0,00	0,00	11,57	0,00	80,46	0,00
OLCC balance	2,57		-179,99		0,00		11,57		80,46	
Greenhouse gas emissions										2,65
Atmospheric pollutant emission										0,16
Avoided acoustic pollution			6,48							
Landscape value			13,81							
Travel induced				-0,42						
OLCC	0,00	0,00	20,30	-0,42	0,00	0,00	0,00	0,00	0,00	2,81
OLCC balance	0,00		20,71		0,00		0,00		-2,81	

OVERALL LIFE CYCLE COST — in Euro per m^2 of living area — Consortio COPALC, Bologna — **Traditional project**

	Cooperative		Resident		Local authorities		State		Society	
	benefit	loss	benefit	loss	benefit	loss	benefit	loss	benefit	loss
Construction cost		132,58							66,29	
VAT		6,55					6,55			
Purchase/sale of the building	139,13			139,13						
Property taxes				2,06			2,06			
Maintenance				4,00			0,36		1,82	
Heating				14,19			1,29		3,87	
Sanitary hot water heating				3,47			0,32		0,95	
Electricity self-production				0,00			0,00		0,00	
Common areas electricity consumption				1,65			0,15		0,60	
Flat electricity consumption				8,87			0,81		3,22	
Flat water consumption				1,35			0,12		0,61	
Common areas water consumption				0,00			0,00		0,00	
OLCC	139,13	139,13	0,00	174,72	0,00	0,00	11,66	0,00	77,36	0,00
OLCC balance	0,00		-174,72		0,00		11,66		77,36	
Greenhouse gas emissions										3,49
Atmospheric pollutant emission										0,31
Avoided acoustic pollution			0,00							
Landscape value			13,81							
Travel induced				-0,42						
OLCC	0,00	0,00	13,81	-0,42	0,00	0,00	0,00	0,00	0,00	3,80
OLCC balance	0,00		14,23		0,00		0,00		-3,80	

OVERALL LIFE CYCLE COST — in Euro per m^2 of living area — Consortio COPALC, Bologna — **Balance between SHE and traditionnal buildings**

	Cooperative		Resident		Local authorities		State		Society	
	benefit	loss	benefit	loss	benefit	loss	benefit	loss	benefit	loss
Construction cost	0,00	13,17	0,00	0,00	0,00	0,00	0,00	0,00	6,59	0,00
VAT	0,00	0,95	0,00	0,00	0,00	0,00	0,95	0,00	0,00	0,00
Purchase/sale of the building	16,70	0,00	0,00	16,70	0,00	0,00	0,00	0,00	0,00	0,00
Property taxes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Maintenance	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heating	0,00	0,00	0,00	-6,20	0,00	0,00	-0,56	0,00	-1,69	0,00
Sanitary hot water heating	0,00	0,00	0,00	-2,62	0,00	0,00	-0,24	0,00	-0,71	0,00
Electricity self-production	0,00	0,00	0,00	-0,92	0,00	0,00	-0,08	0,00	-0,42	0,00
Common areas electricity consumpt	0,00	0,00	0,00	0,51	0,00	0,00	0,05	0,00	0,18	0,00
Flat electricity consumption	0,00	0,00	0,00	-1,55	0,00	0,00	-0,14	0,00	-0,56	0,00
Flat water consumption	0,00	0,00	0,00	-0,64	0,00	0,00	-0,06	0,00	-0,29	0,00
Common areas water consumption	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
OLCC	16,70	14,13	0,00	5,28	0,00	0,00	-0,08	0,00	3,09	0,00
OLCC balance	2,57		-5,28		0,00		-0,08		3,09	
Greenhouse gas emissions	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,84
Atmospheric pollutant emission	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,15
Avoided acoustic pollution	0,00	0,00	6,48	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Landscape value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Travel induced	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
OLCC	0,00	0,00	6,48	0,00	0,00	0,00	0,00	0,00	0,00	-0,99
OLCC balance	0,00		6,48		0,00		0,00		0,99	

Source: SET-SHE model, La Calade for SHE

CHAPTER 4 – THE ANALYSIS OF THE SHE PILOT-PROJECTS

4.1. – THE RESULTS FOR EACH SHE PROJECT

The SHE projects are the following ones:

- Preganziol Project, COIPES Consortium, Mestre
- Mazzano Project, CONSEDI Consortium, Brescia
- Villa Fastiggi, COPES Consortium, Pesaro
- Ozzano Project, COPALC Consortium, Bologna
- Teramo Project, CCICASA Consortium, Teramo
- Bourgoin – Jallieu Project, OPAC 38, Grenoble
- Porto Project, NORBICETA, Porto
- Aarhus Project, Ringaarden

4.1.1 – The Preganziol project, COIPES CONSORTIUM, Mestre

The data about the project and the overcost assessment come from a common work of La Calade with Matteo Pilotto and Alain Lusardi. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Preganziol project

Source: COPES Consortium

Technical aspects of the project

The project concerns the construction of 67 flats for a built volume of 28 962 m^3, a heated volume of 22 461 m^3 and a **heated surface of 8 070 m^2.**

The actions in regards to sustainability are :

Improvement of insulation:

- acoustic insulation including floor insulation (5 dB (A) win)
- double glazing windows
- strong thermal inertia masonry:
    - walls (included outdoor partitions) built with Isotex insulation
    - floor composed by recycled plastic (Pavigran®)

Daylight strategies, windows and shading:

- improvement of natural light within indoor spaces
- winter solar gains, passive cooling strategies and shading devices

Renewable Energy: solar water heater and solar collector for heating system

Heating: low temperature heating distribution in floors

Ventilation and cooling: ventilation duct for communal areas

Building materials:

- friendly environmental material
- use of rubble from around the building site (40 % of materials needs for ways, streets and embankment)
- retaining walls in concrete block composed by concrete and recycled wood
- wood joinery
- flooring: ecological certification for tiling; certification of non exotic wood for wood flooring

Water management:

- water saving: grey water recovery, use of locally cleansed water and rain water : toilets, garden watering
- sustainable drainage: private ways for pedestrians are carried out with a material using compressed earth with a specific binding agent : Glorit product.

Waste management: selective sorting of building site waste

Movement facilities:

- organisation of pedestrians circulation
- reduction of the car occupation of public spaces

Other comfort and health features:

- painting and plasterwork: ecological paints and plasterwork
- electric installation without electromagnetism in bedrooms

Economic analysis

Construction Cost

The cost only for construction is 8706 k€ and the investment cost (IC) for the project is 11 061 k€ (without tax), i.e. 1 371 €/m^2.

The investment overcost is assessed to 589 k€, i.e. 5.6 % of the IC. The investment overcost is 75 €/m^2.

Running costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.3 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves energy efficiency with an energy consumption of 91 kWh/m^2 for heating and hot water in regards to 144 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 16.7 to 14.9 kWh/m^2.

Water consumption reaches 82 m^3 per flat (0.68 m^3/m^2) compared to 148 m^3 for a traditional flat.

The operating cost is 80 k€ i.e. 9.9 €/m^2, in regards to 118 k€ (14.6 €/m^2) for a traditional building.

The Preganziol energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	83	128
Sanitary Hot Water	kWh/m^2	8	16
Electricity Autoproduction	kWh/m^2	0	
Heating Autoproduction	kWh/m^2	0	
Flat Electricity consumption	kWh/m^2	14.9	16.7
Common Electricity consumption	kWh/m^2	1.7	
Flat Water consumption	m^3/m^2	0.7	1.2
Common Water consumption	m^3/m^2	0	
Operating costs	**€/m^2**	**9.9**	**14.6**
Saving	**€/m^2**	**-4.7**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

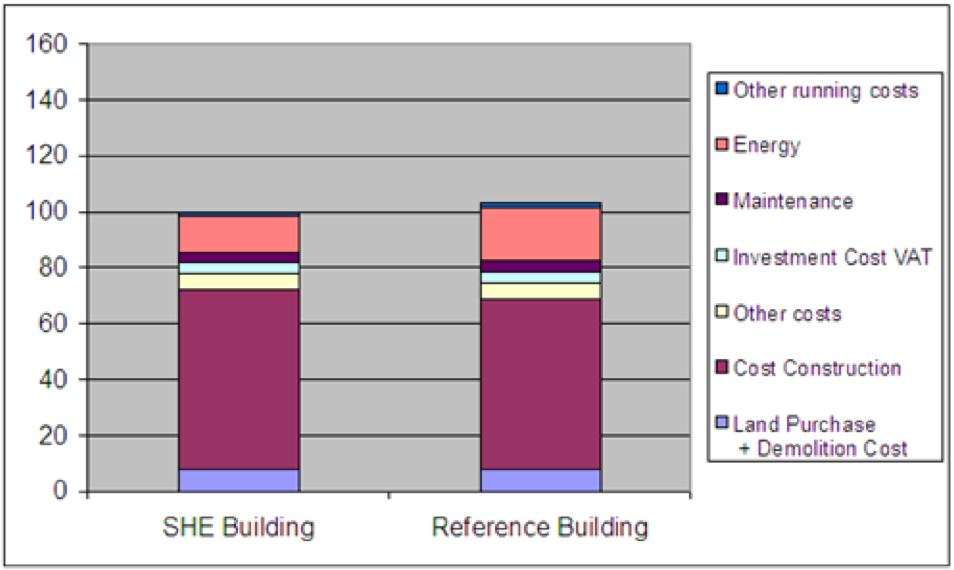
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 27 757 € in favour of the sustainable building, i.e. 414 € per flat (Direct Life Cycle Cost).

The direct life-cycle cost is indeed 99.7 € / m^2 for the SHE building compared to 103.2 € /m^2 for the reference building. Savings represent 3.4 % of the cost.

Preganziol Direct Life Cycle Cost for a 30-year-calculation period (in euro/m²)



Source: La Calade for SHE

Preganziol Direct Life Cycle Cost for a 30-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	7.8	
Cost Construction	64.2	61.0
Other construction costs	5.8	
VAT	3.8	3.8
Maintenance	4.0	
Energy	13.2	19.3
Other running costs	0.9	1.5
30 years DLCC	**99.7**	**103.2**

Source: La Calade for SHE

Externalities analysis

External costs have been assessed for the sustainable building and for the reference building.

Externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as reduction of electrical and electromagnetism fields, use of environmental friendly material, sustainable drainage etc.

Net present value of externalities for Preganziol project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	11 788	19 086	-7 298
2 - Atmospheric pollutant emission	1089	1 494	- 405
3 – Avoided acoustic pollution	- 25 779	0	- 25 779
4 – Landscape value	- 61 767	- 61 767	0
5 – Time value	0	0	0
6 – Travel induced	0	0	0
Total externalities	**- 74 669**	**-41 187**	**-33 482**
Externalities per square meter	**- 9.3**	**- 5.2**	**- 4.1**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 4,1 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

The Preganziol Overall Life Cycle Costing (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	804 935	99.7	832 692	103.2	-27 757	-3.5
Externalities (cost)	- 74 669	- 9.2	- 41 187	- 5.1	-33 482	-4.1
OLCC Value	**730 266**	**90.5**	**791 505**	**98.1**	**-61 239**	**-7.6**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 7,7 % to the reference building one, that is to say approximately 914 € by year and by dwelling.

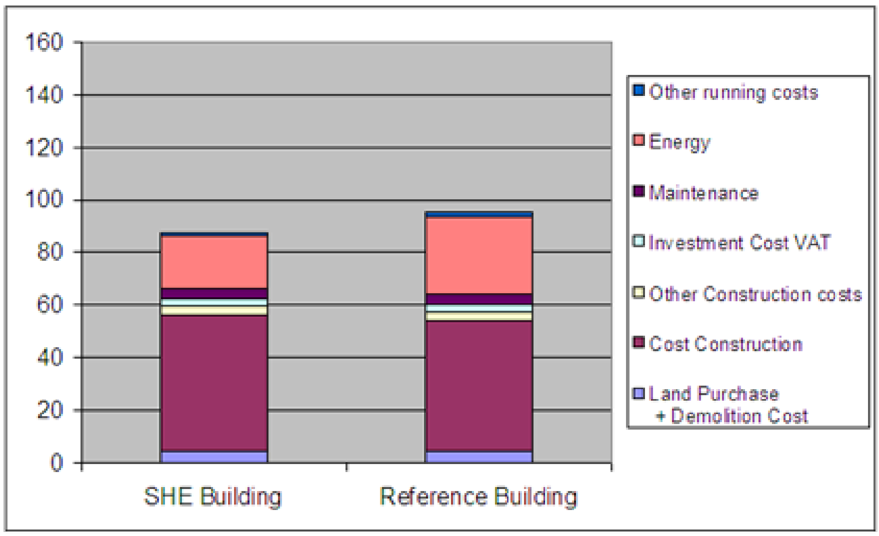
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 65 498 € in favour of the sustainable building, i.e. 978 € per flat.

The direct life-cycle costing is 87.4 € / m^2 for the SHE building compared to 94.8 € /m^2 for the reference building. Savings represent 7.8 % of the cost.

The Preganziol Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)



Source: La Calade for SHE

The Preganziol Direct Life Cycle Cost for a 60-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	4.2	
Cost Construction	52.2	50.0
Other construction costs	3.1	
VAT	2.9	2.1
Maintenance	4,0	
Energy	20.1	29.6
Other running costs	1.0	1.8
60 years DLCC	**87.4**	**94.8**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Preganziol project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	14 304	21 833	-7 529
2 – Atmospheric pollutant emission	1089	1 494	- 405
3 – Avoided acoustic pollution	-13 836	0	-13 836
4 – Landscape Value	-33 152	-33 152	0
5 – Time value	0	0	0
6 – Travel induced	0	0	0
Total externalities	**-31 595**	**-9 825**	**-21 770**
Externalities per square meter	**-3.9**	**-1.2**	**-2.7**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 2,7 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

The Preganziol Overall Life Cycle Costing (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	705 576	87.4	765 036	94.8	- 59 460	- 7.4
Externalities (cost)	- 31 595	- 3.9	-9 825	-1.2	- 21 770	-2.7
OLCC Value	**673 981**	**83.5**	**755 211**	**93.6**	**- 81 230**	**-10.1**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 10.8 % to the reference building one, that is to say approximately 1 200 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and society (benefiting from positive externalities) is on average of 10.1 € by m² and by year.

Construction overcost : + 2.9 € / m² - year

Running costs savings: - 10.3 € / m² - year

Externality "savings": - 2.7 € / m² - year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

We have also to consider the sale price of the different flats to households. We don't suppose that a sustainable building can benefit from a sale price bonus as we do not have any information on the eventual surplus of the market price for sustainable constructions. So the cooperative does not get direct advantages in building a sustainable building. However, this could change as for the Ozzano project (Bologna), whose the six first flats have been sold with a bonus of 12%.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

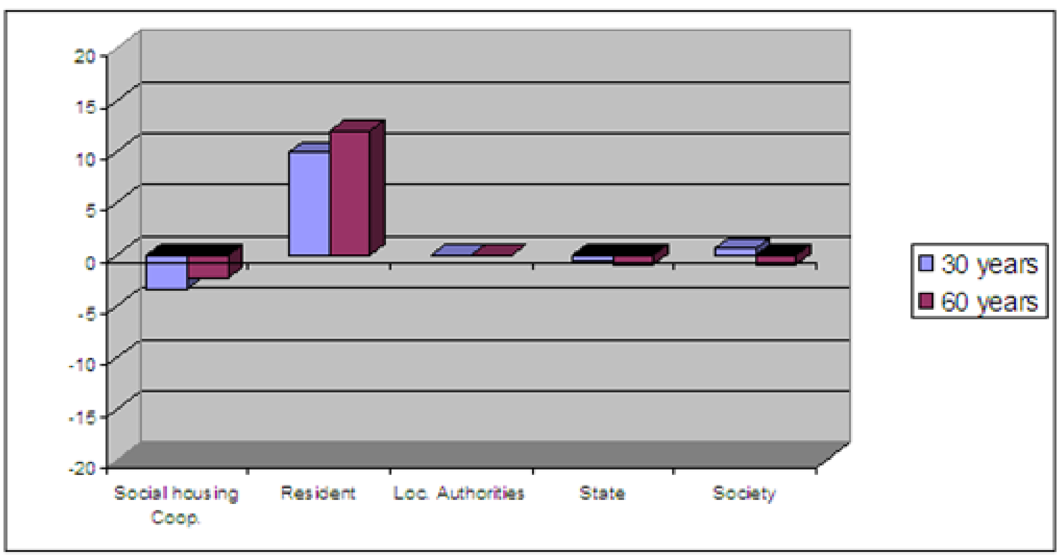
For a 30-year-calculation period, the benefits and costs are shared between stakeholders as following:

- a benefit for residents of 9.94 €/m²
- a benefit for Society of 0.57 € / m²
- a loss for the cooperative of 3.30 €/m² (depends on the real market price of sustainable construction)
- a loss for national authorities (State) of 0.55 €/m².

For a 60-year-calculation period:

- a benefit for residents of 12.03 €/m²
- a loss for Society of 0.94 € / m²
- a loss for the cooperative of 2.2 €/m² (depends on the real market price of sustainable construction)
- a loss for national authorities (State) of 0.91 €/m².

Preganziol benefits and costs for the different stakeholders (in euro/m²)
for a 30 and 60-year calculation period



Source: La Calade for SHE

The SHE project has a DLCC and OLCC benefits, for a 30-year-calculation period as well as for a 60-year-calculation period. This is due principally to the energy saving and to the reduction of acoustic pollution and CO_2 emission, linked to a relatively low investment overcost (cf. Chapter 4.2).

4.1.2 – The Mazzano project, CONSEDI Consortium, Brescia

The data about the project and the assessment of the overcost come from a common work of La Calade with Mario Rubagotti and Andrea Rosoli. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Brescia project.

Source: CONSEDI Consortium

Technical aspects of the project

The project concerns the construction of 36 flats for a built volume of 15 115 m^3, a heated volume of 11 950 m^3 and a **heated surface of 2 981 m^2.**

The actions in regards to sustainability are :

Improvement of the microclimate

Improvement of insulation:

- acoustic insulation (12 dB (A) win)
- high insulated glass with argon
- strong thermal inertia masonry built with Isotex:
    - external wall in concrete and fiberwood; U=0.45
    - roofs and floors in concrete, fiberwood and clay; respectively U=0.37 and 0.96

Daylight strategies, windows and shading:

- improvement of natural light within indoor spaces
- winter solar gains, passive cooling strategies
- shading devices: louvers/wood shutters for south side, portico for west and south sides, overhangs roof, movable jalousies

Renewable Energy: photovoltaic and thermal solar systems

Heating: centralised and radiant heating system with high efficiency boiler

Electricity saving: low consumption lighting system

Ventilation and cooling: mechanically controlled ventilation

Building materials:

- environmental friendly materials

- wood joinery

Water management:
- rainwater for toilet flush and washing
- minimum of metalled areas

Waste management: areas for common composting, waste sorting

Movement facilities: link to the pedestrian and cycle path system of Naviglio canal

Visual Quality: respect of local housing tradition, creation of a green park

Other comfort and health features: reduction of electric and electromagnetic fields

Economic analysis

Construction Cost

The cost for construction only is 5 141 k€ and the investment cost (IC) for the project is 6 452 k€ (without tax), i.e. 2 164 €/m^2.

The investment overcost of building the SHE project instead of a traditional building is assessed to 891 k€, i.e. 16 % of the Investment cost and 299 €/m^2.

Running Costs

Maintenance cost includes the maintenance of the building and repairing. Maintenance does not include utilities expenses (or operating costs). The annual maintenance cost is 0.2% of the investment cost.

The operating cost includes energy and water costs. The project improves energy efficiency with an energy consumption of 76 kWh/m^2 for heating and hot water in regards to 142 kWh/m^2 in a traditional new building. Electricity consumption also decreases from 33 to 27 kWh/m^2.

The water consumption reaches 137 m^3 per flat (1.65 m^3/m^2) compared to 169 m^3 for a traditional flat.

The operating cost is 36.6 k€ i.e. 12.3 €/m^2, in regards to 70.9 k€ (23.8 €/m^2) for a traditional building.

Mazzano energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	65	120
Sanitary Hot Water	kWh/m^2	11	22
Electricity Autoproduction	kWh/m^2	4.4	0
Heating Autoproduction	kWh/m^2	40	0
Flat Electricity consumption	kWh/m^2	27	33
Common Electricity consumption	kWh/m^2	5.2	9.6
Flat Water consumption	m^3/m^2	1.65	2.04
Common Water consumption	m^3/m^2	0.07	0.40
Operating costs	**€/m^2**	**12.3**	**23.8**
Saving	**€/m^2**	**- 11.5**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

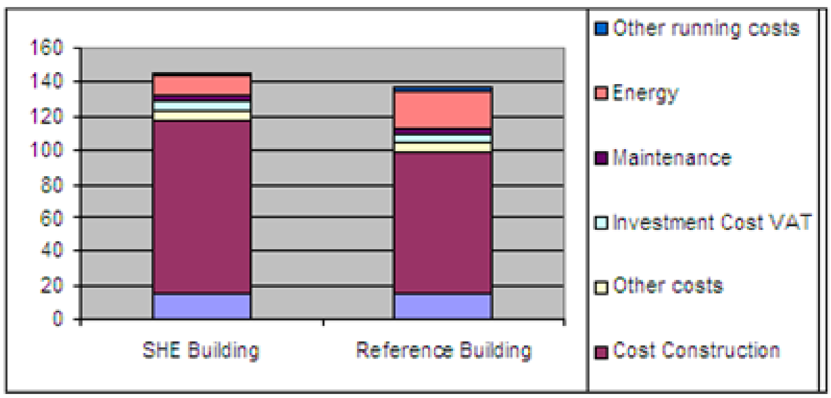
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could be more interesting only on longer analysis period.

The annual balance gives a benefit (or savings) of 20 884 € in favour of the reference building, i.e. 580 € per flat (Direct Life Cycle Cost).

The direct life-cycle cost is 144.1 € / m² for the SHE building compared to 137.0 € /m² for the reference building. The overcost represents 4.9 % of the cost.

Mazzano Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)



Source: La Calade for SHE

Mazzano Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)

	SHE Building	**Traditional Building**
Ground cost	14.5	
Cost Construction	102.1	84.3
Other construction costs	6.0	
VAT	5.2	4.4
Maintenance	4.0	
Energy	11.0	21.9
Other running costs	1.3	1.9
30 years DLCC	**144.1**	**137.0**

Source: La Calade for SHE

Externalities analysis

External costs have been assessed for the sustainable building and for the reference building.

Externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as light pollution reduction (linked to external lighting), reduction of electrical and electromagnetism fields, environmental friendly materials, minimum of metalled areas, areas for common composting, waste sorting etc.

Net present value of externalities for the Mazzano project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	5 618	9 009	- 3 391
2 – Atmospheric pollutant emission	539	814	- 275
3 – Avoided acoustic pollution	- 21 655	0	- 21 655
4 – Landscape value	-32 031	-32 031	0
5 – Time value	-8 092	-8 092	0
6 – Travel induced	-1 221	-1 221	0
Total externalities	**-56 841**	**-31 521**	**- 25 320**
Externalities per square meter	**-19.1**	**-10.6**	**- 8.5**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 8.5 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Mazzano Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	429 284	144.0	408 400	137.0	20 884	7.0
Externalities (cost)	-56 841	-19.1	-31 521	-10.6	- 25 320	- 8.5
OLCC Value	**372 443**	**124.9**	**376 879**	**126.4**	**- 4 436**	**- 1.5**

Source: La Calade for SHE

The Overall Life Cycle Cost of the SHE project is inferior by 1.2 % to the reference building one, that is to say approximately 124 € by year and by dwelling.

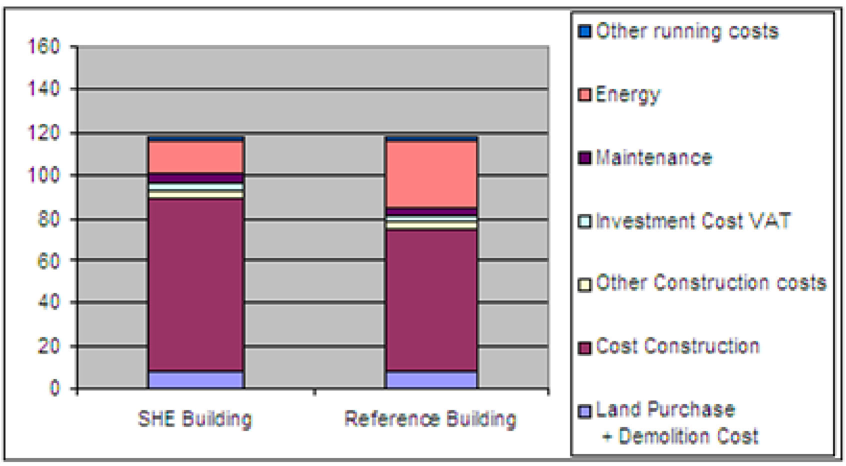
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 1 000 € in favour of the SHE building, i.e. 12 € per flat.

The direct life-cycle costing is 117.9 € / m^2 for the SHE building compared to 118.3 € /m^2 for the reference building. The savings represent 0.3 % of the cost.

Mazzano Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Mazzano Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)

	SHE Building	**Traditional Building**
Ground cost	7.8	
Cost Construction	81.7	66.7
Other construction costs	3.2	
VAT	3.9	3.3
Maintenance	4.0	
Energy	15.8	31.1
Other running costs	1.5	2.2
60 years DLCC	**117.9**	**118.3**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for the Mazzano project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	6 427	10 306	- 3 879
2 – Atmospheric pollutant emission	539	814	- 275
3 – Avoided acoustic pollution	- 11 623	0	- 11 623
4 – Landscape value	-17 192	-17 192	0
5 – Time value	-8 092	-8 092	0
6 – Travel induced	-1 221	-1 221	0
Total externalities	**- 31 161**	**- 15 385**	**- 15 776**
Externalities per square meter	**- 10.5**	**-5.2**	**-5.3**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 5.3 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Mazzano Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		**Traditional building (TB)**		**Balance (SB – TB)**	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	351 643	117.9	352 633	118.3	- 990	- 0.4
Externalities (cost)	- 31 161	- 10.5	- 15 385	- 5.2	- 15 776	- 5.3
OLCC Value	**320 482**	**107.4**	**337248**	**113.1**	**- 16 766**	**- 5.7**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 5.0 % to the reference building one, that is to say approximately 202 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and society (benefiting from positive externalities) are on average of 5.7 € / m² and by year.

Construction overcost : + 15.6 € / m² / year

Running costs savings: - 16.0 € / m² / year

Externality "savings": - 5.3 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

We also have to consider the sale price of the different flats to households. Without available information, we have as for the Preganziol project not consider that the SHE building would benefit from an higher market sale price, whereas Ozzano project flats has been sold with a premium.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

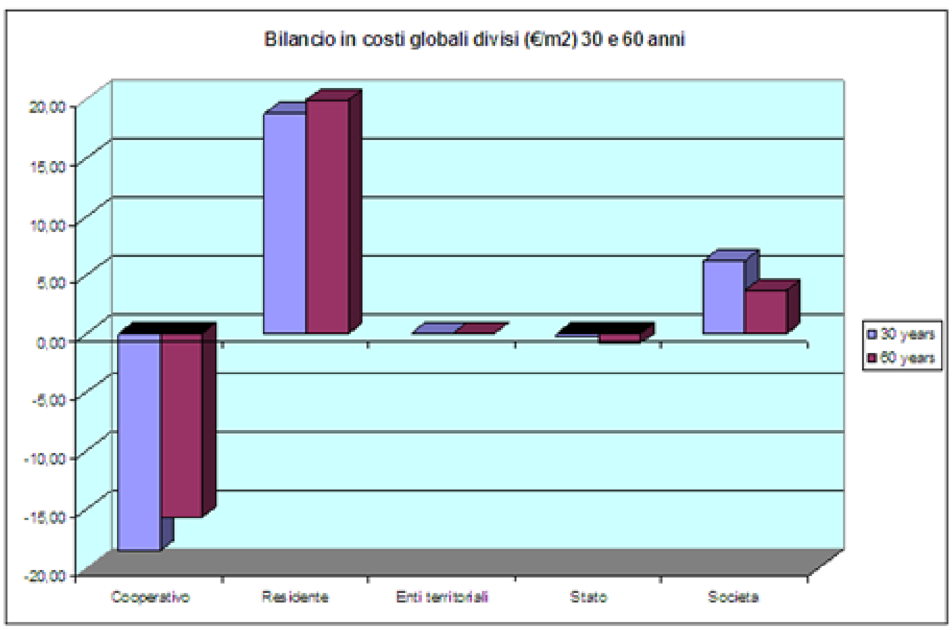
For a 30-year-calculation period, the benefits and costs are shared as following:

- a benefit for residents of 18.8 €/m^2
- a benefit for Society of 6.2 € / m^2
- a loss for the cooperative of 18.5 €/m^2 (depends on the real market price of sustainable construction)
- a loss for national authorities (State) of 0.3 €/m^2.

For a 60-year-calculation period:

- a benefit for residents of 19.9 €/m^2
- a benefit for Society of 3.7 € / m^2
- a loss for the cooperative of 15.7 €/m^2 (depends on the real market price of sustainable construction)
- a loss for national authorities (State) of 0.9 €/m^2.

Mazzano benefits and costs for the different stakeholders (in euro/m^2) for a 30 and 60-year calculation period



Source: La Calade for SHE

The Overall Life Cycle Cost for Brescia is in favour of the sustainable building for two calculation periods.

We notice a relative high investment overcost (17 % of the investment cost, the highest of the SHE project, cf. chapter 4.2), which is just compensated by higher energy or externalities savings.

4.1.3 – The Villa Fastiggi 8 flats project, COPES Consortium, Pesaro

The data about the project and the assessment of the overcost come from a common work of La Calade with Sergio Bottiglioni from Ricerca&Progetto and Pierino Mei. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Villa Fastiggi project for 8 dwellings in the AG1 building.

Source: COPES Consortium

Technical aspects of the project

The project concerns the construction of flats 8 for a built volume of 2 151 m^3, a heated volume of 2 099 m^3 and a **heated surface of 478 m^2.**

The actions in regards to the sustainability are :

Improvement of insulation:

- acoustic insulation (10 dB (A) win) at district and building scale
- windows with high insulated glass
- strong thermal inertia masonry insulation
  - external walls built with Bioton porous brick, 0.36<U<0.40
  - interior partitions with Bioton porous bricks
  - horizontal concrete roof (ventilated roof with fir boards and hip-tiles), U=0.43
  - brick and concrete floors, with floor over car boxes in concrete, U=0.44

Daylight strategies, windows and shading:

- improvement of natural light within indoor spaces
- winter solar gains, passive cooling strategies
- shading devices: brise-soleil on windows facing south, balconies on the south side

Renewable Energy: solar collector (27.2 m^2)
Heating: centralised low temperature and radiant heating system with high efficiency boiler
Ventilation and cooling: natural ventilation

Water management: rainwater harvesting for toilet flushing, car washing, private garden watering

Waste management: sorting of waste including of organic waste

Movement facilities:
- connection between inner and outer pathways
- independent walk and cycle ways

Visual Quality:
- new urban park which respects the landscape features
- light pollution control

Participation and training: participatory design process, building user manual and information/practical tips about best management strategies

Economic analysis

Construction Cost

The cost for construction only is 854 k€ and the investment cost (IC) for the project is 1 243 k€ (without tax), i.e. 2601€/m^2.

The investment overcost for building sustainable housing is assessed to 137 k€, i.e. 11 % of the IC and 287 €/m^2.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.15 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves the energy efficiency with an energy consumption of 92.9 kWh/m^2 for heating and hot water in regards to 163 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 30 to 20 kWh/m^2.

The water consumption reaches 51 m^3 per flat (0.86 m^3/m^2) compared to 74 m^3 for a traditional flat.

The operating cost is 5.6 k€ i.e. 11.7 €/m^2, in regards to 8.9 k€ (18.6 €/m^2) for a traditional building.

Fastiggi 8 flats energy consumption and operating costs

		Sustainable building	Traditional building
Heating	kWh/m²	70,9	131
Sanitary Hot Water	kWh/m²	22	32
Electricity Autoproduction	kWh/m²	0	
Heating Autoproduction	kWh/m²	7	0
Flat Electricity consumption	kWh/m²	20	30
Common Electricity consumption	kWh/m²	0,8	
Flat Water consumption	m³/m²	0,86	1,24
Common Water consumption	m³/m²	0	
Operating costs	**€/m²**	**11,6**	**18,7**
Saving	**€/m²**	**-7,1**	

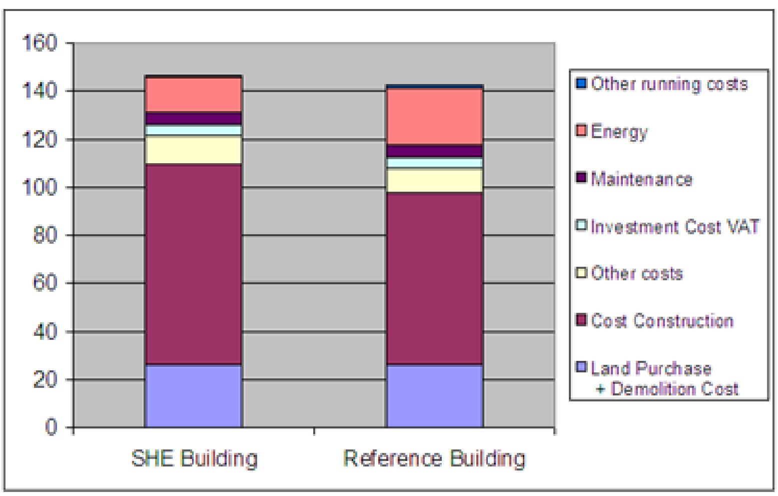
Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

The annual balance gives a benefit (or savings) of 1 914 € in favour of the reference building, i.e.239 € per flat (Direct Life Cycle Cost). The direct life-cycle cost is indeed 146.2 € /m² for the SHE building compared to 142.2 € /m² for the reference building. The increase represents 2.8 % of the cost.

Fastiggi 8 flats Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)



Source: La Calade for SHE

Fastiggi 8 flats Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	26,5	
Cost Construction	83,3	70,8
Other construction costs	11,5	10,5
VAT	4,8	4,3
Maintenance	5,2	
Energy	14,4	24,1
Other running costs	0,5	0,7
30 years DLCC	**146,2**	**142,2**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as participatory design process, light pollution control, waste sorting etc.

Net present value of externalities for Fastiggi 8 flats in € per year

	Sustainable building	Traditional building	Balance (SHE – Ref)
1 - Greenhouse gas emission	590	1 422	-832
2 – Atmospheric pollutant emission	73	119	- 46
3 – Avoided acoustic pollution	- 5 796	0	-5 796
4 – Landscape value	- 6 944	- 6 944	0
5- Time value	0	0	0
6 –Travel induced	0	0	0
Total externalities	**- 12 077**	**- 5 403**	**- 6674**
Externalities per square meter	**- 25.3**	**- 11.4**	**- 13.9**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 13.9 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Fastiggi 8 flats Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SHE)		**Traditional building (Ref)**		**Balance (SHE – Ref)**	
	€ / year	€/m² – year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	69 905	146,2	67 991	142,2	1 914	4.0
Externalities (cost)	-12 077	-25,3	-5 403	-11,4	-6 674	-13.9
OLCC Value	**57 828**	**120,9**	**62 588**	**130,8**	**-4 760**	**-9,9**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 7.6 % to the reference building one, that is to say approximately 595 € by year and by dwelling.

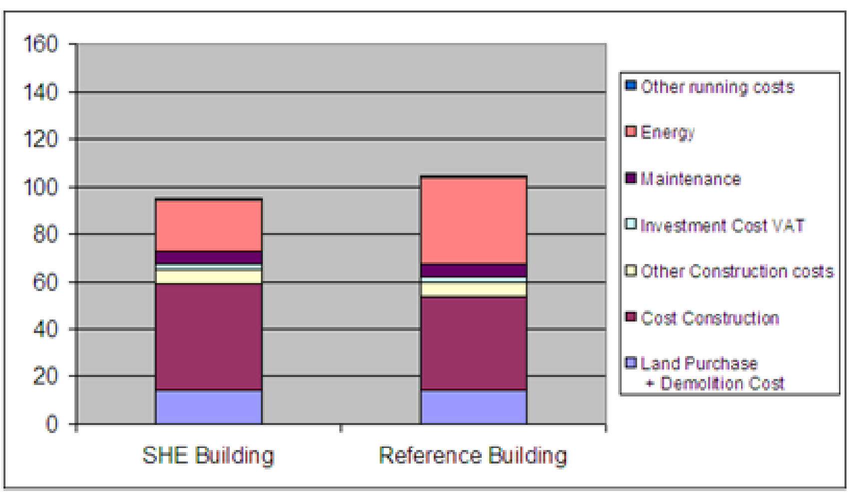
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 4 620 € in favour of the sustainable building, i.e. 577 € per flat.

The direct life-cycle costing is 95.3 € / m² for the SHE building compared to 104.9 € /m² for the reference building. The savings represent 10 % of the cost.

Fastiggi 8 flats Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)



Source: La Calade for SHE

Fastiggi 8 flats Direct Life Cycle Cost for a 60-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	14.3	
Cost Construction	44.7	39.5
Other construction costs	6.1	
VAT	2.6	2.4
Maintenance	5.2	
Energy	21.8	36.6
Other running costs	0.6	0.8
60 years DLCC	**95.3**	**104.9**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Fastiggi 8 flats in € per year

	Sustainable building (SHE)	Traditional building (Ref)	Balance SHE - Ref
1 – Greenhouse gas emission	835	1 626	-791
2 – Atmospheric pollutant emission	73	119	-46
3 – Avoided acoustic pollution	-3 111	0	-3 111
4 – Landscape value	-3 727	-3 727	0
5 – Time value	0	0	0
6 – Travel induced	0	0	0
Total externalities	**-5 930**	**-1 982**	**-3 948**
Externalities per square meter	**-12.4**	**-4.2**	**-8.2**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 8.2 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Fastiggi 8 flats Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SHE)		**Traditional building (Ref)**		**Balance SHE – Ref**	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	45 522	95,3	50 142	104,9	-4 620	-9,6
Externalities (cost)	-5 930	-12,4	-1 982	-4,2	-3 932	-8,2
OLCC Value	**39 592**	**82,9**	**48 160**	**100,7**	**-8 568**	**-17,8**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 17.7 % to the reference building one, that is to say approximately 1071 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 17.8 € by m² and by year.

Construction overcost : + 5.4 € / m² / year

Running costs savings: - 15.0 € / m² / year

Externality "savings": - 8.2 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders, without taking into account a premium for the sale on the real estate market of the flats.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

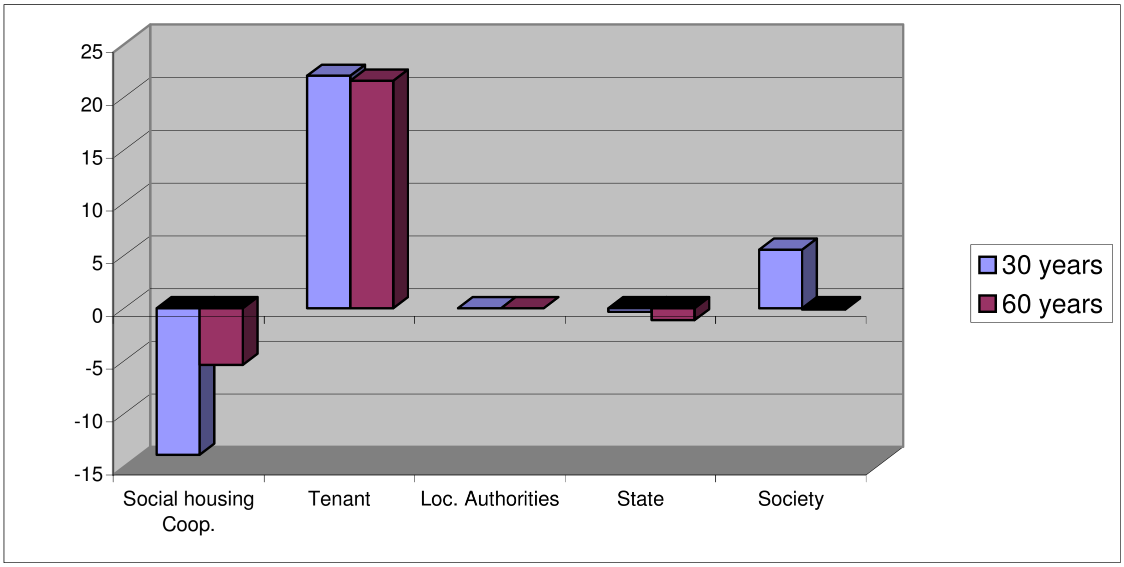
For a 30-year-calculation period, the benefits and costs between the stakeholders are allocated as following:

- a benefit for residents of 22.0 €/m²
- a benefit for Society of 5.6 € / m²
- a loss for the cooperative of 13.9 €/m² (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.4 €/m².

For a 60-year-calculation period:

- a benefit for residents of 21.5 €/m²
- a loss for Society of 0.1 € / m²
- a loss for the cooperative of 5.4 €/m² (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 1.2 €/m²

Benefits and costs for the different stakeholders (in euro/m²)
for a 30 and 60-year calculation period



Source: La Calade for SHE

This SHE project has OLCC benefits for a 30-year-calculation period as well as for a 60-year-calculation period (and DLCC benefit for the 60-year-calculation period). This is due to the efficiency of the investment overcost on the reduction of charges and on the reduction of carbon dioxide's and pollutant's emission and of sound pollution (even if the overcost is relatively important, cf. Chapter 4.2). The win of 10 dB (A) plays a central part in the increase of externalities: indeed, for each decibel under the legal threshold, there is a benefit for the sustainable building OLCC of 1% of the building investment cost. Even if the benefit of acoustic insulation was only corresponding to 0.4% (which corresponds to a Laeq of day< 60 dB (A) and a Laeq of night < 50 dB (A), cf. chapter 3.3.5), there would still be a benefit of 1 244 euro for the SHE project, which corresponds to 6.7 euro by square meter instead of 8.2 (60-year-calculation period).

4.1.4 – The Villa Fastiggi two flats project, COPES Consortium, Pesaro

The data about the project and the assessment of the overcost come from a common work of la Calade with Sergio Bottiglioni from Ricerca&Progetto and Pierino Mei. The data from energy and water consumption come from the SHE simulation.

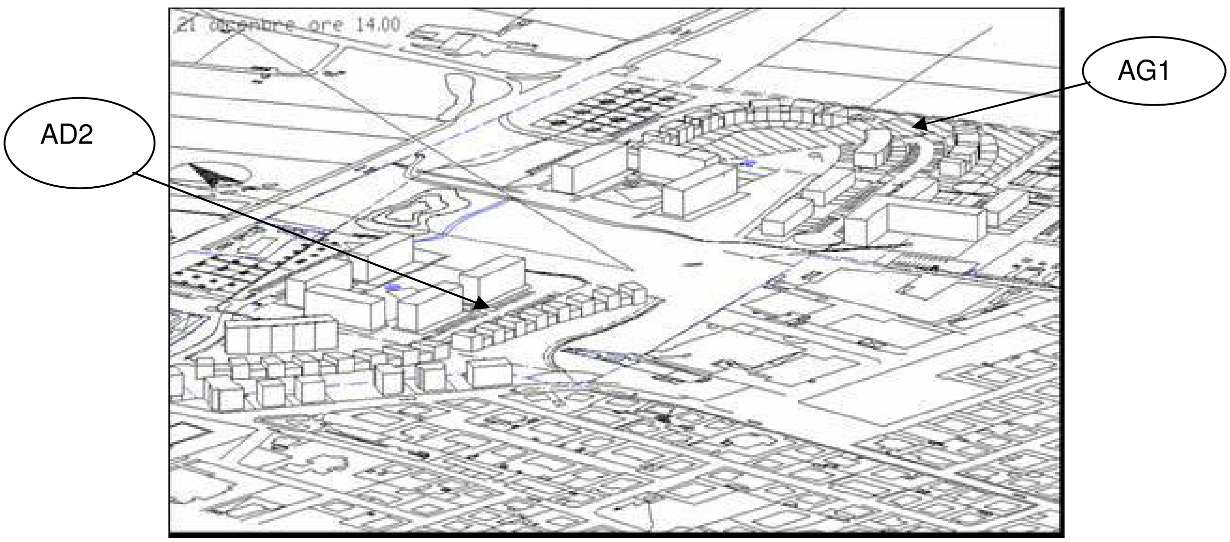
The objective is to assess the overall life cycle costing (OLCC) of the Villa Fastiggi two flats project of the building AD2.

<u>Technical aspects of the project</u>

The project concerns the construction of 2 flats for a built volume of 635 m^3, a heated volume of 550 m^3 and a **heated surface of 141 m^2.**

The project is located in the building AD2, whereas the Fastiggi 8 flats project is located in the building AG1:

Locations of AD2 and AG1 buildings (respectively Fastiggi 2 and 8 flats projects)



Source: COPES

The detail of actions in regards to the sustainability are described in the previous chapter (4.1.4.)

Economic analysis

Construction Cost

The cost only for construction (without the purchase land and the technical studies) is 225 k€ and the investment cost (IC) for the project is 330 k€ (without tax), i.e. 2 341 €/m^2.

The investment overcost for building SHE project instead of a traditional building is assessed to 16 k€, i.e. 5 % of the IC. The investment overcost is 115 €/m^2.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.17 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves the energy efficiency with an energy consumption of 90.3 kWh/m^2 for heating and hot water in regards to 176 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 30 to 20 kWh/m^2.

The water consumption reaches 51 m^3 per flat (0.73 m^3/m^2) compared to 74 m^3 for a traditional flat.

The operating cost is 1559 € i.e. 11.1 €/m^2, in regards to 2667 € (18.9 €/m^2) for a traditional building.

Fastiggi 2 flats energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	68.3	144
Sanitary Hot Water	kWh/m^2	22	32
Electricity Autoproduction	kWh/m^2	0	
Heating Autoproduction	kWh/m^2	9	0
Flat Electricity consumption	kWh/m^2	20	30
Common Electricity consumption	kWh/m^2	0	
Flat Water consumption	m^3/m^2	0.73	1.05
Common Water consumption	m^3/m^2	0	
Operating costs	**€/m^2**	**11.1**	**18.9**
Saving	**€/m^2**	**-7.8**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

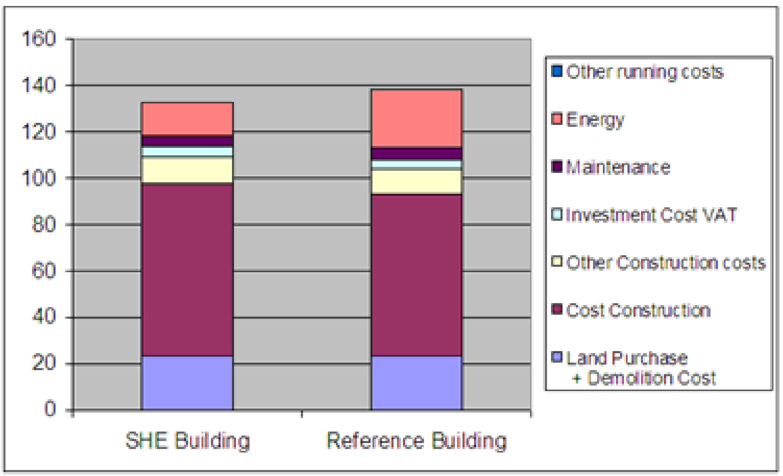
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 821 € in favour of the sustainable building, i.e. 410 € per flat (Direct Life Cycle Cost).

The direct life cycle cost is indeed 132.7€ / m^2 for the SHE building compared to 138.6€ /m^2 for the reference building. The savings represent 5.0 % of the cost.

Fastiggi 2 flats Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)



Source : La Calade for SHE

Fastiggi 2 flats Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	23.3	
Cost Construction	74.4	70.0
Other construction costs	11.3	10.4
VAT	4.4	4.1
Maintenance	5.0	
Energy	13.9	25.2
Other running costs	0.4	0.6
30 years DLCC	**132.7**	**138.6**

Source : La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as participatory design process, light pollution control, waste sorting etc.

Net present value of externalities for Fastiggi 2 flats project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	171	437	- 266
2 – Atmospheric pollutant emission	21	36	- 15
3 – Avoided acoustic pollution	- 1 539	0	- 1 539
4 – Landscape value	- 1 843	- 1 843	0
5- Time value	0	0	0
6 –Travel induced	0	0	0
Total externalities	**- 3 190**	**- 1 370**	**- 1 820**
Externalities per square meter	**- 22.7**	**- 9.8**	**- 12.9**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 12.9 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Fastiggi 2 flats Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 – year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	18 724	132.7	19 545	138.6	- 821	- 5.9
Externalities (cost)	-3 190	- 22.7	-1 370	- 9.8	- 1 820	- 12.9
OLCC Value	**15 534**	**110.0**	**18 175**	**128.8**	**- 2 641**	**- 18.8**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 14.6 % to the reference building one, that is to say approximately 1 320 € by year and by dwelling.

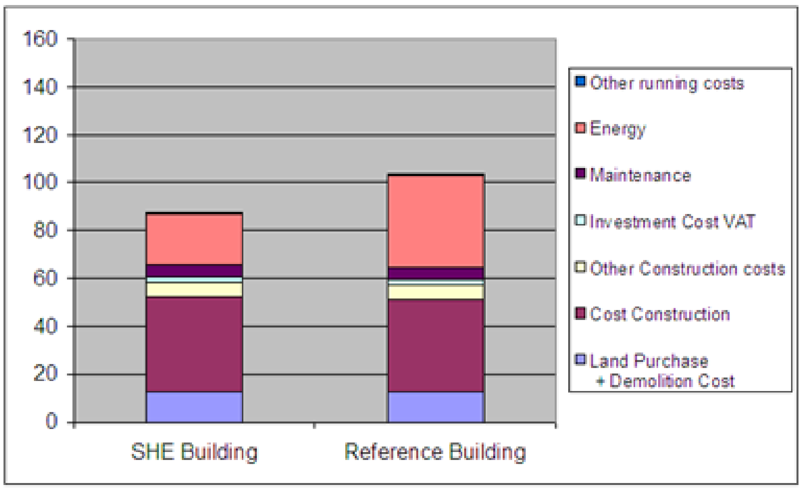
Analysis for a 60-year-calculation period

The 60-year-calculation period correspond to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 2 305 € in favour of the sustainable building, i.e. 1 152 € per flat.

The direct life-cycle costing is 87.4 € / m^2 for the SHE building compared to 103.7 € /m^2 for the reference building. The savings represent 15.8% of the cost.

Fastiggi 2 flats Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Fastiggi 2 flats Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	12.5	
Cost Construction	39.9	38.8
Other construction costs	6.1	
VAT	2.3	2.3
Maintenance	5.0	
Energy	21.1	38.3
Other running costs	0.5	0.7
60 years DLCC	**87.4**	**103.7**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Fastiggi 2 flats project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	239	500	- 261
2 – Atmospheric pollutant emission	21	36	- 15
3 – Avoided acoustic pollution	- 826	0	- 826
4 – Landscape value	- 989	- 989	0
5 – Time value	0	0	0
6 – Travel induced	0	0	0
Total externalities	**- 1 555**	**- 453**	**- 1 102**
Externalities per square meter	**- 11.1**	**- 3.3**	**- 7.8**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 7,8 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Fastiggi 2 flats Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	12 321	87.4	14 626	103.7	- 2 305	- 16.3
Externalities (cost)	- 1 555	- 11.1	- 463	- 3.3	- 1 097	- 7.8
OLCC Value	**10 766**	**76.3**	**14 163**	**100.4**	**- 3 397**	**- 24.1**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 24 % to the reference building one, that is to say approximately 1 700 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 24.1 € by m² and by year.

Construction overcost : + 1.1 € / m² / year

Running costs savings: - 17.4 € / m² / year

Externality "savings": - 7.8 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

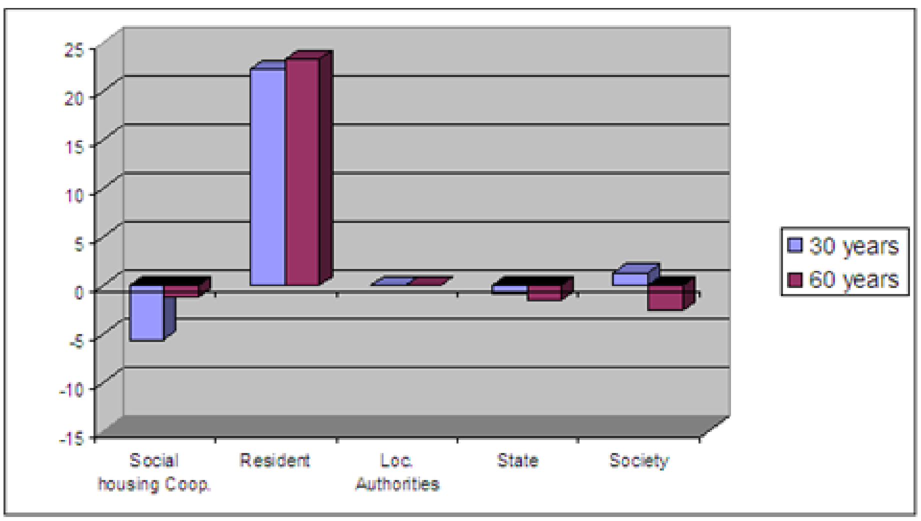
For a 30-year-calculation period, the benefits and costs are shared between stakeholders as following:

- a benefit for residents of 22.3 €/m^2
- a benefit for Society of 1.3 € / m^2
- a loss for the cooperative of 5.6 €/m^2 (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.8 €/m^2.

For a 60-year-calculation period:

- a benefit for residents of 23.3 €/m^2
- a loss for Society of 2.6 € / m^2
- a loss for the cooperative of 1.1 €/m^2 (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 1.5 €/m^2.

Fastiggi 2 flats benefits and costs for the different stakeholders (in euro/m^2) for a 30 and 60-year-calculation period



Source: La Calade for SHE

The SHE project has OLCC and DLCC benefits, for a 30-year-calculation period as well as for a 60-year-calculation period.

4.1.5 – The Ozzano project, COPALC Consortium, Bologna

The data about the project and the assessment of the overcost come from a common work of La Calade with Stefano Matteuci. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Ozzano project.



Source: COPALC Consortium

Technical aspects of the project

The project concerns the construction of 12 flats for a built volume of 5068 m^3, a heated volume of 3498 m^3 and a **heated surface of 875 m^2.**

The actions in regards to the sustainability are:

Improvement of insulation:

- acoustic insulation (5 dB (A) avoided in comparison with the region regulation) including improvement of the insulation between dwellings

- strong thermal insulation masonry:

  - wall built with cellular bricks, natural hydraulic lime with an high thermal and acoustic insulation (λ = 0,066)
  - baked clay roof (natural ventilation) and improvement of insulation of not used attic
  - improvement of insulation on ground floors: hydraulic lime, clay and insulation material

Daylight strategies, windows and shading : solar shielding

Renewable Energy : photovoltaic and thermal solar system

Heating : centralized and radiant heating system with high efficiency boiler

Electricity saving: low consumption lighting system, reduction of the light pollution from public lighting

Ventilation and cooling : natural ventilation with control

Building materials :

- natural materials for the structure : natural hydraulic lime, clay, clay brick stemming from an energy efficient process with $\lambda = 0,15$.
- natural hydraulic lime

The objectives are :

- to use at least 10 % of recycling materials, 10 % of recycled materials and 60 % of natural materials;
- to reduce energy used to extract and carry the building materials;
- to use at least 60 % of local products.

Water management:

- individual consumption meters; reduction of the water pressure, use of taps reducing the flow
- reuse and recycle water system: use of locally cleansed water and rain water : toilets, garden watering

Waste management :

- reduction of the building site waste
- reuse or recycling of the maximum quantity of building site waste
- support to the selective collect of household waste (separated collection in the dwellings of paper, organic, glass, dangerous, plastic)
- contribution to the production of local compost

Other comfort and health features: reduction of the electric and electromagnetic fields

<u>Economic analysis</u>

Construction Cost

The cost only for construction (without the purchase land and the technical studies) is 1 792 k€ and the investment cost (IC) for the project is 2434 k€ (without tax), i.e. 2 782 €/m^2.

The investment overcost for building SHE project instead of a traditional building is assessed to 176 k€, i.e. 7.8 % of the Investment Cost and 202 €/m^2.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.14 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves the energy efficiency with an energy consumption of 84.1 kWh/m^2 for heating and hot water, in regards to 168 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 40 to 33 kWh/m^2.

The water consumption reaches 42 m^3 per flat (0.57 m^3/m^2) compared to 79 m^3 for a traditional flat.

The operating cost is 13 k€ i.e. 14.5 €/m^2, in regards to 18 k€ (21 €/m^2) for a traditional building.

Ozzano energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	76	135
Sanitary Hot Water	kWh/m^2	8	33
Electricity Autoproduction	kWh/m^2	1.6	0
Heating Autoproduction	kWh/m^2	11	0
Flat Electricity consumption	kWh/m^2	33	40
Common Electricity consumption	kWh/m^2	9.7	7.4
Flat Water consumption	m^3/m^2	0.6	1.1
Common Water consumption	m^3/m^2	0	0.1
Operating costs	**€/m^2**	**14.5**	**21.0**
Saving on operating cost	**€/m^2**	**- 6.5**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

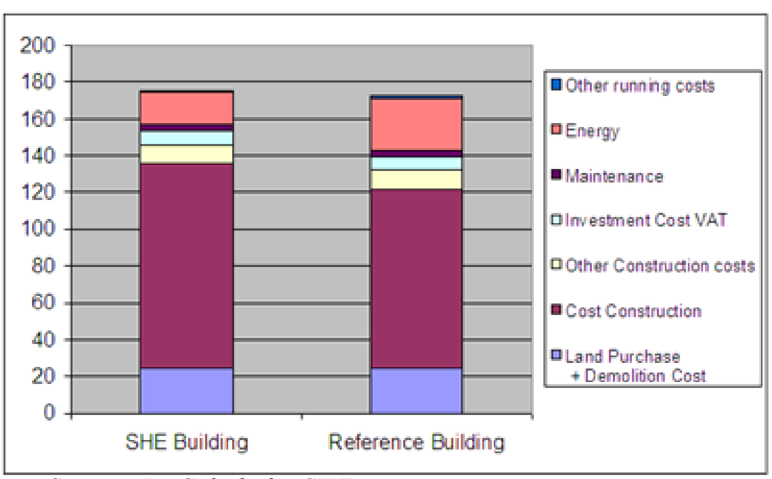
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 2 368 € in favour of the reference building, i.e. 197 € per flat (Direct Life Cycle Cost).

The direct life cycle costing is indeed 175.5€ / m^2 for the SHE building compared to 172.7 € /m^2 for the reference building. The overcost for the SHE building represents 1.6 % of the cost.

Ozzano Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Ozzano Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	24.1	
Cost Construction	111.6	97.4
Other construction costs	10.2	11.1
VAT	7.5	6.5
Maintenance	4.0	
Energy	17.4	28.2
Other running costs	0.7	1.4
30 years DLCC	**175.5**	**172.7**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as light pollution reduction (linked to external lighting), reduction of electrical and electromagnetism fields, use of natural and recyclable materials produced by high efficiency process, the use of local materials (thus reducing the energy consumed by transport) etc.

Net present value of externalities for Ozzano project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	2 002	3 055	- 1 053
2 – Atmospheric pollutant emission	198	273	- 75
3 – Avoided acoustic pollution	- 5 674	0	- 5 674
4 – Landscape value	- 12 085	- 12 085	0
5- Time value	- 306	- 306	0
6 –Travel induced	- 58	- 58	0
Total externalities	**- 15 923**	**- 9 121**	**- 6 802**
Externalities per square meter	**- 18.3**	**-10.6**	**- 7.7**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 7,7 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Ozzano Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		**Traditional building (TB)**		**Balance (SB – TB)**	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	153 444	175.5	151 076	172.7	2 368	2.8
Externalities (cost)	- 15 923	- 18.3	- 9 121	- 10.6	- 6 802	- 7.7
OLCC Value	**137 521**	**157.2**	**141 955**	**162.1**	**- 4 434**	**- 4,9**

Source: La Calade for SHE

The SHE project OLCC is inferior by 3,1 % to the reference building one, that is to say 370 € by dwelling and by year.

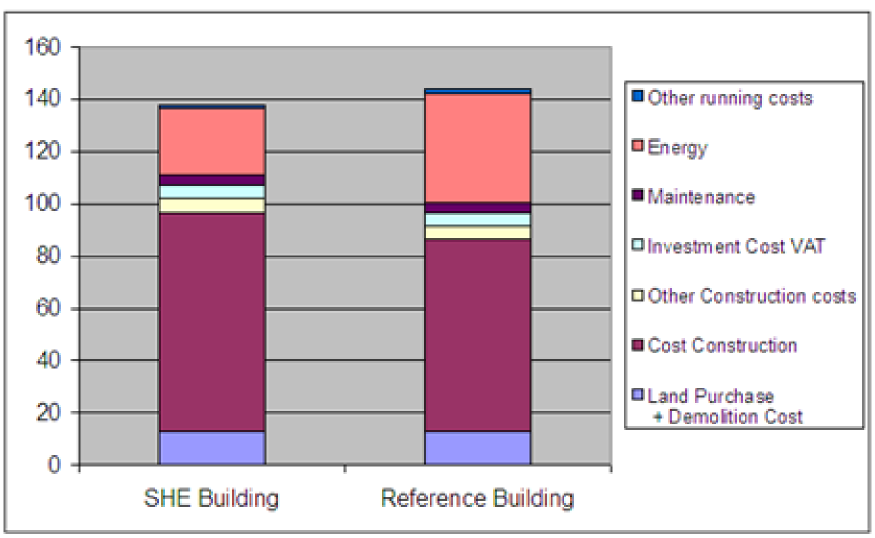
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 5 621 € in favour of the sustainable building, i.e. 468 € per flat and per year.

The direct life-cycle costing is 137.5 € / m² for the SHE building compared to 143.9 € /m² for the reference building. The savings represent 4.7% of the cost.

Ozzano Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)



Source: La Calade for SHE

Ozzano Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	12.9	
Cost Construction	83.5	73.3
Other construction costs	5.5	
VAT	5.2	4.5
Maintenance	4.0	
Energy	25.5	42.1
Other running costs	0.9	1.6
60 years DLCC	**137.5**	**143.9**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Ozzano project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	2 290	3 495	- 1 205
2 – Atmospheric pollutant emission	198	273	-75
3 – Avoided acoustic pollution	- 3 045	0	- 3 045
4 – Landscape value	- 6 486	- 6 486	0
5 – Time value	- 306	- 306	0
6 – Travel induced	- 58	- 58	0
Total externalities	**- 7 407**	**- 3 082**	**- 4 325**
Externalities per square meter	**- 8.6**	**- 3.7**	**- 4.9**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 4.9 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Ozzano Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	120 237	137.5	125 858	143.9	- 5 621	- 6.4
Externalities (cost)	- 7 407	- 8.6	- 3 082	- 3.7	- 4 325	- 4.9
OLCC Value	**112 830**	**128.9**	**122 776**	**140.2**	**- 9 946**	**- 11.3**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 8.1 % to the reference building one, that is to say approximately 830 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 11.3 € by m² and by year.

Construction overcost: + 10.9 € / m² / year

Running costs savings: - 17.3 € / m² / year

Externality "savings": - 4.9 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

An additional question is the sale price of the different flats to households. There are some difficulties to include the overcost of the sustainable building except if the market is receptive to ecological issues. In the Ozzano case, the SHE flats have already been sold and we can have the real value on the market. There was a surprise as the sustainable flats have been sold with a bonus of 12 %.

In this balance, we include the benefits or the losses for the different stakeholders. We also include the benefit for the construction industry related to a higher activity in the construction process.

For a 30-year-calculation period, the benefits and costs are shared between stakeholders as following :

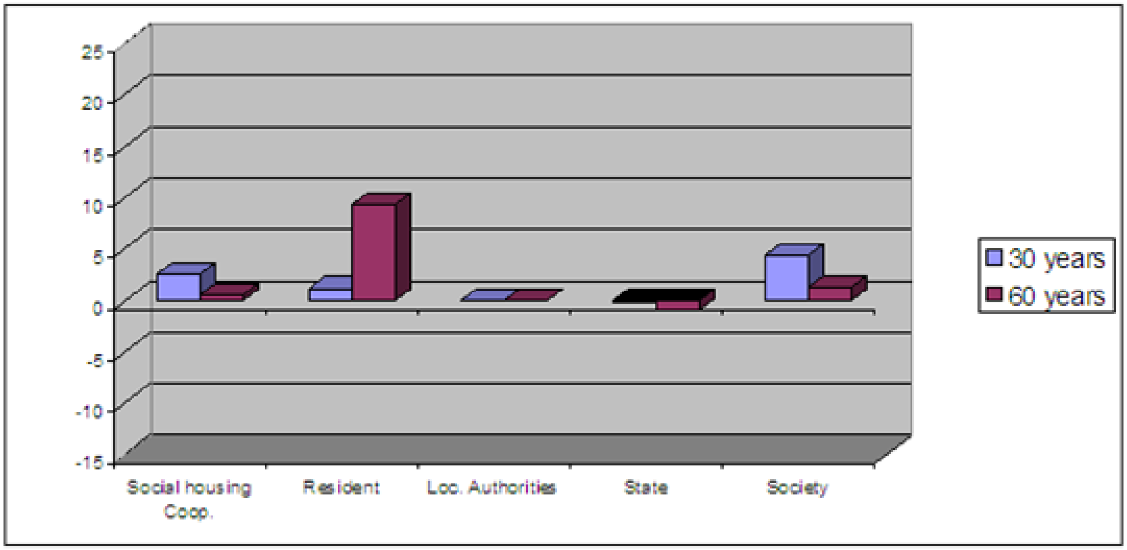
- a benefit for residents of 1.2 €/m^2
- a benefit for Society of 4.4 € / m^2
- a benefit for the cooperative of 2.6 €/m^2 (which depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.1 €/m^2.

For a 60-year-calculation period:

- a benefit for residents of 9.3 €/m^2
- a benefit for Society of 1.3 € / m^2
- a benefit for the cooperative of 0.6 €/m^2 (which depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.9 €/m^2.

The project provides on the long term an important benefit for the resident. The operation is balanced for the cooperative which has been able to include the overcost in the sale price. The operation is also profitable for the society thanks to the reduction of the greenhouse effect gas emissions and to additional construction activity

Ozzano benefits and costs for the different stakeholders (in euro/m²) for a 30 and 60-year calculation period

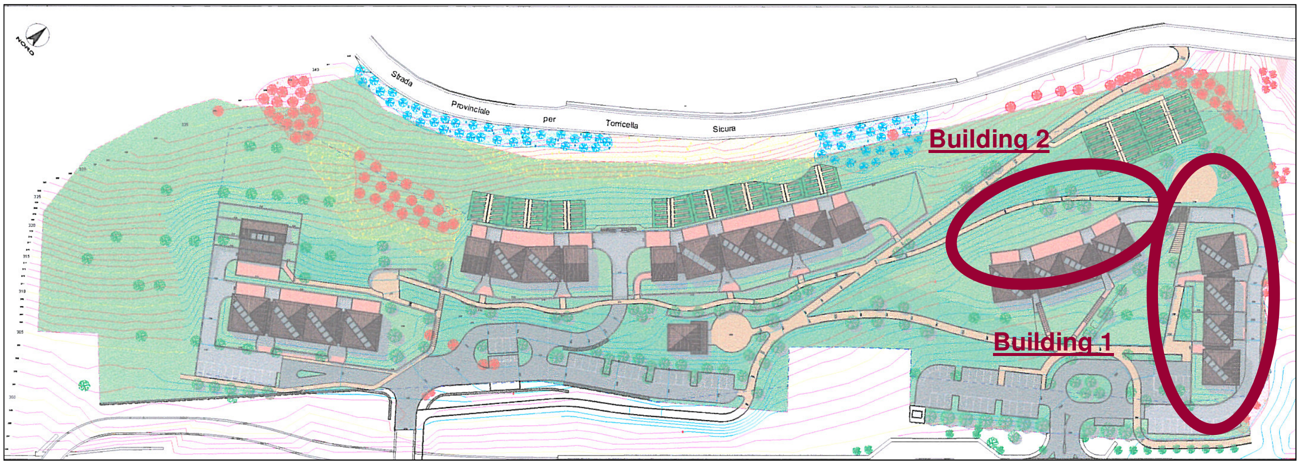


Source: La Calade for SHE

4.1.6 – The Teramo project, CCICASA Consortium, Teramo

The data about the project and the assessment of the overcost come from a common work of La Calade with Barbara Bonadies (Italian National Institute of Bioarchitecture) and Corrado De Luliis. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Teramo project.



Technical aspects for the project

The project concerns the construction of 12 flats for a built volume of 4 637 m^3, a heated volume of 3 000 m^3 and a **heated surface of 971 m^2.**

The actions in regards to the sustainability are :

Improvement of the microclimate

Improvement of insulation :

- acoustic insulation (5 dB (A) win)
- strong thermal inertia masonry built:
    - bearing walls in wood cement and concrete; insulation with 31 cm Isotex; U = 0.40
    - roofs in concrete and bricks ; U = 0.37
    - floor over carboxes in wood cement and concrete ; U = 0.36 ; Insulation floor with 42 cm Isotex
    - Interior partitions insulated with 31 cm Isotex and 15 cm porous bricks

Daylight strategies, windows and shading:

- optimisation of day light components within indoor spaces
- winter solar gains, passive cooling strategies and shading devices

Renewable Energy:

- photovoltaic panels
- thermal solar system : 26 m² solar collectors

Heating: centralized and radiant heating system with high efficiency boiler

Electricity saving: low consumption lighting system (efficient HF ballasts and lamps), reduction of installed power

Ventilation and cooling: natural and night ventilation

Use of improved controls: temperature modulation

Building materials: environmental friendly materials

Water management:

- reuse and recycle water system
- minimum of metalled areas

Waste management: areas for common composting, and waste sorting

Movement facilities: bicycle and footpaths

Other comfort and health features: reduction of electric and electromagnetic fields

Visual Quality: constitution of a natural wooded park for the development and the city

Participation and training: building user manual and information/practical tips about best management strategies

Economic analysis

Construction Cost

The cost only for construction (without the purchase land and the technical studies) is 1 731 k€ and the investment cost (IC) for the project is 1 907 k€ (without tax), i.e. 1963 €/m^2.

The investment overcost for building SHE project instead of a traditional building is assessed to 174 k€, i.e. 10 % of the Investment Cost and 178.5 €/m^2.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.2 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves the energy efficiency with an energy consumption of 61 kWh/m^2 for heating and hot water in regards to 95 kWh/m^2 in a traditional new building. **We have no data regarding electricity and water consumptions.**

The operating cost is 4 146 k€ i.e. 4.3 €/m^2, in regards to 6 457 k€ (6.7 €/m^2) for a traditional building.

Teramo energy consumption and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	43	65
Sanitary Hot Water	kWh/m^2	18	30
Electricity Autoproduction	kWh/m^2	0	
Heating Autoproduction	kWh/m^2	15	0
Flat Electricity consumption	kWh/m^2	NA	
Common Electricity consumption	kWh/m^2	NA	
Flat Water consumption	m^3/m^2	NA	
Common Water consumption	m^3/m^2	NA	
Operating costs	**€/m^2**	**4.3**	**6.7**
Saving on operating cost	**€/m^2**	**- 2.4**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water.

Analysis for a 30-year-calculation period

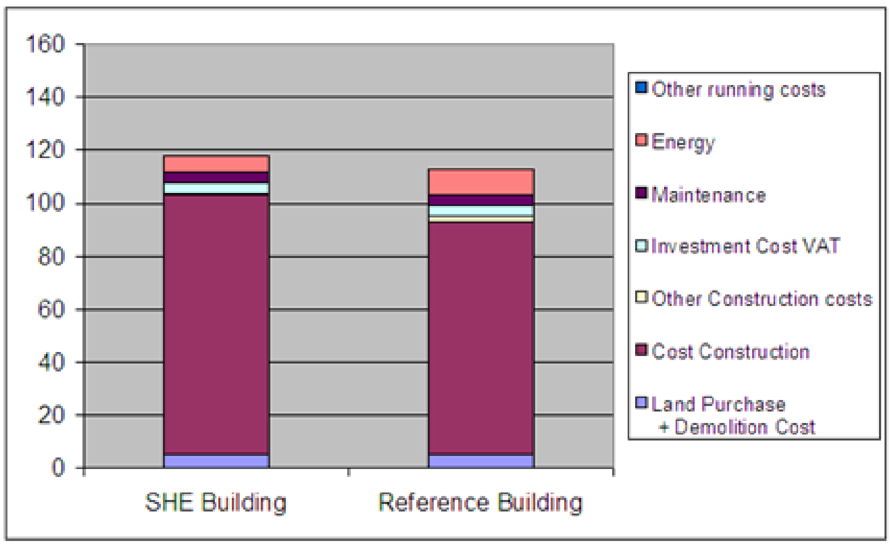
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 5 098 € in favour of the reference building, i.e. 425 € per flat (Direct Life Cycle Cost).

The direct life-cycle cost is indeed 118.2 € / m^2 for the SHE building compared to 113 € /m^2 for the reference building. The overcost for the SHE building represents 4.4 % of the cost.

Teramo Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Teramo Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	5.2	
Cost Construction	98.3	87.9
Other construction costs	0.2	2.2
VAT	4.1	3.9
Maintenance	4.0	
Energy	6.4	10.0
Other running costs	0.0	
30 years DLCC	**118.2**	**113.0**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brougt by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given, such as reduction of electric and electromagnetic fields, use of natural and recyclable materials, waste management, footpaths and bicycle ways …

Net present value of externalities for Teramo project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	- 335	1 176	- 1 511
2 – Atmospheric pollutant emission	48	75	- 27
3 – Avoided acoustic pollution	- 4 444	0	- 4 444
4 – Landscape value	- 10 647	- 10 647	0
5- Time value	0	0	0
6 –Travel induced	0	0	0
Total externalities	**- 15 377**	**- 9 396**	**- 5 982**
Externalities per square meter	**- 15.8**	**- 9.7**	**- 6.1**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 6.1 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Teramo Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	114 857	118.2	109 759	113.0	5 098	5.2
Externalities (cost)	- 15 377	- 15.8	- 9 396	- 9.7	- 5 981	- 6.1
OLCC Value	**99 480**	**102.4**	**100 364**	**103.3**	**- 883**	**- 0.9**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 0,9 % to the reference building one, that is to say approximately 74 € by year and by dwelling.

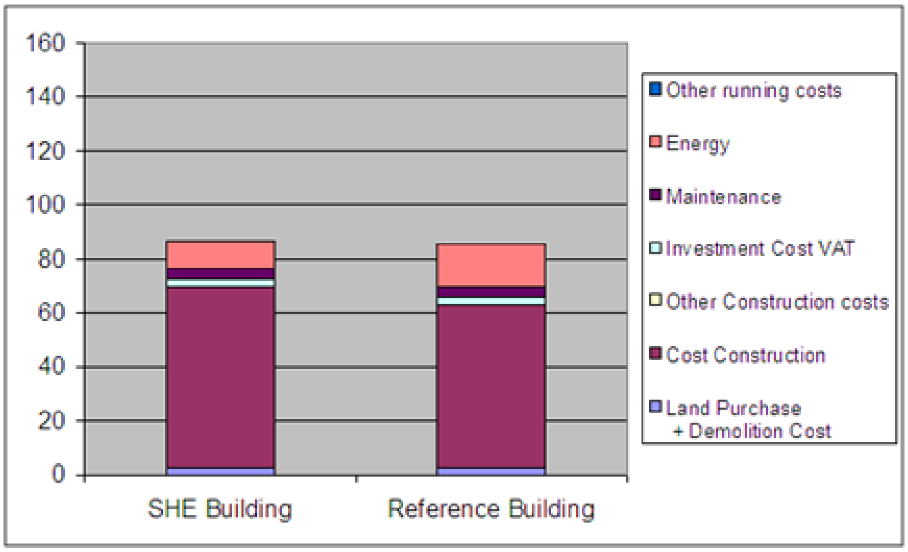
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 973 € in favour of the reference building, i.e. 81 € per flat.

The direct life-cycle costing is 86.6 € / m^2 for the SHE building compared to 85.6 € /m^2 for the reference building. The overcost of the SHE building represents 1.2% of the cost.

Teramo Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Teramo Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)

	SHE Building	**Traditional Building**
Ground cost	2.8	
Cost Construction	66.7	60.3
Other construction costs	0.1	
VAT	2.8	2.5
Maintenance	4.0	
Energy	10.2	15.9
Other running costs	0.0	
60 years DLCC	**86.6**	**85.6**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Teramo project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	279	1 346	- 1 067
2 – Atmospheric pollutant emission	48	75	- 27
3 – Avoided acoustic pollution	- 2 385	0	- 2 385
4 – Landscape value	- 5 714	- 5 714	0
5 – Time value	0	0	0
6 – Travel induced	0	0	0
Total externalities	**- 7 772**	**- 4 294**	**- 3479**
Externalities per square meter	**- 8.0**	**- 4.4**	**- 3.6**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 3.6 € / m² in comparison with the reference building.

Overall Life-cycle costing

The overall life cycle costing is the sum of direct cost and externalities.

Teramo Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	84 095	86,6	83 122	85,6	973	1,0
Externalities (cost)	- 7 772	- 8.0	- 4 294	- 4.4	- 3 478	- 3.6
OLCC Value	**76 323**	**78.6**	**78 828**	**81.2**	**- 2 505**	**- 2.6**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 3.2 % to the reference building one, that is to say approximately 210 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 2.6 € by m² and by year.

Construction overcost : + 6.7 € / m² / year

Running costs savings: - 3.7 € / m² / year

Externality "savings": - 5.6 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

We don't suppose that a sustainable building can benefit from a sale price bonus as for the other SHE projects except Ozzano whose flats have finally been sold with a premium of 12%.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

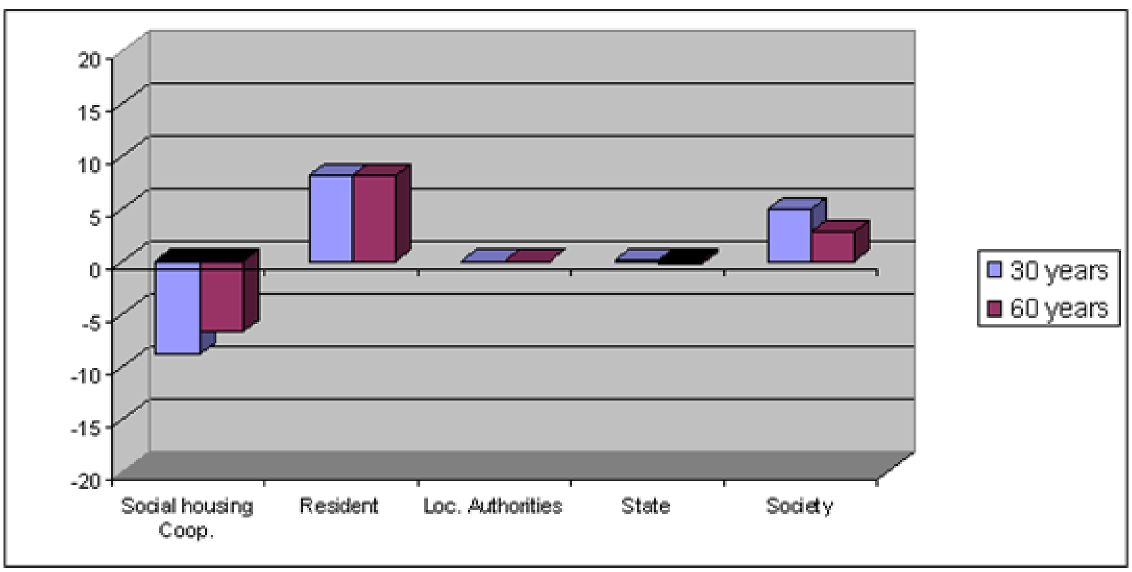
For a 30-year-calculation period, the benefits and costs are allocated between the stakeholders as following:

- a benefit for residents of 8.15 €/m^2
- a benefit for Society of 4.85 € / m^2
- a loss for the cooperative of 8.82 €/m^2 (depends on the real market price of sustainable constructions)
- a benefit for national authorities (State) of 0.01 €/m^2.

For a 60-year-calculation period:

- a benefit for residents of 8.14 €/m^2
- a benefit for Society of 2.79 € / m^2
- a loss for the cooperative of 6.69 €/m^2 (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.26 €/m^2

Teramo benefits and costs for the different stakeholders (in euro/m^2) for a 30 and 60-year calculation period



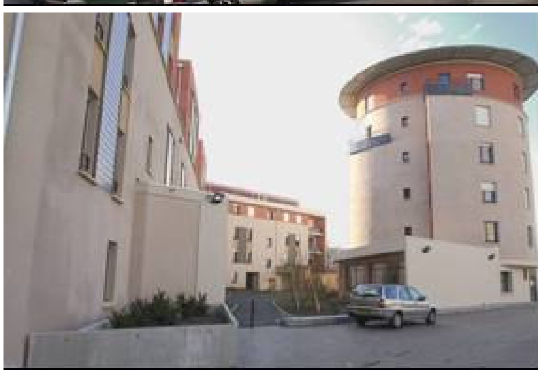
Source: La Calade for SHE

The SHE project has OLCC benefits, for a 30-year-calculation period as well as for a 60-year-calculation period, but DLCC loss. This could be linked to the lack of data on electricity and water consumption, which result in a operating cost saving of only 2.4.euro per square meter of living area, the smallest saving of all the SHE projects (cf. chapter 4.2.).

4.1.7 – The Bourgoin-Jallieu Project, OPAC 38, Grenoble (F)

The data about the project and the assessment of the overcost come from a common work of La Calade with Benoit Jehl and Michel Gilbert. The data from energy and water consumption come from the SHE simulation. However, all results are under the single liability of the author.

The objective is to assess the overall life cycle costing (OLCC) of the Bourgoin Jallieu project.



Source: OPAC 38

Technical aspects of the project

The project concerns the construction of 61 flats for an **usable area of 3 600 m^2.**

The actions in regards to the sustainability are :

Improvement of insulation: strong thermal inertia masonry

Daylight strategies, windows and shading:

- creation of sunspaces in dwellings for passive solar energy
- natural lighting for dwellings/common areas

Renewable Energy: 60m^2 thermal solar panels and 20m^2 photovoltaic panels

Heating: central natural gas heating for heating and hot water with high energy and environmental efficiency boiler

Electricity saving: saving systems for private and public areas: TV sockets switch, low consumption bulb, sensor lighting in common areas etc.

Ventilation and cooling: controlled ventilation

Building materials:

- low embedded energy
- wood joinery

- paint “NF Environment” (French environmental labeling)

Water management:
- water saving systems: double flow flush 3/6 litre, flow reducer and roof rainwater collector
- individual meters
- sustainable drainage

Waste management:
- control of the working waste and selective refuse process
- taking into account the local selective household’s refuse

Movement facilities: cycle storage facilities

Visual Quality: harmonious relation between the buildings and its surroundings

Construction Cost

The investment cost (IC) for the project is 4418 k€ (without tax), i.e. 1227 €/m^2 of usable area.

The investment overcost for building SHE project instead of a traditional building is assessed to 483 k€, i.e. 12.2 % of the Investment Cost and 134 €/m^2.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.5 % of the investment cost.

The operating cost includes essentially energy and water costs. The project improves the energy efficiency with an energy consumption of 83 kWh/m^2 for heating and hot water in regards to 162 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 31.3 to 25 kWh/m^2.

The water consumption reaches 87 m^3 per flat (1.6 m^3/m^2) compared to 94 m^3 for a traditional flat.

The operating cost is 44.2 k€ i.e. 13.3 €/m^2, in regards to 69.5 k€ (20.9 €/m^2) for a traditional building.

Bourgoin Jallieu energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	61	123,3
Sanitary Hot Water	kWh/m^2	22	39
Electricity Autoproduction	kWh/m^2	0,7	0
Heating Autoproduction	kWh/m^2	6,7	0
Flat Electricity consumption	kWh/m^2	25	31
Common Electricity consumption	kWh/m^2	4,8	14,5
Flat Water consumption	m^3/m^2	1,6	1,9
Common Water consumption	m^3/m^2	0	
Operating costs	**€/m^2**	**13,3**	**20,9**
Saving	**€/m^2**	**-7,6**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 1 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

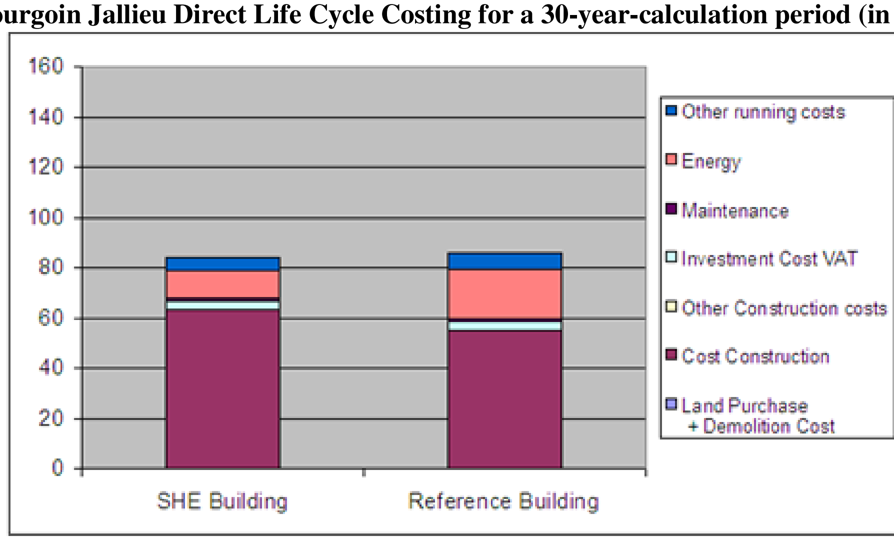
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 5 944 € in favour of the sustainable building, i.e. 97 € per flat (Direct Life Cycle Cost).

The direct life-cycle cost is indeed 84.2 € / m^2 for the SHE building compared to 85.9 € /m^2 for the reference building. The savings represent 2 % of the cost.

Bourgoin Jallieu Direct Life Cycle Costing for a 30-year-calculation period (in €/m^2)



Source: La Calade for SHE

Bourgoin Jallieu Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	0.0	
Cost Construction	63.2	55.4
Other construction costs	0.0	
VAT	3.5	3.1
Maintenance	1.5	
Energy	10.6	19.4
Other running costs	5.4	6.5
30 years DLCC	**84.2**	**85.9**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brougt by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as cycle storage facilities, low embedded energy building materials, sustainable drainage etc.

Net present value of externalities for Bourgoin Jallieu project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	3 778	7 247	- 3 469
2 – Atmospheric pollutant emission	307	565	- 258
3 – Avoided acoustic pollution	0	0	0
4 – Landscape value	0	0	0
5- Time value	- 17 808	- 17 808	0
6 –Travel induced	- 2 649	- 2 649	0
Total externalities	**- 16 372**	**- 12 645**	**- 3 727**
Externalities per square meter of usable area	**- 4.5**	**- 3.5**	**- 1.0**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 1.0 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Bourgoin Jallieu Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	303 147	84.2	309 091	85.9	- 5 944	- 1.7
Externalities (cost)	- 16 372	- 4.5	- 12 645	-3.5	- 3 727	- 1.0
OLCC Value	**286 775**	**79.7**	**296 446**	**82.3**	**- 9 671**	**- 2.7**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 3.2 % to the reference building one, that is to say approximately 158 € by year and by dwelling.

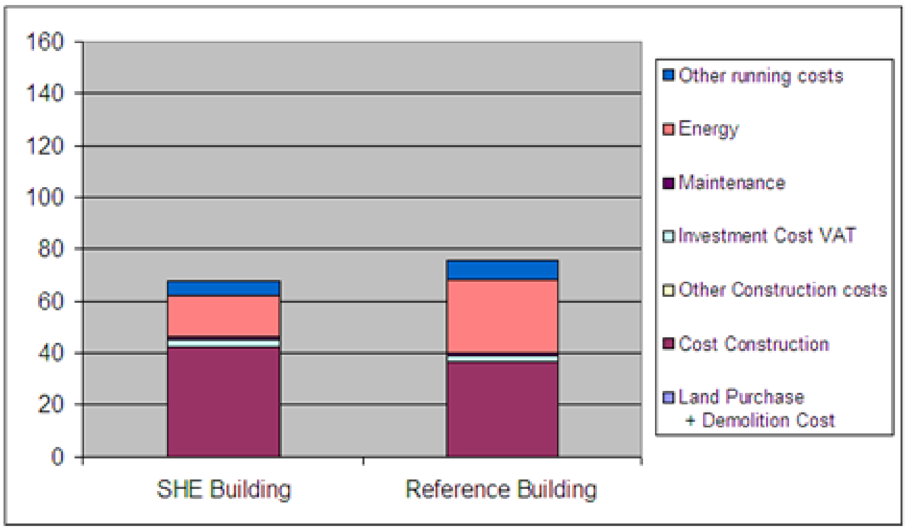
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 28 789 € in favour of the sustainable building, i.e. 472 € per flat.

The direct life cycle costing is 67.5 € / m^2 for the SHE building compared to 75.4 € /m^2 for the reference building. The savings represent 11,2 % of the cost.

Bourgoin Jallieu Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Bourgoin Jallieu Direct Life Cycle Costing for a 60-year-calculation period (in euro/m^2)

	SHE Building	Traditional Building
Ground cost	0	
Cost Construction	42.2	36.3
Other construction costs	0	
VAT	2.3	2.0
Maintenance	1.5	
Energy	15.4	28.5
Other running costs	6.1	7.1
60 years DLCC	**67.5**	**75.4**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Bourgoin Jallieu project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	4 303	8 272	- 3 969
2 – Atmospheric pollutant emission	307	565	- 258
3 – Avoided acoustic pollution	0	0	0
4 – Landscape value	0	0	0
5 – Time value	- 17 808	- 17 808	0
6 – Travel induced	- 2 649	- 2 649	0
Total externalities	**- 15 847**	**- 11 620**	**- 4 227**
Externalities per square meter of usable area	**- 4.4**	**- 3.2**	**- 1.2**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 1.1 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Bourgoin Jallieu Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	242 749	67.5	271 538	75.4	- 28 789	- 7.9
Externalities (cost)	- 15 847	- 4.4	- 11 620	- 3.3	- 4 227	- 1.1
OLCC Value	**226 901**	**63.1**	**259 918**	**72.1**	**-33 017**	**- 9.0**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 12.5 % to the reference building one, that is to say approximately 541 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 9.0 € by m² and by year.

Construction overcost : + 6.2 € / m² / year

Running costs savings: - 14.1 € / m² / year

Externality "savings": - 1.1 € / m² / year

<u>Benefits and costs for the different stakeholders</u>

The overall life cycle costing has been shared between the different stakeholders.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process. Moreover, we include the raise of the rent of 1% which benefits the social owner.

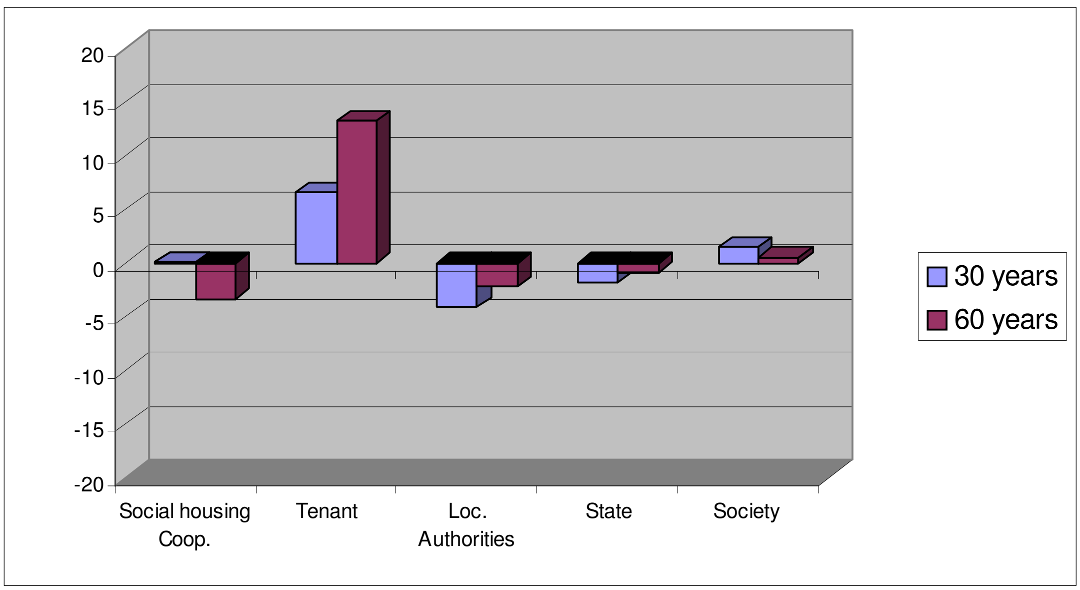
For a 30-year-calculation period, the benefits and costs are shared between the stakeholders as following:

- a benefit for residents of 6.73 €/m²
- a benefit for Society of 1.49 € / m²
- a benefit for the cooperative of 0.06 €/m² (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 1.83 €/m²
- a loss for local authorities of 4.1€/m².

For a 60-year-calculation period:

- a benefit for residents of 13.53 €/m²
- a loss for Society of 0.62 € / m²
- a loss for the cooperative of 3.35 €/m² (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.85 €/m²
- a loss for local authorities of 2.2 €/m².

Bourgoin Jallieu benefits and costs for the different stakeholders (in euro/m²) for 30 and 60-year calculation period



Source: La Calade for SHE

The SHE project has OLCC and DLCC benefits, for a 30-year-calculation period as well as for a 60-year-calculation period.

This is due to a relatively low investment overcost linked to a relatively important reduction of charges, especially thanks to energy saving (c.f. Chapter 4.2). The creation of externalities plays a less important role than this reduction of charges, particularly because one of the greatest creation of externalities, the acoustic avoided pollution, is not particularly taken into account in the project.

4.1.8 – The Porto Project, NORBICETA, Porto (P)

The data about the project and the assessment of the overcost come from a common work of La Calade with Liliana Marques. The data from energy and water consumption come from the SHE simulation.

The objective is to assess the overall life cycle costing (OLCC) of the Porto project.

Source: Norbiceta

Technical aspects of the project

The project concerns the construction of 61 flats (one building of a bigger development) for a living area of **6 509 m²** and an **usable area of 8 794 m².**

The actions in regards to the sustainability are :

Insulation:

- strong thermal inertia masonry (4 cm of polyuréthane insulation for external walls, 4 cm of rockwool and double bricks between flats)
- optimised treatment of the envelope to avoid thermal bridges
- double glazing

Daylight strategies, windows and shading: passive solar system and roller blinds in most windows and special blinds for balconies

Renewable Energy: solar sanitary water heating system

Heating: space electricity heating (generally space heating is not included by the cooperative in the social dwellings)

Electricity saving: low consumption bulb

Ventilation and cooling: natural and controlled ventilation for the exhaustion in kitchen and toilets

Building materials: no toxic natural material

Water management: water saving systems: double flow flush 3/6 litre, flow reducer and roof and garden rainwater collector for garden watering and flushing toilets

Waste management:

- taking into account the local selective household's refuse
- control of the working waste and selective refuse process

Economic analysis

Construction Cost

The investment cost (IC) for the project is 4 262 k€ (without tax), i.e. 655 €/m^2 of living area.

The investment overcost for building SHE Project instead of a traditional building is assessed to 372 k€, i.e. 9.6 % of the Investment Cost and 58 €/m^2 of living area.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.4 % of the investment cost.

The operating cost includes energy and water costs. The project improves the energy efficiency with an energy consumption of 46 kWh/m^2 for heating and hot water in regards to 78 kWh/m^2 in a traditional new building. The electricity consumption also decreases from 48 to 34.2 kWh/m^2.

The water consumption is however the same for SHE and reference building (0.44m^3/m^2).

The operating cost is 73.9 k€ i.e. 11.4 €/m^2, in regards to 95.4 k€ (14.7 €/m^2) for a traditional building.

Norbiceta energy consumptions and operating costs

		Sustainable building	Traditional building
Heating	kWh/m^2	36	48
Sanitary Hot Water	kWh/m^2	10	30
Electricity Autoproduction	kWh/m^2	0	
Heating Autoproduction	kWh/m^2		0
Flat Electricity consumption	kWh/m^2	34.2	48
Common Electricity consumption	kWh/m^2	17.6	
Flat Water consumption	m^3/m^2	0.44	
Common Water consumption	m^3/m^2	0.09	
Operating costs	**€/m^2**	**11.4**	**14.7**
Saving	**€/m^2**	**-3.3**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for gas, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

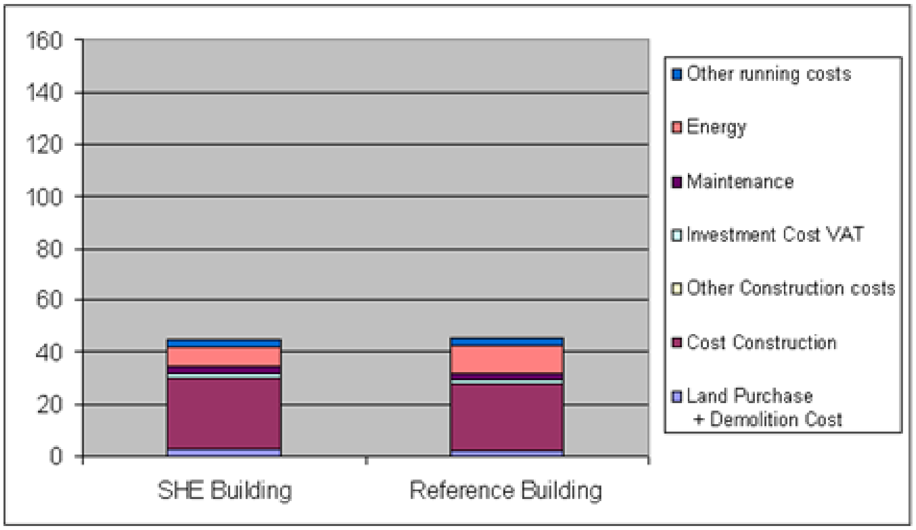
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a benefit (or savings) of 6 057 € in favour of the sustainable building, i.e. 99 € per flat (Direct Life Cycle Cost).

The direct life-cycle cost is indeed 45.1 €/m² of usable area for the SHE building compared to 45.8 €/m² for the reference building. The savings represent only 1.5 % of the cost.

Norbiceta Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)



Source: La Calade for SHE

Norbiceta Direct Life Cycle Costing for a 30-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	2.5	
Cost Construction	27.8	25.2
Other construction costs	0	
VAT	1.7	1.6
Maintenance	2.5	2.5
Energy	7.5	10.9
Other running costs	3.1	3.1
30 years DLCC	**45.1**	**45.8**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emission's and sound pollution's reduction.

The SHE project comprises also other positive externalities to which no money value is given such as non toxic building materials, control of the working waste and selective refuse process etc

Net present value of externalities for Norbiceta project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	6 601	10 154	- 3 553
2 – Atmospheric pollutant emission	3 362	5 479	- 2 117
3 – Avoided acoustic pollution	0	0	0
4 – Landscape value	- 33 231	- 33 231	0
5- Time value	- 4 118	- 4 118	0
6 –Travel induced	- 1 588	- 1 588	0
Total externalities	**- 28 974**	**- 23 305**	**- 5 669**
Externalities per square meter of usable area	**- 4.5**	**- 3.6**	**- 0.9**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 0.7 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Norbiceta Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	396 874	45,1	402 931	45,8	- 6 057	- 0,7
Externalities (cost)	- 28 974	- 3,3	- 23 305	- 2,6	- 5 669	- 0,7
OLCC Value	**367 900**	**41,8**	**379 627**	**43,2**	**- 11 727**	**- 1.4**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 3.2 % to the reference building one, that is to say approximately 192 € by year and by dwelling.

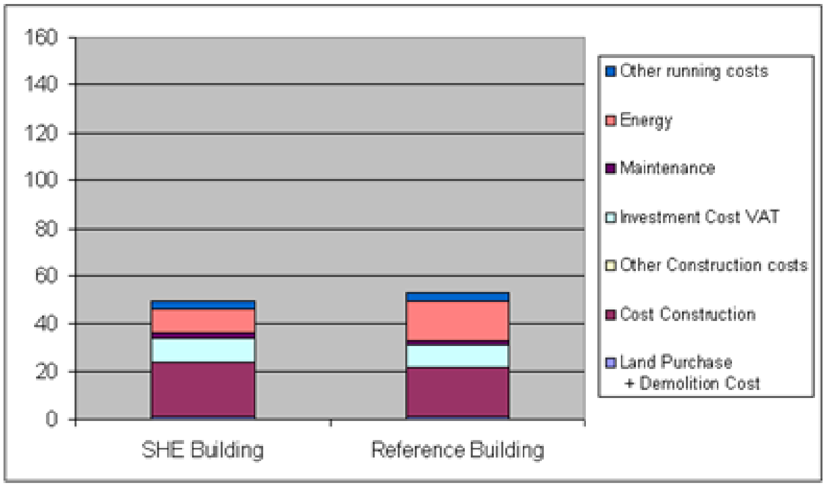
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 34 775 € in favour of the sustainable building, i.e. 570 € per flat.

The direct life-cycle costing is 40.7 € / m² for the SHE building compared to 44.7 € /m² for the reference building. The savings represent 9.1 % of the cost.

Norbiceta Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)



Source: La Calade for SHE

Norbiceta Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	1.3	
Cost Construction	22.5	20.3
Other construction costs	0	
VAT	1.3	1.2
Maintenance	2.5	2.4
Energy	9.8	16.2
Other running costs	3.3	3.3
60 years DLCC	**40.7**	**44.7**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Norbiceta project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 - Greenhouse gas emission	7 551	11 616	-4 064
2 – Atmospheric pollutant emission	3 362	5 479	-2 117
3 – Avoided acoustic pollution	0	0	0
4 – Landscape value	-17 836	-17 836	0
5 – Time value	-4 118	-4 118	0
6 – Travel induced	-1 588	-1 588	0
Total externalities	**-12 629**	**-6 448**	**-6 181**
Externalities per m² of usable area	**-1.9**	**-1.0**	**-0.9**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 0.7 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

Norbiceta Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		**Traditional building (TB)**		**Balance (SB – TB)**	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	358 426	40.7	393 201	44.7	- 34 775	- 4.0
Externalities (cost)	- 12 629	- 1.4	- 6 448	- 0.7	- 6 187	- 0.7
OLCC Value	**345 797**	**39.3**	**386 753**	**44.0**	**- 40 956**	**- 4.7**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 10.7 % to the reference building one, that is to say approximately 671 € by year and by dwelling.

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 4.7 € by m² and by year.

Construction overcost : + 2.3 € / m² / year

Running costs savings: - 6.3 € / m² / year

Externality "savings": - 0.7 € / m² / year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

For the social owner, without available data, the sale price for the sustainable building have not been raised.

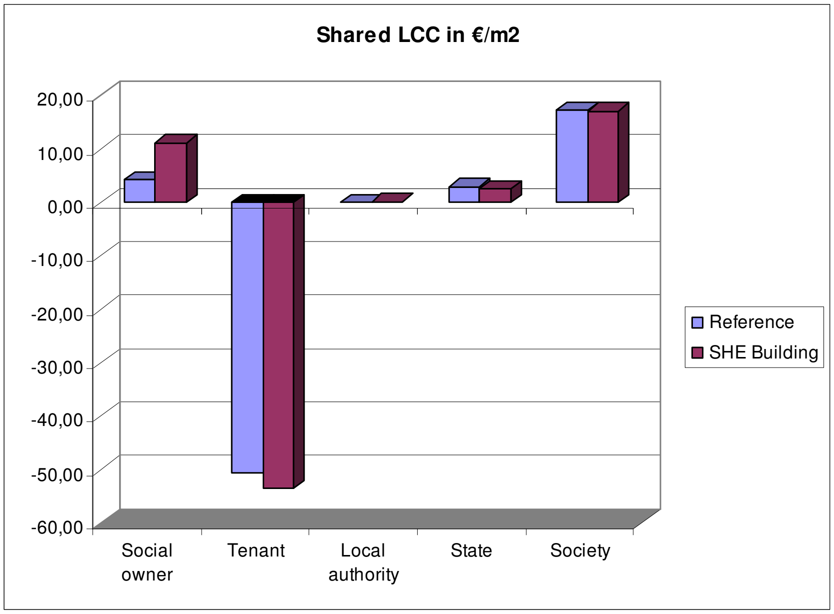
For a 30-year-calculation period, the benefits and costs are shared between the stakeholders as following:

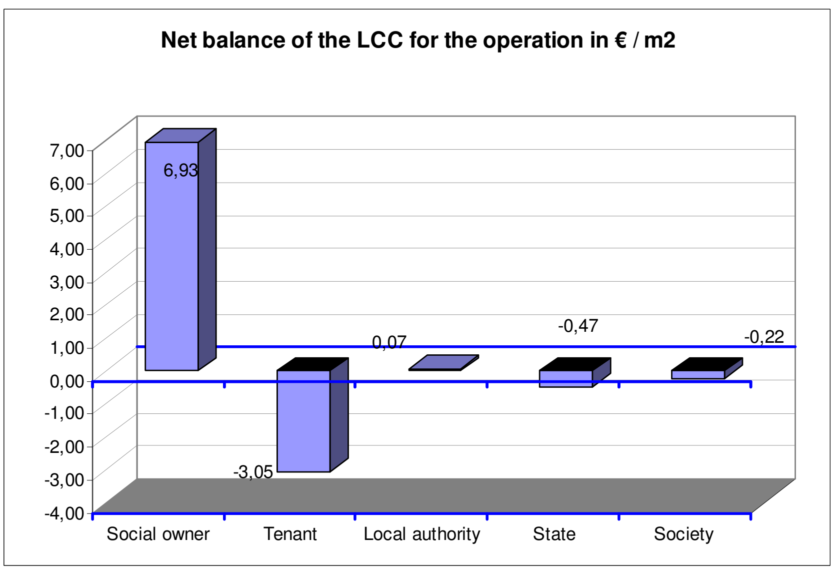
- a loss for residents of 5.95 €/m² (due to the increase of the rent by 32 %)
- a benefit for Society of 0.76 € / m^2
- a benefit for the cooperative of 6.57 €/m^2 (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.38 €/m^2
- a benefit for local authorities of 0.07 €/m^2.

For a 60-year-calculation period:

- a loss for residents of 3.05 €/m² (due to the increase of the rent by 32 %)
- a benefit for Society of 0.22 € / m^2
- a benefit for the cooperative of 6.93 €/m^2 (depends on the real market price of sustainable constructions)
- a loss for national authorities (State) of 0.47 €/m^2
- a benefit for local authorities of 0.07 €/m^2.

Norbiceta benefits and costs for the different stakeholders (in euro/m^2) for 60-year calculation period





Source : La Calade for SHE

The SHE project has OLCC and DLCC benefits for a 30-year-calculation period as well as for a 60-year-calculation period, even if the running costs and externalities saving constitute only a small percentage of the investment cost. The benefits are more linked to the relatively low investment overcost.

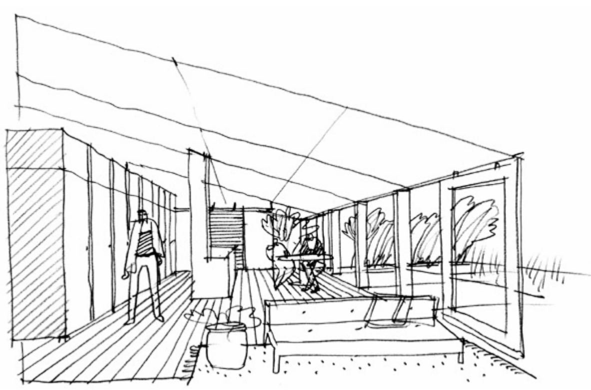
Moreover, the creation of externalities plays a less important role than the reduction of charges, particularly because one of the great creation of externalities saving, the acoustic avoided pollution, is not a specific measure of the project. However, the Norbiceta project has a relative higher atmospheric pollution cost, linked to the great use of electricity.

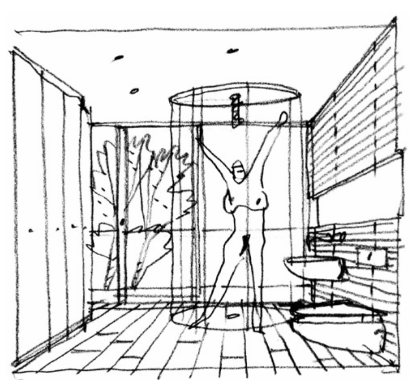
4.1.9 – The Aarhus project, Ringaarden, Aarhus (DK)

Data about the project come from Palle Jørgensen, Managing Director in Boligforeningen Ringgården.

Data details the different costs and expected consumptions. Unfortunately a lot of differences in ways of running a building process in Denmark and Italy or France makes it impossible to divide the economy in the small parts. The Danish way to tender gives the owner a total sum for the contract – a major split up would have had a negative impact on the prize which we could not fit into the budget.

The objective is to assess the overall life cycle costing (OLCC) of the Aarhus project.





Technical aspects of the project

The project concerns the construction of 50 flats for a useful space of 4 799 m².

The actions in regards to the sustainability are :

Insulation and thermal comfort: The SHE project is a low energy housing project with a maximum of approximately 44 kWh per sq meter per year including DHW. All over the year the tenants have the possibility of deciding for themselves the individual use of passive sun heating by a system of removable shutters that also will protect the dwellings for overheating in the hot periods

Daylight strategies, windows and shading: The dwellings are mainly orientated with big window openings to the south thereby maximizing the light and the possibility of passive sun gain. To the cold north the window area is minimized to eliminate cold bridge.

The visual contact to the nature and view of the bay of Aarhus is in the SHE project outstanding and not normal for a social housing project.

Renewable Energy: solar sanitary water heating system and PV production

Heating: space heating from a district heating

Electricity saving: LED light in the dwellings

Ventilation: mechanical exhausting in the kitchen and the bathroom

Building materials: The indoor climate is improved by the use of healthy materials i.e. wood, sound paintings etc. 80%-85% of the used materials in the project is renewable and all materials are healthy thereby minimizing the pollution from unhealthy materials

Water management: All known water saving systems are used in the project.

Economic analysis

Construction Cost

The investment cost (IC) for the project is 9 493 k€ (without tax), i.e. 1 978 €/m^2 of living area.

The investment overcost for building SHE Project instead of a traditional building is assessed to 1 100 k€, i.e. 13.1 % of the Investment Cost and 229 €/m^2 of living area.

Running Costs

The maintenance cost includes the maintenance of the building and repairing. The maintenance does not include the utilities expenses (or operating costs). The annual maintenance cost is 0.9 % of the investment cost.

The operating cost includes energy and water costs. The project improves the energy efficiency with an energy consumption of 44 kWh/m^2 for heating and hot water in regards to 91 kWh/m^2 in a traditional new building. The electricity consumption also decreases thanks to a high efficiency lamps.

The water consumption is reduced thanks to the installation of all available water savings systems.

The operating cost is 74.8 k€ i.e. 15.6 €/m^2, in regards to 119.6 k€ (24.9 €/m^2) for a traditional building.

Aarhus energy consumptions and operating costs

		Sustainable building	**Traditional building**
Heating and sanitary hot water	kWh/m^2	44	91
Electricity Autoproduction	kWh/m^2	10	0
Flat Electricity consumption	kWh/m^2	22	30

Flat Water consumption	m^3/m^2	0.8	1.4
Operating costs	**€/m^2**	**15.6**	**24.9**
Saving	**€/m^2**	**- 9.3**	

Source: La Calade for SHE

The DLCC calculates the net present value of all initial costs plus operating and maintenance cost based on an increase of prices of non renewable sources equal to 3 % per year for district heating, 2 % for electricity and 1 % for water (real price increase).

Analysis for a 30-year-calculation period

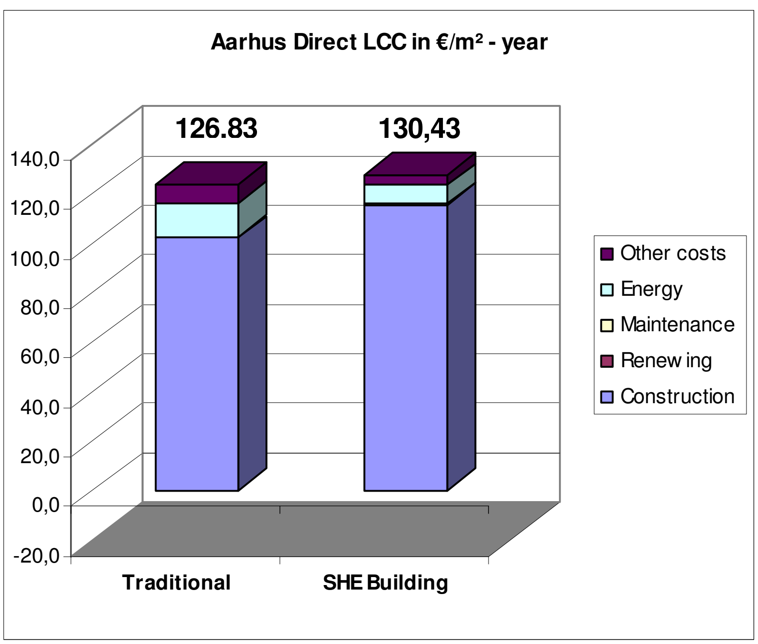
An analysis for a 30-year-calculation period corresponds to the average loan duration (25 to 35 years). The life cycle costing is thus applied on the same period than the financial analysis.

The results thus obtained don't favour construction projects with high investment costs and low running costs. In other terms, if the SHE building is more economically interesting on this short period of time, it could only be more interesting on longer analysis period.

The annual balance gives a loss of 17 269 € for the sustainable building, i.e. 345 € per flat and per year (Direct Life Cycle Cost).

The direct life-cycle cost is indeed 130.4 €/m^2 of usable area for the SHE building compared to 126.8 €/m^2 for the reference building. The overcost of the SHE project represents only 2.8 % of the cost.

Aarhus Direct Life Cycle Costing for a 30-year-calculation period (in euro/m^2)



Source: La Calade for SHE

Aarhus Direct LCC for a 30-year-calculation period (in euro/m²)

	SHE Building	Traditional Building
Ground cost	12.57	
Cost Construction	71.92	62.54
Other construction costs	7.38	6.42
VAT	22.97	20.38
Maintenance	0.56	0.66
Energy and running costs	15.03	24.26
30 years Direct LCC	**130.43**	**126.83**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

The externalities underline the benefits brought by the SHE project in term of greenhouse effect gas emissions reduction. The landscape quality is also enhanced.

The SHE project comprises also other positive externalities to which no money value is given such as non toxic building materials, healthy housings…

Net present value of externalities for Aarhus project in € per year

	Sustainable building	Traditional building	Balance (SB – TB)
1 – Greenhouse gas emission	7 744	13 509	
2 – Atmospheric pollutant emission	793	1 081	
3 – Avoided acoustic pollution	0	0	
4 – Landscape value	- 1 095	- 498	
5- Time value	29 838	29 838	
6 –Travel induced	2 009	2 009	
Total externalities	**39 290**	**45 940**	**- 6 650**
Externalities per square meter of usable area	**8.2**	**9.6**	**1.4**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 1.4 € / m² in comparison with the reference building.

Overall Life-Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

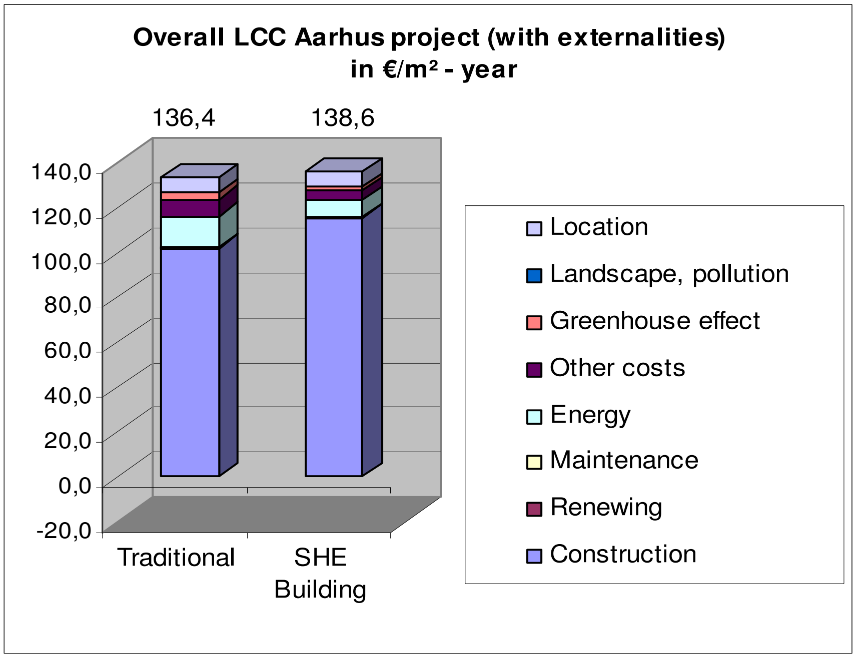
Aarhus Overall Life Cycle Costing for a 30-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m² - year	€ / year	€/m² - year	€ / year	€/m² - year
DLCC value	625 931	130.4	608 662	126.8	17 269	+ 3.6
Externalities (cost)	39 290	8.2	45 940	9.6	- 6 650	- 1.4
OLCC Value	**665 220**	**138.6**	**654 602**	**136.4**	**+ 10 619**	**+ 2.2**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is superior by 1.6 % to the reference building one, that is to say approximately 212 € by year and by dwelling.

Aarhus Overall Life Cycle Costing for a 30-year-calculation period (OLCC)



Source: La Calade for SHE

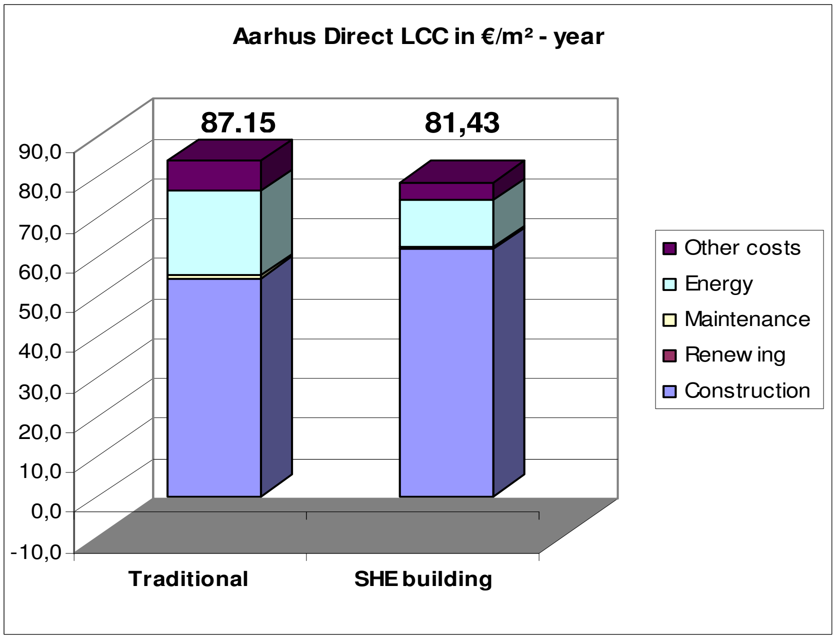
Analysis for a 60-year-calculation period

The 60-year-calculation period corresponds to the building technical depreciation, because even if the building's lifespan is superior to 60 years, the building will need after this time important retrofitting works, including renovation to fit the norms…

The annual balance gives a benefit (or savings) of 27 463 € in favour of the sustainable building, i.e. 549 € per flat.

The direct life-cycle costing is 81.4 € / m^2 for the SHE building compared to 87.1 € /m^2 for the reference building. The savings represent 7 % of the cost.

Aarhus Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)



Source: La Calade for SHE

Aarhus Direct Life Cycle Costing for a 60-year-calculation period (in euro/m²)

	SHE Building	**Traditional Building**
Ground cost	6.75	
Cost Construction	42.56	37.01
VAT	12.33	10.94
Maintenance	0.56	0.66
Energy and other running costs	19.23	31.79
60 years Direct LCC	**81.43**	**87.15**

Source: La Calade for SHE

Externalities analysis

The external costs have been assessed for the sustainable building and for the reference building.

Net present value of externalities for Aarhus project in € per year

	Sustainable building	**Traditional building**	**Balance (SB – TB)**
1 - Greenhouse gas emission	10 346	18 047	- 7 701
2 – Atmospheric pollutant emission	793	1 081	- 288
3 – Avoided acoustic pollution	0	0	0
4 – Landscape value	- 588	- 267	- 321
5 – Time value	29 838	29 838	0
6 – Travel induced	2 009	2 009	0
Total externalities	**42 399**	**50 709**	**- 8 310**
Externalities per m² of usable area	**8.83**	**10.57**	**- 1.74**

Source: La Calade for SHE

The externalities to which a money value is given contribute to a Life Cycle Cost reduction for the SHE project of 1.7 € / m² in comparison with the reference building.

Overall Life Cycle Costing

The overall life cycle costing is the sum of direct cost and externalities.

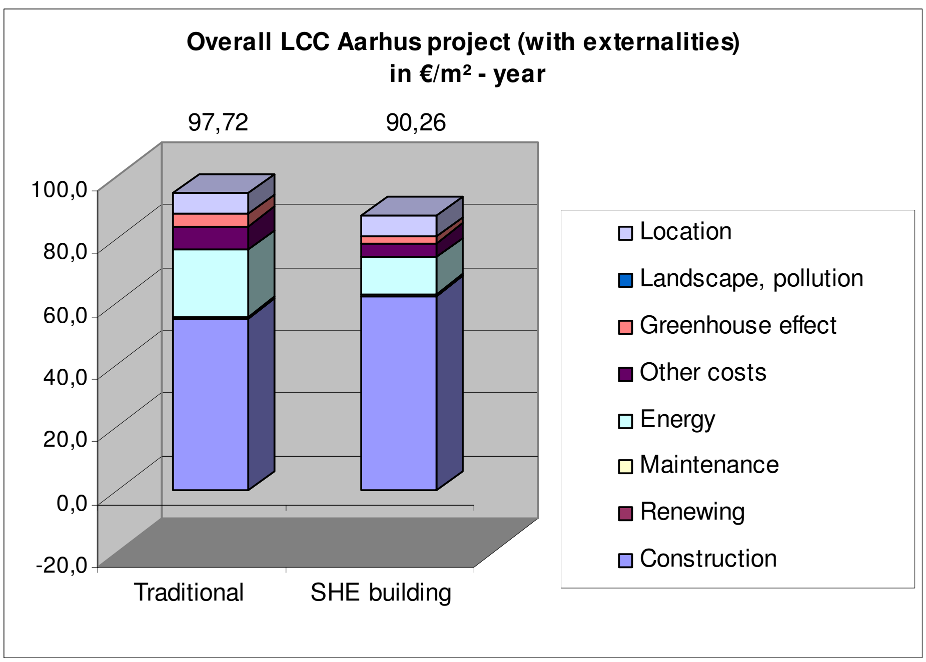
Aarhus Overall Life Cycle Costing for a 60-year-calculation period (OLCC)

	Sustainable building (SB)		Traditional building (TB)		Balance (SB – TB)	
	€ / year	€/m^2 - year	€ / year	€/m^2 - year	€ / year	€/m^2 - year
DLCC value	390 771	81.43	418 234	87.15	- 27 473	- 5.72
Externalities (cost)	42 399	8.83	50 709	10.57	- 8 310	- 1.74
OLCC Value	**433 170**	**90.26**	**468 943**	**97.72**	**- 35 783**	**- 7.46**

Source: La Calade for SHE

The Overall Life Cycle Cost of SHE project is inferior by 7.6 % to the reference building one, that is to say approximately 715 € by year and by dwelling.

Aarhus Overall Life Cycle Costing for a 60-year-calculation period (OLCC)



Source: La Calade for SHE

On the almost entire building lifetime, the savings for the resident and the society (benefiting from positive externalities) is on average of 7.5 € /m².year.

Construction overcost : + 6.9 € / m².year

Running costs savings: - 12.7 € / m².year

Externality "savings": - 1.7 € / m².year

Benefits and costs for the different stakeholders

The overall life cycle costing has been shared between the different stakeholders.

In this balance, we also include the benefit for the construction industry related to a higher activity in the construction process.

For the social owner, without available data, the sale price for the sustainable building has not been raised.

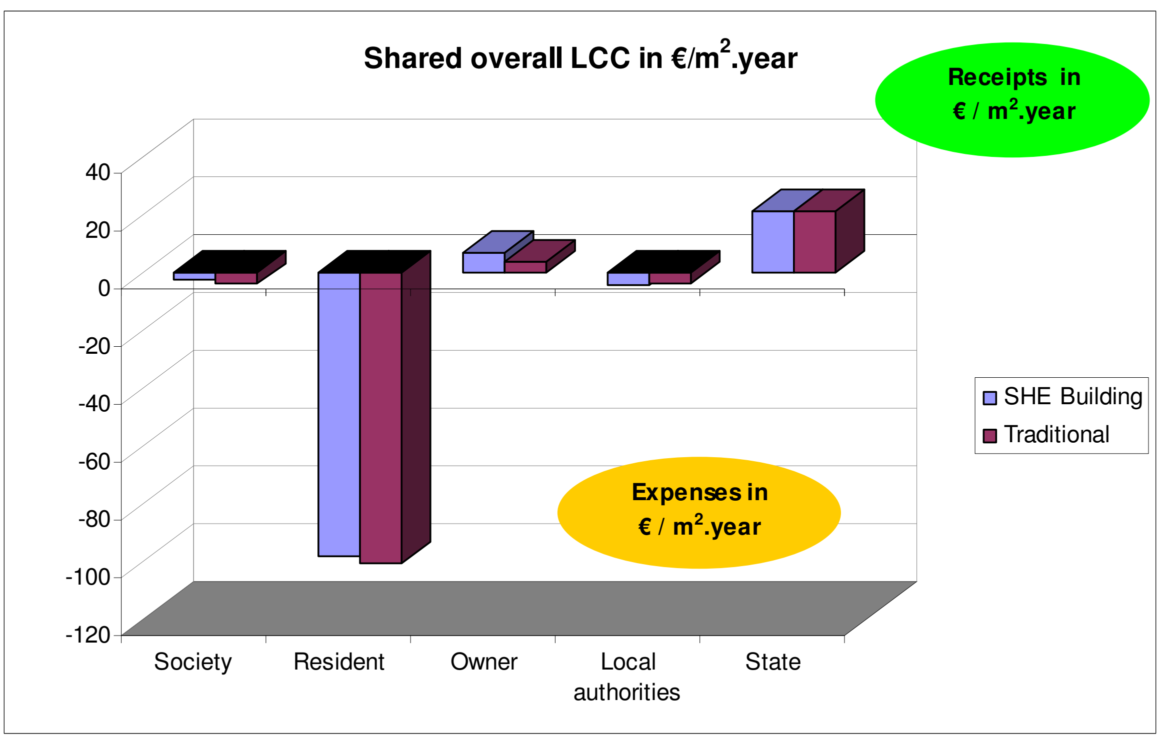
For a 30-year-calculation period:

- a cost for residents of 1.2 €/m^2
- a win for Society of 1.3 € / m^2
- a win for the cooperative of 2.4 €/m^2
- a win for national authorities (State) of 1.4 €/m^2
- a cost for local authorities of 1.0 €/m$^{2.}$

For a 60-year-calculation period:

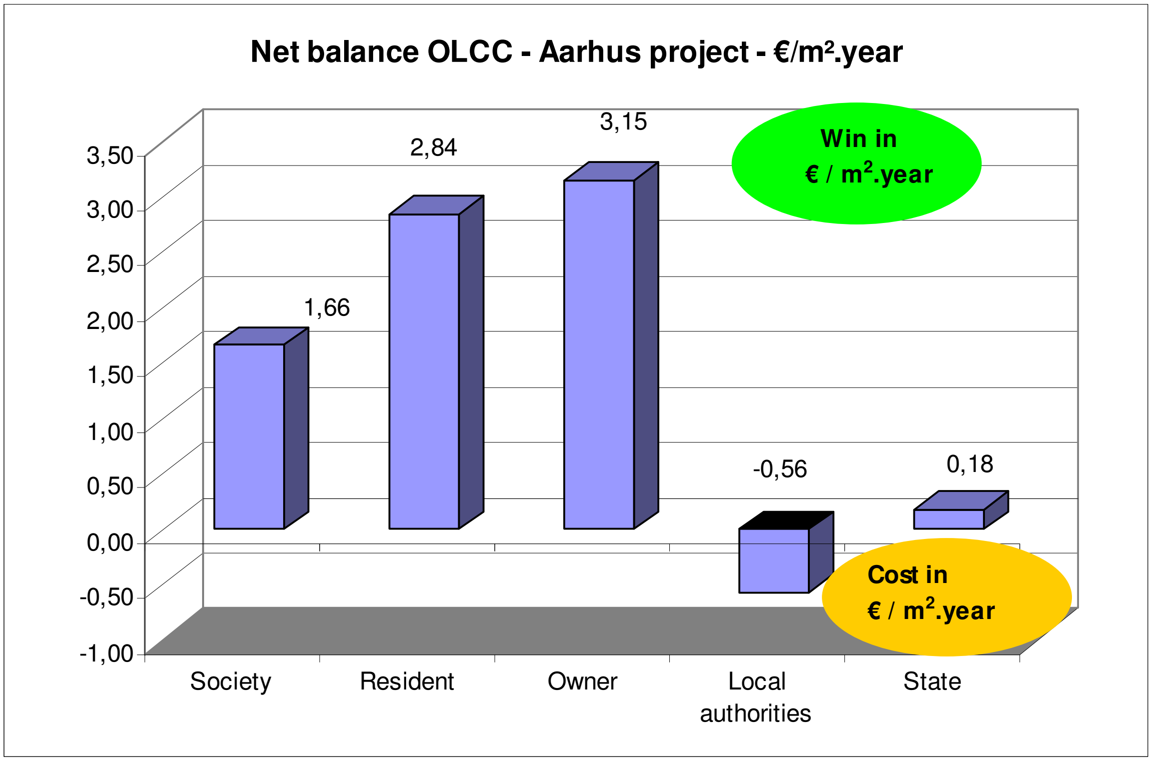
- a win for residents of 2.8 €/m^2
- a win for Society of 1.7 € / m^2
- a win for the cooperative of 3.2 €/m^2
- a win for national authorities (State) of 0.2 €/m^2
- a cost for local authorities of 0.5 €/m$^{2.}$

Aarhus shared OLCC for the different stakeholders (in euro/m^2)
for 60-year calculation period



Source: La Calade for SHE

Aarhus benefits and costs for the different stakeholders (in euro/m^2)
for 60-year calculation period



Source: La Calade for SHE

4.2.- THE OVERALL RESULTS GIVEN BY THE SET-SHE MODEL

4.2.1 – Reminder of the hypothesis

Hypothesis of the SET-SHE Model

Period of calculation	30 and 60 years
Discount rate	2.5 % (30 years) and 1.5 % (60 years)

	Italy	France	Portugal	Denmark
Heating and SHW energy source	gas	gas	gas	District heating
Energy price	0.07 € / kWh	0.057 € / kWh	0.059€ / kWh	0.060 €/kWh
Energy price evolution in % per year (real price)	3 %	3 %	3 %	3 %
Electricity price	0.17 € / kWh	0.12 € / kWh	0.076 € / kWh (0.062 for night)	0.107 € / kWh
Electricity price evolution in % per year (real price)	2 %	1 %	2 %	2%
Water price	1.1 € / m^3	3.1 € / m^3	1.8 € / m^3	5.4 € / m^3
Water price evolution in % per year (real price)	1 %	1 %	1 %	1 %
PV sale tariff	0.43 € / kWh	0.30 € / kWh		0.107 €/ kWh
CO_2 ton value	50 €	50 €	50 €	50 €
Annual growth rate of the CO_2 ton price	1 %	1 %	1 %	1 %

(*Source: La Calade for SHE*) *Note: the utilities prices evolution are given without inflation ; in current euro, we must add the annual inflation rate*

The SET-SHE Model calculates Direct Life Cycle Costing (DLCC) and Overall Life Cycle Costing (OLCC) for 30 and 60-year-calculation periods for each project. 60 years corresponding more to the lifespan of a building than 30, the DLCC and OLCC for 60-year-calculation period is thus more representing of a building life cycle.

The analysis will thus be made particularly on a 60-year-calculation basis.
The acronym NPV stands for Net Present Value.

4.2.2 – Basic data concerning the area and construction cost

Basic Data (SB=Sustainable Building, TB=Traditional Building)

SHE Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES, Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Number of units/flats		67		36		10		12		23		61		61		50	
Living Area	m^2	8 070		2 981		619		875		971		3 324		6 509		4 799	
Heated Volume (HV)	m^3	22 461		11 950		2 649		3 498		3 000		8 310		16 272			
Investment Cost without VAT	k€	11 061	10 472	6 452	5 561	1 573	1 420	2 434	2 258	1 907	1 733	4 418	3 935	4 262	3 890	9 493	8 394
Overcost	k€	589		891		153		176		174		483		372		1 099	
Overcost / investment cost	%	5.6%		16.0%		10.8%		7.8%		10.0%		12.2%		9.6%		13.1%	
Other ratios																	
Construction cost (CC)	k€	8 706	8 114	5 141	4 230	1 079	938	1 792	1 598	1 731	1 518	4 418	3 935	3 787	3 415	7 405	6 439
Ratio in of LC/(IC-VAT)	%	*12%*	*13%*	*12%*	*14%*	*22%*	*24%*	*19%*	*20%*	*6%*	*6%*	*0%*	*0%*	*10%*	*11%*	*14%*	*15%*
Ratio in of CC/(IC-VAT)	%	*79%*	*77%*	*80%*	*76%*	*69%*	*66%*	*74%*	*71%*	*91%*	*88%*	*100%*	*100%*	*89%*	*88%*	*78%*	*77%*
Ratio of other costs/(IC-VAT)	%	*9%*	*10%*	*8%*	*10%*	*10%*	*10%*	*8%*	*9%*	*4%*	*6%*	*0%*	*0%*	*1%*	*1%*	*8%*	*8%*

CC : construction cost, LC : land acquisition cost, IC : investment cost, VAT : value added tax,

SHE Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES, Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Number of units/flats		67		36		10		12		23		61		61		50	
Living Area	m^2	8 070		2 981		619		875		971		3 324		6 509		4 799	
Investment Cost	€/m²	1 438	1 363	2 164	1 865	2 643	2 386	2 926	2 709	2 042	1 857	1 402	1 249	655	597	1 978	1 749
Overcost	€/m²	74		299		257		217		185		153		58		229	

Source: La Calade for SHE

The investment overcost for building sustainable housing corresponds on average to 10.3 % of the investment cost; e.g. 178 euro / m² of living space.

The projects can be ranges from the more important overcost (€/m²) to the less important one from 299 to 58 **€/m².**

186 €/m²

Investment Overcost in €/m²

Mazzano	Fastiggi	Aarhus	Ozzano	Teramo	Bourgoin	Preganziol	Porto
299 (16 %)	257 (10.8%)	229 (13.1%)	217 (7.8%)	185 (10%)	153 (12.2%)	74 (5.6%)	58 (9.6%)

Porto project has the smaller overcost per square meter. This is only partly linked with the purchasing power of Portugal comparing of the ones of France and Italia (in 2006, 81% of Italy purchasing power and 78% of France purchasing power, Source OECD).

We could also benchmark the projects according to the overcost in percentage of investment cost. The average investment overcost is 10%, going from 15.9 to 5.5%.

10.6 %

Investment Overcost in %

Mazzano	Aarhus	Bourgoin	Fastiggi	Teramo	Porto	Ozzano	Preganziol
16 %	13.1 %	12.2 %	10.8 %	10 %	9.6 %	7.8 %	5.6 %

To explain these differences in the investment overcost, we could look at the composition of this cost in the following table:

Composition of investment cost

SHE Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES, Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Land purchase cost	€/m²	166		269		553		515		111		0		17		270	
Demolition cost	€/m^2	0		42		0		0		0		0		0		0	
Technical studies	€/m²	32	39	-	-	139	81	147	99	134	103	161	157	20	15	119	103
Urbanisation cost	€/m²	126		129		199	178	161	182	0	41	-		-		40	34
Financial costs	€/m²	-		-		48		57		5		-		-		-	
Construction cost	€/m²	1 047	966	1 716	1 418	1 604	1 434	1 901	1 727	1 649	1 460	1 168	1 027	602	549	1 543	1 342
Construction only overcost	€/m²	81		298		170		174		189		141		53		201	

Source: La Calade for SHE

The difference of investment cost between SHE project and a traditional building stems principally from the construction cost. Excluding the technical studies cost, the average construction overcost is 165 €/m^2, going between 22 and 7.5% of the lone construction costs.

13 %

Construction Overcost in %

Mazzano	Aarhus	Bourgoin	Teramo	Fastiggi	Ozzano	Porto	Preganziol
21 %	15 %	14 %	13 %	12 %	10 %	10 %	8 %

4.2.3 - Running Costs and Direct Life Cycle Cost

The SHE Building having reduction targets concerning energy and water consumptions and sometimes electricity and heating autoproduction, the SHE Buildings will benefit from a reduction of operating costs and consequently of running costs (cf. table on the next page).

Operating Costs per square meter of living area

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Heating	kWh/m²	83	128	65	120	71	131	76	135	43	65	61	123	36	48	44	91
Sanitary Hot Water	kWh/m²	8	16	11	22	22	32	8	33	18	30	22	39	10	30		
Electricity Autoproduction	kWh/m²	0		4.4		0		1,6		0		0.7				10	
Heating Autoproduction	kWh/m²			40		7		11		15		6.7					
Flat Electricity consumption	kWh/m²	14.9	16.7	27	33	20	30	33	40			25		34	48	22	30
Common Electricity consumption	kWh/m²	1.7		5.2	9.6	0.8		9.7	7.4			4.8		17.6		-	
Flat Water consumption	m³/m²	0.7	1.2	1.65	2.04	0.86	1.24	0.6	1.1			1.6	1.9	0.44		0.8	1.4
Common Water consumption	m³/m²	0		0.07	0.40	0		0	0.1			0		0.09		-	
Operating costs	**€/m²**	**9.9**	**14.6**	**12.3**	**23.8**	**11.6**	**18.7**	**14.5**	**21.0**	**4.3**	**6.7**	**13.3**	**20.9**	**11.4**	**14.7**	**15.6**	**24.9**
Savings (per year)	**€/m²**	**- 4.7**		**- 11.5**		**- 7.1**		**- 6,5**		**- 2.4**		**- 7.6**		**- 3.3**		**- 9.3**	

Source: La Calade for SHE

Savings represent on average 6.6 €/m², e.g. 36% of the average traditional building operating cost (18.2 €/m²), and ranges from 2.4 to 11.5 €/m²:

6.6 €/m²

Savings €/m².year

Teramo	Porto	Preganziol	Ozzano	Fastiggi	Bourgoin	Aarhus	Mazzano
2.4	3.3	4.7	6.5	7.1	7.6	9.3	11.5

Annual Direct Life Cycle Cost per square meter of living area

CALCULATION PERIOD: 30 years

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Net Present Value (investment)	€ /m²	81,7	78,4	127.8	109.2	123.6	111.4	153,3	139,1	107,9	99,1	72,2	63,4	43,3	39,6	114.8	101.9
Running	€/m²	18.1	24.8	16.3	27.8	20.0	30.1	22,1	33,5	10,4	14,0	19,1	29,6	17,7	22,3	15.6	24.9
Direct Life-Cycle Cost	€ / m²	99.8	103.2	144.1	137.0	143.6	141.5	175.4	172.6	118.3	113.1	91.3	93.0	61.0	61.9	130.4	126.8
BALANCE	€ / m²		+ 3.4		- 7.1		- 2.1		- 2.8		- 5.2		+ 1.7		+ 0.9		- 3.6

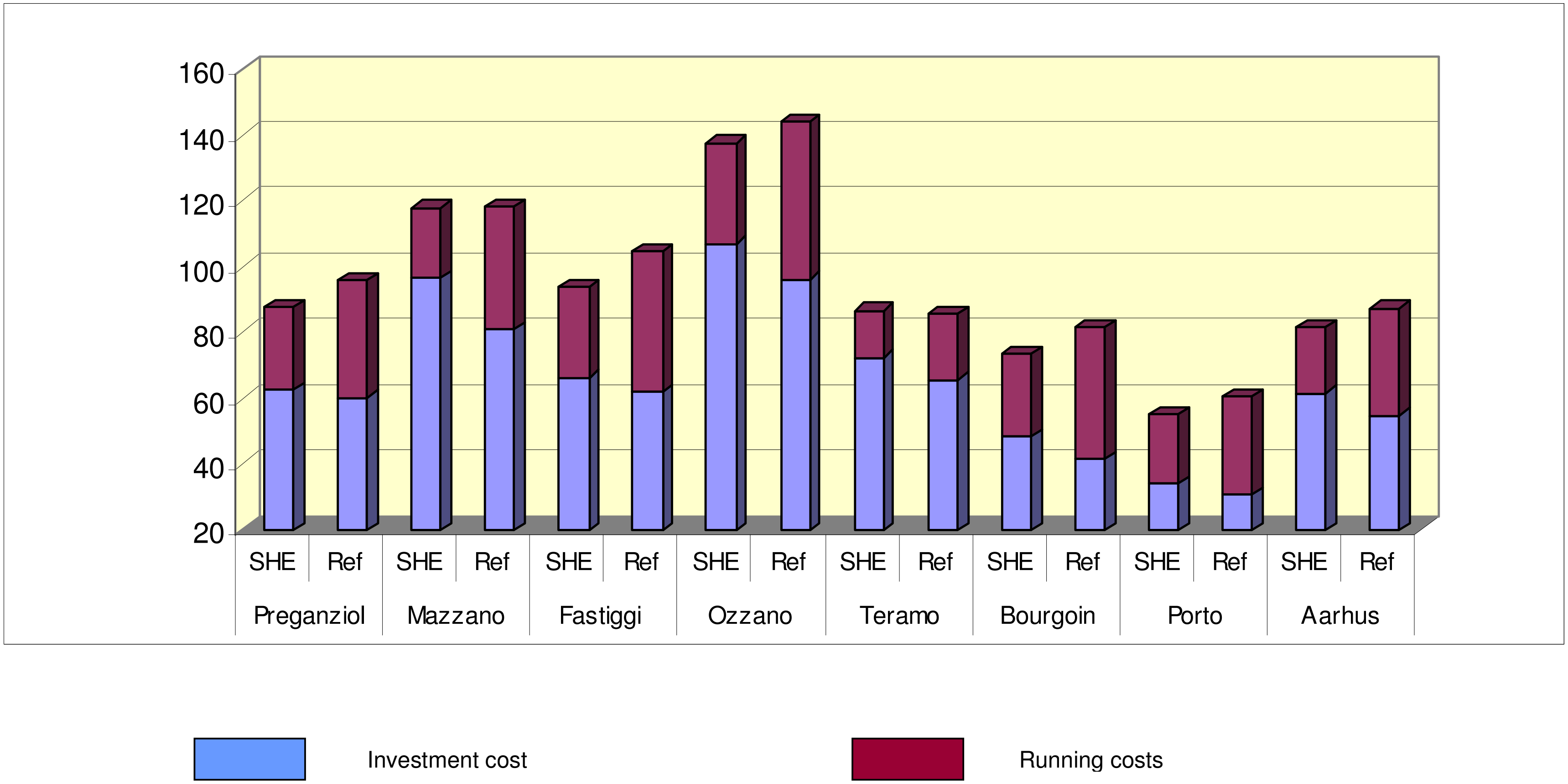
CALCULATION PERIOD: 60 years

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Net Present Value (investment)	€ /m²	62.4	60,2	96.6	81.0	66.3	61.8	107.1	96.2	72.4	65.7	48.2	41.5	34.0	30.8	61.6	54.7
Running	€/m²	25.1	35,4	21.3	37.3	27.4	42.9	30.3	47.7	14.2	19.9	25.2	40.2	21.0	29.6	19.8	32.5
Direct Life-Cycle Cost	€ / m²	87.5	95.6	117.9	118.3	93.7	104.7	137.4	143.9	86.6	85.6	73.4	81.7	55.0	60.4	81.4	87.2
BALANCE	€ / m²		+ 8.1		+0.4		+ 11.0		+ 6.5		- 1.0		+ 8.3		+ 5.4		+ 5.8

Source: La Calade for SHE

The Direct Life Cycle Cost of Sustainable Building is on average of 92 €/m^2 for a 60-year-calculation period and of 120 €/m^2 for 30 years for the SHE projects. The DLCC are respectively 97 € / m² for the 60-year period and 118 €/m² for the 30-year period for the reference buildings.

The Direct Life Cycle Costs for a 60-year-calculation period for the SHE Building and for the Traditional Building (Ref) (in €/m².year)



Source: La Calade for SHE

OVERALL RESULTS

For the SHE projects the Direct Life Cycle Cost savings are on average of 5.6 €/m^2 for a **60-year-calculation period** and range from - 1 up to + 11 €/m^2. We can benchmark the projects by Direct Life Cycle Cost saving per square meter:

Teramo	Mazzano	Porto	Aarhus	Ozzano	Preganziol	Bourgoin	Fastiggi
-1	**+ 0.4**	**5.4**	**5.8**	**6.5**	**8.1**	**8.3**	**11**

DLCC Saving for a 60-year-calculation period (€/m^2)

For explaining these results, we can calculate for each SHE project an "economic efficiency of overcost" which measures how the reduction of running costs (in €/m².year) is when we increase the investment overcost (of 1 €/m².year in terms of NPV). This tool is however to use with precaution as an optimised economic impact doesn't systematically correspond with an optimised sustainable building (it could indeed correspond with a too small number of sustainable features).

The projects could be ranged from the less to the more important economic efficiency of "resources saving" for a **60-year-calculation period**:

Teramo	Mazzano	Ozzano	Aarhus	Bourgoin	Porto	Fastiggi	Preganziol
0.9	**1.0**	**1.6**	**1.8**	**2.2**	**2.7**	**3.4**	**4.7**

Economic Efficiency of overcost

In average for the overall SHE project, for ONE EURO invested per year, the savings for users go up to 1.8 EURO per year.

We also notice that the investment overcost level is not correlated with the reduction of running costs. An important methodological point is also linked to the definition of the Reference Building which could be standardized in each Member State in regards to a typology (social status, level of price, construction process, regional location…).

The SHE projects can be distinguished according to their results in terms of Direct Life Cycle Cost. The DLCC of the SHE project is higher than the reference building one for Aarhus, Ozzano, Fastiggi, Mazzano and Teramo SHE projects result in a loss for a 30-year-calculation period.

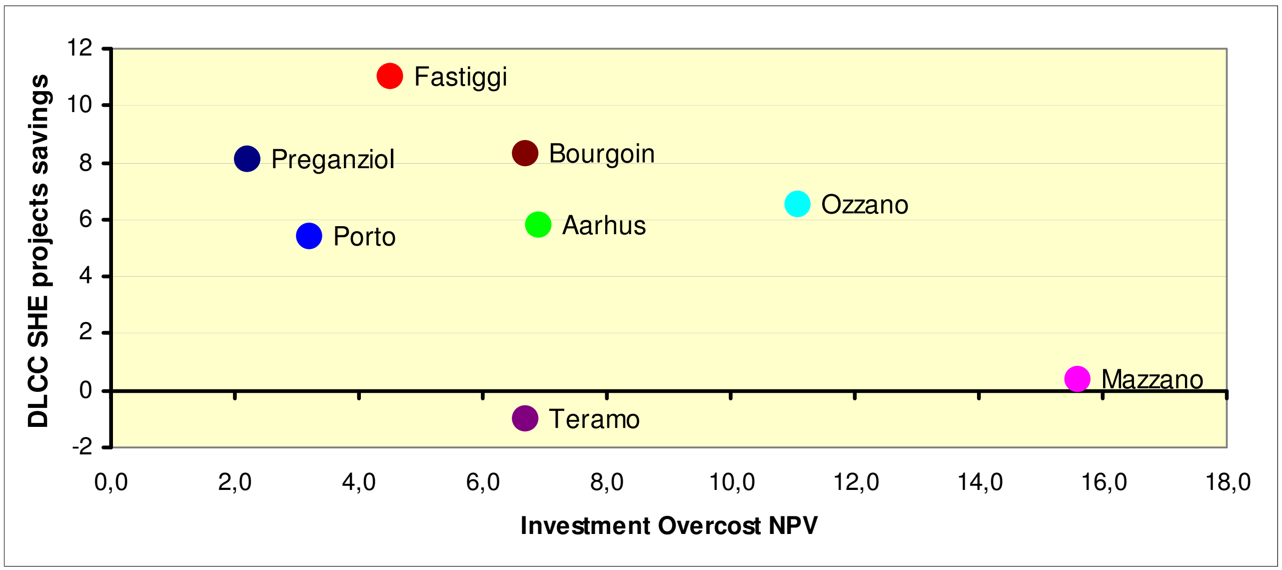
The Bourgoin, Preganziol and Porto SHE projects result in a saving of DLCC for a 30-year-calculation period.

All the SHE projects result in a saving of DLCC for a 60-year-calculation period (except Teramo near 0)

The saving of Direct Life Cycle Costing depends a lot on the evolution of the energy prices on a long-term. For example, for Bourgoin project, with an addition of 1% to the current hypothesis on energy prices increase (fixed at 1 and 3%, cf. 4.2.1), the saving of DLCC increase for a 60 –year-calculation period from 8.3 to 11.6 €/m^2, i.e. an increase by 40 % of the benefit.

The evolution of energy prices is a more important factor than a "virtual" tax on greenhouse effect gas which is taken into account in the OLCC. The issue of water price is also an important factor, particularity with Italia that has a large part of the water price paid by the society through the tax system.

Comparison between the DLCC saving and the initial investment overcost for a 60-year-calculation period (in €/m²)



Source: La Calade for SHE

4.2.4 – Externalities and Overall Life Cycle Cost

This chapter introduce the calculation of externalities in the project's analysis, three of them depending on the building's construction (GEG emission, atmospheric pollution, avoided acoustic pollution) and the other three depending on the localisation of the building (landscape value, time value, travel induced).

Externalities Net Present Values for 30 years per square meter of living area

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Greenhouse gas emission	€ /m²	1,5	2,4	1,9	3.0	1,2	3,0	2,3	3,5	0,35	1,2	1,0	2,0	1,2	1,8	1.6	2.8
Atmospheric pollution	€ /m²	0,13	0,19	0,18	0,27	0,15	0,25	0,23	0,31	0,10	0,17	0,09	0,16	0,5	0,84	0.17	0.23
Avoided Acoustic pollution	€ /m²	-3,2	0	-7.3	0	-11,8	0	-6,5	0	-4,6	0	0	0			0	0
Landscape value	€ /m²	-7.7	-7.7	-10.7	-10.7	-14.2	-14.2	-13.8	-13.8	-11.	-11	0	0	-5.1	-5.1	-0.23	-0.10
Time value	€ /m²			-2.7	-2.7			-0.3	-0.3			-4.9	-4.9	-0.6	-0.6	6.2	6.2
Travel induced	€ /m²			-0.4	-0.4			-0.1	-0.1			-0.7	-0.7	-0.2	-0.2	0.4	0.4
Total externalities	€ /m²	-9.3	-5.2	-19.1	-10.6	-24.7	-11.1	-18.3	-10.6	-15.8	-9.7	-4.5	-3.5	-4.5	-3.6	8.2	9.6
Saving thanks to externalities	€ /m²		4.1		8.5		13.6		7.7		6.1		1.0		0.9		1.4

Source: La Calade for SHE

The saving for a 30-year- calculation period is on average of 5.4 €/m^2.year

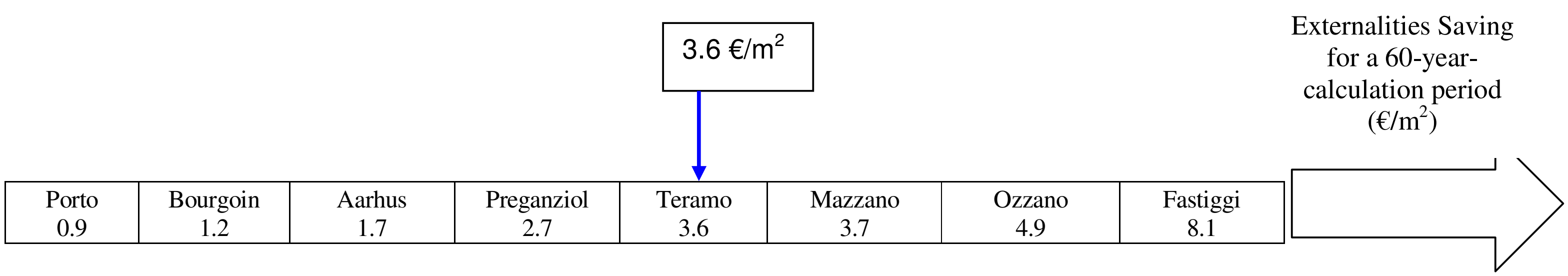
Notice: the cost of externalities like atmospheric pollution, time value and travel induced don't change between 30 and 60-year-calculation periods. However, the greenhouse effect gas emission cost is discounted taking into account the increase of carbon price while the avoided acoustic pollution and landscape value are discounted thanks to the reference discount factor.

Externalities Net Present Values for 60 years per square meter of living area

Project		Preganziol		Mazzano		Fastiggi		Ozzano		Teramo		Bourgoin		Porto		Aarhus	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Greenhouse gas emission	€ /m²	1.8	2.7	2.2	3.5	1.7	3.4	2.6	4.0	0.3	1.4	1.2	2.3	1.2	1.8	2.16	3.76
Atmospheric pollution	€ /m²	0.13	0.19	0.18	0.27	0.15	0.25	0.23	0.31	0.05	0.08	0.09	0.16	0.5	0.84	0.17	0.23
Avoided Acoustic pollution	€ /m²	-1.7	0	-3.9	0	-6.4	0	-3.5	0	-2.5	0	0	0	0	0	0	0
Landscape value	€ /m²	-4.1	-4.1	-5.8	-5.8	-7.6	-7.6	-7.4	-7.4	-5.9	-5.9	0	0	-2.7	-2.7	-0.12	-0.06
Time value	€ /m²			-2.7	-2.7			-0.3	-0.3			-4.9	-4.9	-0.6	-0.6	6.22	6.22
Travel induced	€ /m²			-0.4	-0.4			-0.1	-0.1			-0.74	-0.74	-0.3	-0.3	0.42	0.42
Total externalities	€ /m²	-3.9	-1.2	-10.5	-5.2	-12.15	-3.95	-8.6	-3.7	-8.0	-4.4	-4.4	-3.2	-1.9	-1.0	8.83	10.57
Saving thanks to externalities	€ /m²		2.7		5.3		8.2		4.9		3.6		1.2		0.9		1.74

Source: La Calade for SHE

For a **60-year-calculation period**, the saving thanks to externalities are on average of 3.6 €/m².year, e.g. 4% of the DLCC, and are ranging from 0.9 (Porto) to 8.2 €/m^2 (Fastiggi):



The avoided acoustic pollution is the main source of savings (on average responsible for a saving of 2.5 €/m^2, while greenhouse gas emission and atmospheric pollution savings are respectively of 1.15 €/m^2 and 0.11 €/m^2). Indeed, for each decibel under the legal threshold, the sustainable building has a reduction of overall life cycle cost corresponding to 1% of the investment cost (cf. chapter 3.3.5 for more explanation on the avoided acoustic pollution calculation).

It is why Porto and Bourgoin projects have smaller externalities' savings, as there are no increase of acoustic insulation for the sustainable buildings, which are just respecting the legal threshold.

The spatial externalities such as landscape value, time value and travel induced are not source of saving in the case of SHE projects. They would have make a difference if:

- the location of the development were different for the sustainable building (for example in greater surroundings, or closer to essential amenities)
- the sustainable development comprised essential services or green spaces not included in the reference development

In the case of the SHE project, these differences between the SHE building and the reference building don't exist, the location and amenities being considered to be similar to the traditional building's ones. These externalities when sum up represent however the great amount of 6.3 €/m^2, (4.8 and 1.3 €/m^2 for respectively landscape and time value externalities), that is to say 6.8% of DLCC. This is to compare with the average amounts or savings for other externalities (e.g. saving of 2.4€/m^2 for the acoustic avoided pollution, representing 2.5% of DLCC)**.**

The overall life cycle cost saving that could be obtained through the choice of a location closer to essential amenities and in a more valued surrounding or through the inclusion in the building project of essential amenities and surrounding landscape's improvement could be potentially important enough to justify the corresponding investment's overcost (the issue would then concern the share of benefits and costs between the stakeholders).

Overall Life Cycle Cost (OLCC) per square meter of living area

CALCULATION PERIOD : 30 years

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Direct LCC	€ /m²	99.8	103.2	144.1	137.0	143.6	141.5	175.4	172.6	118.3	113.1	91.3	93.0	61.0	61.9	130.4	126.8
Externalities	€/m²	-9.3	-5.2	-19.1	-10.6	-24.7	-11.1	-18.3	-10.6	-15.8	-9.7	-4.5	-3.5	-4.5	-3.6	8.2	9.6
Overall Life-Cycle Cost	€ / m²	90.5	98.0	125.0	126.4	118.9	130.4	157.1	162.0	102.5	103.4	86.8	89.5	56.5	58.3	138.6	136.4
BALANCE	€ / m²		+ 7.5		+ 1.4		+ 11.5		+ 4.9		+ 0.9		+ 2.7		+ 1.8		- 2.2

CALCULATION PERIOD : 60 years

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
Direct LCC	€ /m²	87.5	95.6	117.9	118.3	93.7	104.7	137.4	143.9	86.6	85.6	73.4	81.7	55.0	60.4	81.4	87.1
Externalities	€/m²	-3.9	-1.2	-10.5	-5.2	-12.2	-4.0	-8.6	-3.7	-8.0	-4.4	-4.4	-3.2	-1.9	-1.0	8.8	10.6
Overall Life-Cycle Cost	€ / m²	83.6	94.4	107.4	113.1	81.5	100.7	128.8	140.2	78.6	81.2	69.0	78.5	53.1	59.4	90.2	97.7
BALANCE	€ / m²		+ 10.8		+ 5.7		+ 19.2		+ 13.4		+ 2.6		+ 9.5		+ 6.3		+ 7.5

Source: La Calade for SHE

The Overall Life Cycle Costing of Sustainable Building is on average of 87 €/m².year for a 60-year-calculation period and of 109 €/m².year for 30.

Thanks to the creation of important externalities benefits linked especially to the avoided acoustic pollution and secondary to the reduction of greenhouse gas and atmospheric pollution emissions (reduction caused by energy saving and renewable energy use), all SHE projects result in a Overall Life Cycle Cost benefit for a 30 (except Arrhus) as well as 60-year-calculation period, which is encouraging. The saving on 60 years is on average of 9.4 €/m².year , and range from 2.6 to 19.2 €/m^{2,} :

OVERALL RESULTS

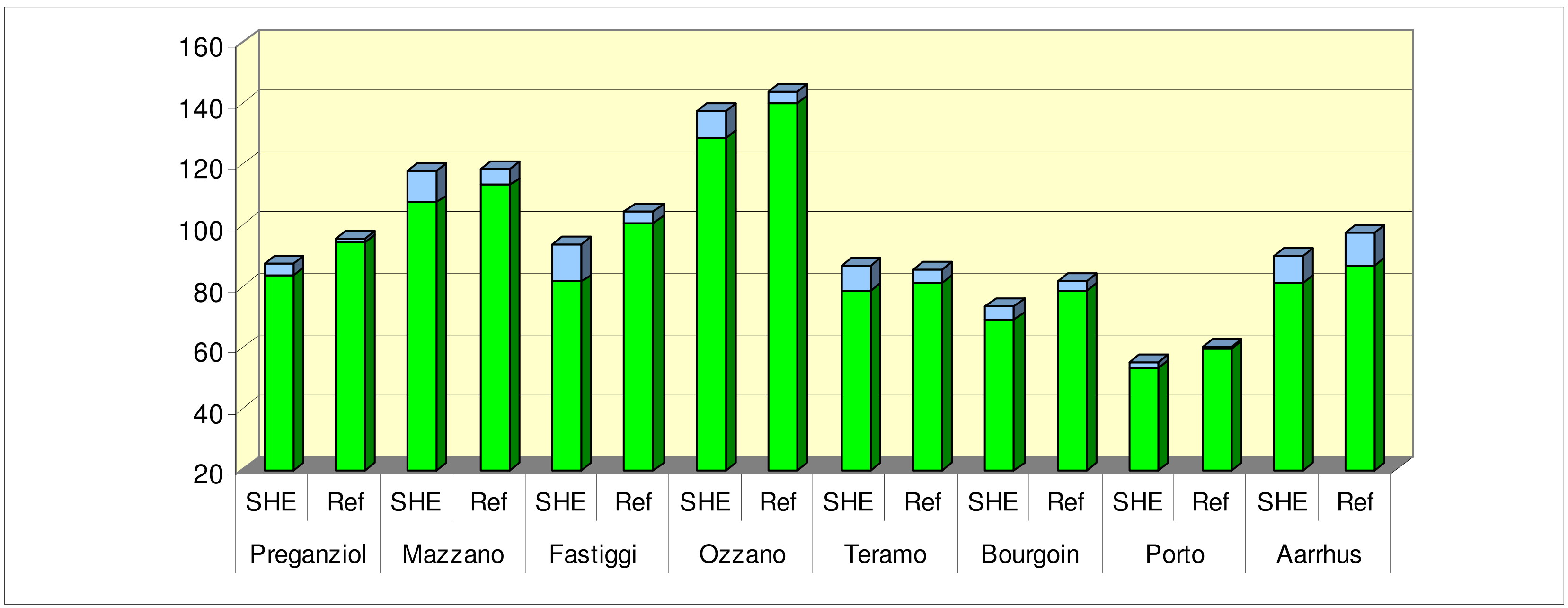
9.4 €/m².year

Teramo	Mazzano	Porto	Aarhus	Bourgoin	Preganziol	Ozzano	Fastiggi
2.6	5.7	6.3	7.5	9.5	10.8	13.4	19.2

OLCC Saving for a 60-year-calculation period (€/m^2)

The Fastiggi projects, having already result in the best DLCC saving, result in the best OLCC saving.

Overall Life Cycle Cost for a 60-year-calculation period (in € / m².year)

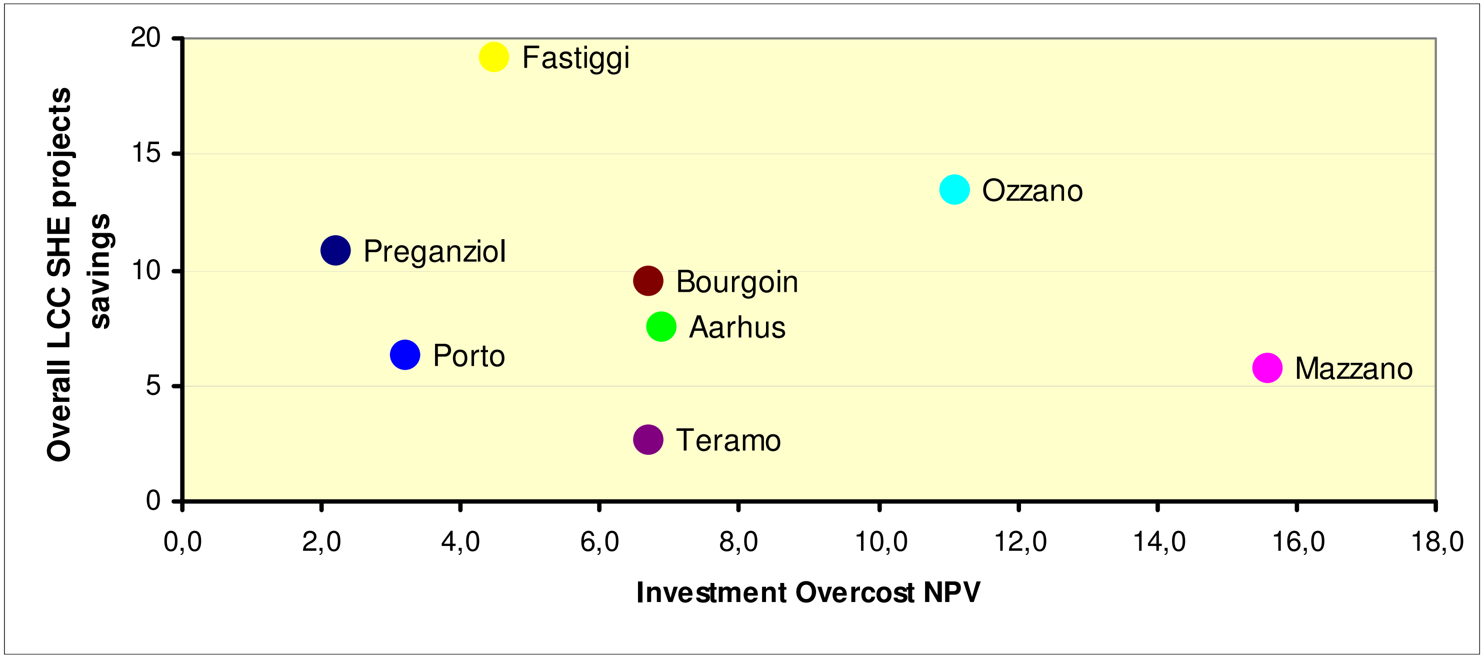


Source: La Calade for SHE

Direct Life Cycle Cost

Externalities

Comparison between the OLCC saving and the initial investment overcost for a 60-year-calculation period (in €/m²)



Source: La Calade for SHE

4.2.5 - Focus on CO_2 emissions

CO_2 emissions avoided thanks to change of type or quantity of energy used

Project		**Preganziol**		**Mazzano**		**Fastiggi**		**Ozzano**		**Teramo**		**Bourgoin**		**Porto**		**Aarhus**	
SHE partner		COIPES Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
SHE Building / Reference Building		SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref	SHE	Ref
CO_2 emission	kg /m².year	29	42	33	53	31	52	40	62	14	21	20	38	18	27	25	43
Of which only heating and SHW	kg/m².year	20		17		21		19		14		18		18		13	
CO_2 avoided emission	tons/year	104		60		13		19		8		61		62		88	

(SHW= Sanitary Hot Water) Source: La Calade for SHE

CO_2 emissions are considered in this study as an externality as they are not subject to taxes. They could however be taxed in the near future and if this happens, it would mean firstly an inclusion of the CO_2 emission in the operating cost linked to energy consumption, then an increase of Direct Life Cycle Costing saving for sustainable housings. This would also still broaden the possibility of selling a sustainable house at an higher price than a traditional one.

Teramo	Porto	Preganziol	Bourgoin	Aarhus	Mazzano	Fastiggi	Ozzano
7	9	13	18	18	20	21	22

CO_2 emissions avoided in **kg/m^2/year**

The 320 flats of the SHE project make possible to avoid the emission of 415 tons CO_2 par year. The average emission is 26 kg CO_2 / m². year (of which 17 kg for heating and SHW) instead of 42 kg CO_2 / m².year in traditional construction.

4.2.6 - Share of Overall Life Cycle Cost (OLCC) between the different stakeholders

Benefits and Losses of SHE buildings by comparison with reference buildings for the various stakeholder for 30 and 60-year-calculation periods (in € / m².year)

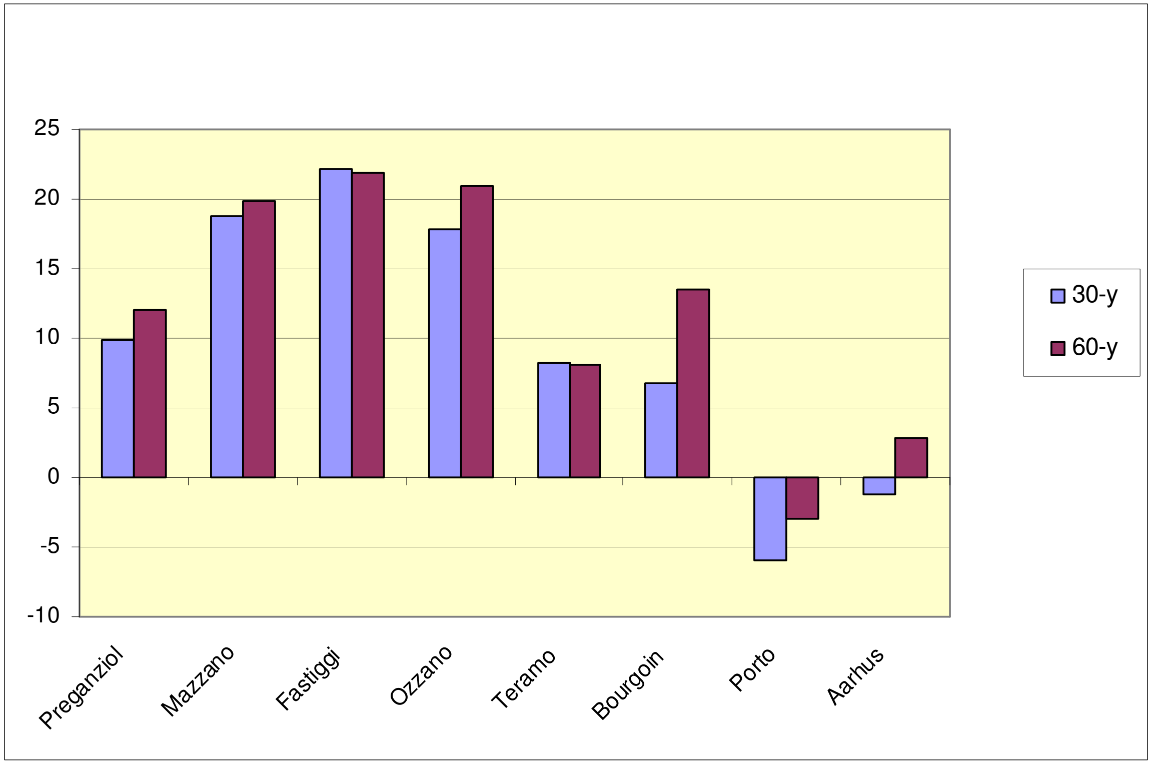
Project	Preganziol		Mazzano		Fastiggi		Ozzano*		Teramo		Bourgoin		Porto		Aarhus	
SHE Partner	COIPES Mestre		CONSEDI Brescia		COPES Pesaro		COPALC Bologna		CCICASA Teramo		OPAC 38 Grenoble		NORBICETA Porto		RINGAARDEN Aarhus	
	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60
Social Housing Cooperative/Owner	-3.3	-2.2	-18.5	-15.7	-12.2	-4.5	2.6	0.6	-8.8	-6.7	0.1	-3.3	6.6	6.9	+ 2.4	+ 3.2
Tenant/Resident	9.9	12.0	18.8	19.9	22.1	21.9	1.2	9.3	8.2	8.1	6.7	13.5	- 5.9	- 3,0	- 1.2	+ 2.8
Local Authorities											-4.1	-2.2	0.1	0.1	- 1.0	- 0.5
State	-0.6	-0.9	-0.3	-0.8	-0.45	-1,24	-0.1	-0.9	0	-0.3	-1.8	-0.8	- 0.4	-0.5	+ 1.4	+ 0.2
Society	0.6	-0.9	6.2	3.7	4.7	-0.6	4.4	1.3	4.8	2.8	1.5	-0.6	0.8	0.2	+ 1.3	+ 1.7

Source: La Calade for SHE ** assumption of a plus-value of 12 % for the SHE flats sale*

In Italy, there is no value for local authorities corresponding to SHE buildings as no grants were given by them for the construction of a more sustainable building.

The State, through its loss of VAT linked to a reduction of operating costs for SHE building, undergo losses. These losses are however corresponding in most cases in a benefit for the society greater than the State's loss.

The Benefits for residents and tenants for 30-year and 60-year-calculation periods (in € / m².year)



Source: La Calade for SHE

The tenants/residents of each SHE project benefits from a reduction of charges. For Italy, this reduction of charges would be more drastic (and the DLCC benefits greater) if the price of water would comprise the waste water treatment, which is not the case today.

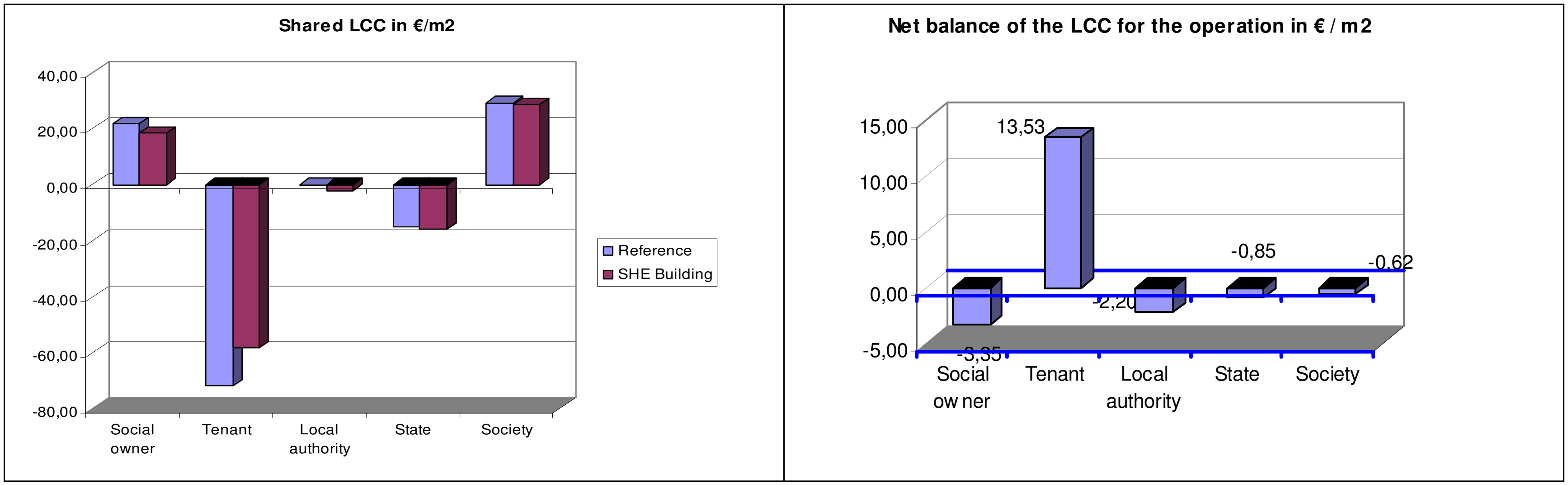
This above chart supposes that the flats are sold to residents at the marke price without plus-value due to the high environmental quality.

The balance for cooperatives depends on the sale price of the flats and consequently on the market price evolution. The last crisis of the estate property makes it more difficult the sale of the SHE flats at a price including the investment overcost. The awareness of the future residents is more urgent than never…

For the French project (Bourgoin), the SHE investment overcost borne by the social owner is not compensated by the small increase of rent (1%) or by the supplementary funding from local and national authorities (or by the small reduction of charges for common areas).

These results raise the question of the sharing out between the various stakeholders of the investment overcost for building more sustainable housing, and particularly of the sharing of benefits and losses between the tenant/resident and the social owner/cooperative.

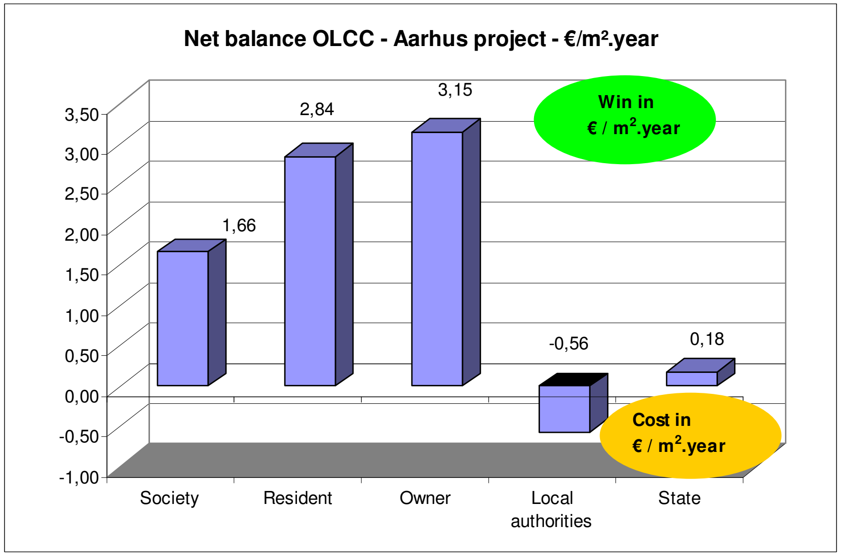
Shared OLCC for the Bourgoin SHE Project



Source : La Calade

For the Danish project, the OLCC is shared between the different stakeholders. The overall benefit is shared between the residents, the owner, the society and the State.

Shared OLCC for the Aarhus SHE Project



Source : La Calade

If we consider that the market price of sustainable building is raised as the Ozzano project by 12% (except for Bourgoin and Aarhus, whose flats are rented), we get the following new sharing out between two stakeholders, the resident and the social cooperative:

Benefits and Losses for the social cooperative and for the resident in case of a sale price premium of 12% (in euro per square meter)

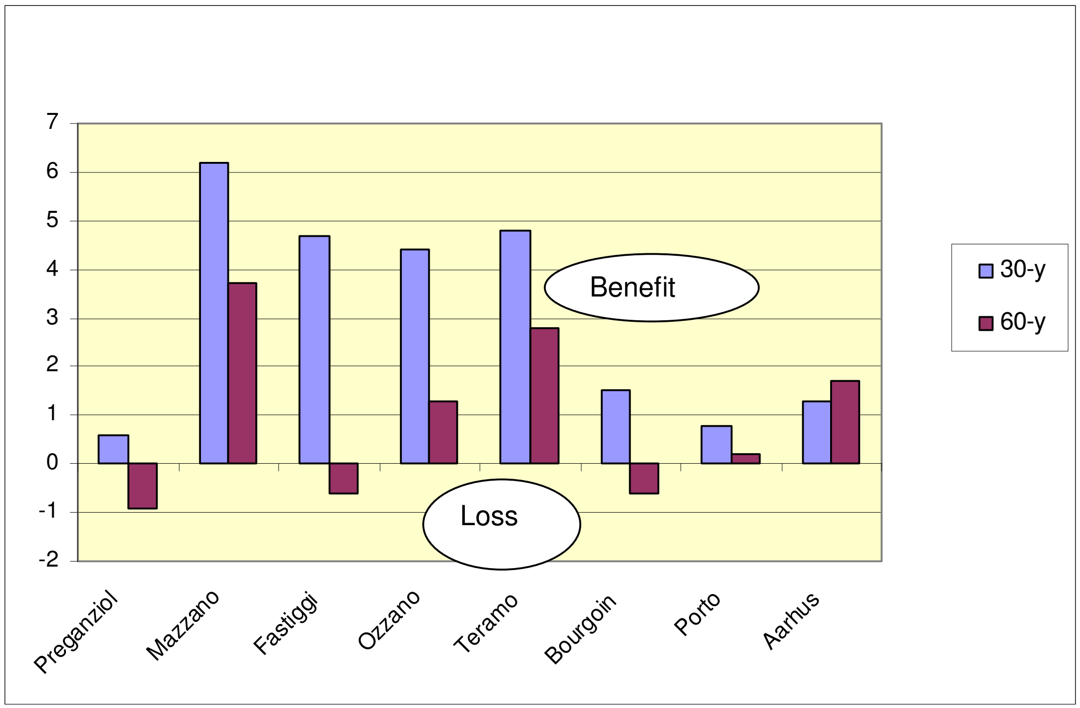
Project	Preganziol		Mazzano		Fastiggi		Teramo	
SHE Partner	COIPES, Mestre		CONSEDI, Brescia		COPES, Pesaro		CCICASA, Teramo	
	30	60	30	60	30	60	30	60
Premium for SHE Building Sale	9.8	7.5	13.1	9.7	14.8	7.9	12.9	8.7
Social Housing Cooperative	6.5	5.3	-5.4	-5.9	2.6	3.5	4.1	2.0
Resident	0.1	4.5	5.7	10.2	7.2	13.9	-4.8	-0.5

Source: La Calade for SHE

All the SHE projects are now beneficial for the social owner either for 30 or 60-year-calculation periods, except for Brescia project. For the resident, the projects are still beneficial for 30 or 60-year-calculation periods for all the SHE projects except for Teramo for the 30-year-calculation period (remind that water and electricity savings are not included in the evaluation).

We have moreover not considered the benefits for the social owner/cooperative of exoneration of property taxes or of a reduction for high environmental efficient buildings of urbanisation costs (in France "Taxe Locale d'Equipement" or something similar). This is susceptible of changing the social owner/cooperative losses into benefits.

The Benefits and Losses for society for a 30- year and 60-year-calculation period (in €/m².year)



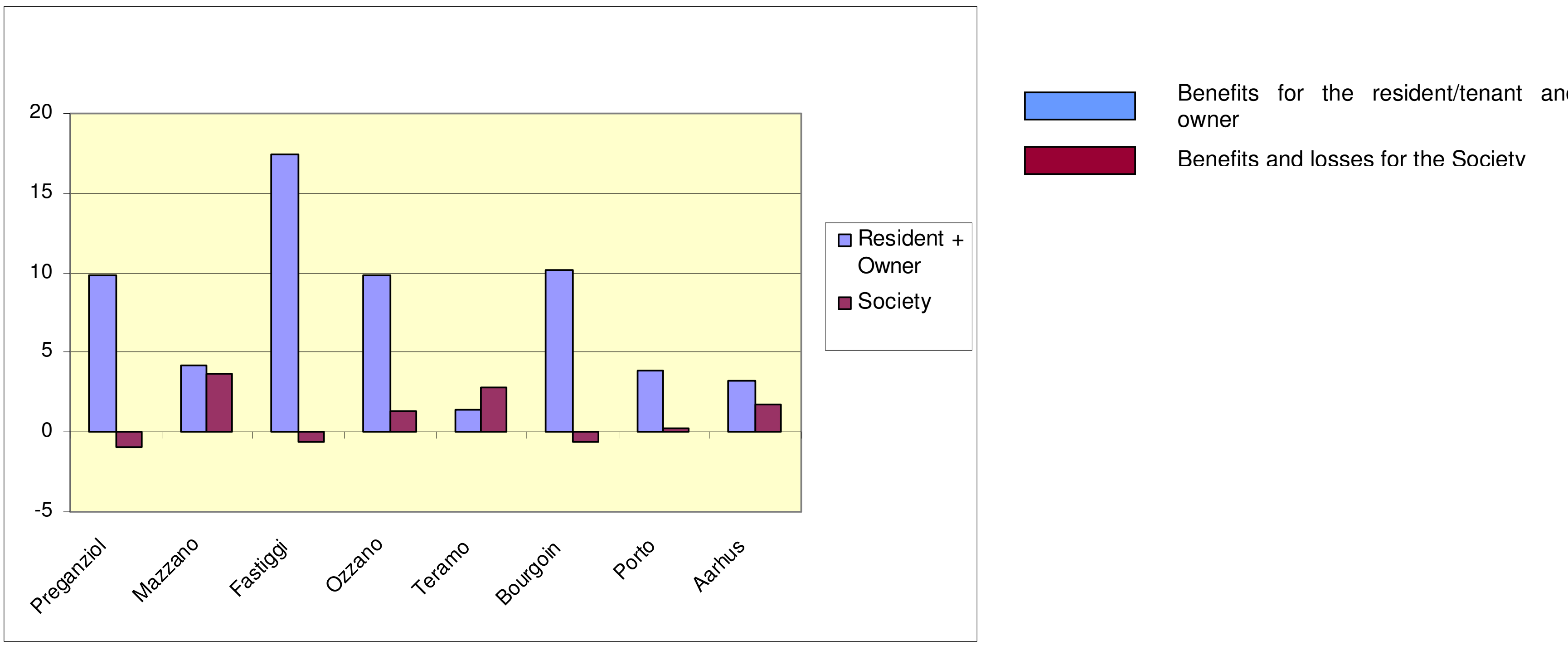
Source: La Calade for SHE

For Preganziol, Fastiggi and Bourgoin-Jallieu projects, the losses for society correspond to reductions of energy and water economic activities' added value (activities of distribution or of production), linked to energy and water saving.

However, only a part of the benefits brought to the society by the construction of a more sustainable building is taken into account in the SET-SHE model; e.g. benefits for the society stemming from the reduction of greenhouse gas and atmospheric pollution emissions and from the avoided acoustic pollution. We could imagine that if more externalities were taken into account, or if the ton of carbon were rapidly increasing, all the SHE projects would result in benefits for the society.

Moreover, the calculation of benefits or losses for the society doesn't take into account the return to the society of a part of the supplementary money that is at the tenant/resident's disposal thanks to charges reduction. The resident would indeed save a part of it and spend the other part, the proportion being difficult to know. Even if only a part of the benefits for the resident is commuted into benefits for the society, we could assume that more sustainable housing is meaning benefits for the society.

The benefits and losses for the society and for the resident/tenant and owner for a 60-year-calculation period (in euro per square meter)



Source: La Calade for SHE

4.3 - ELEMENTS OF DISCUSSION FOR IMPROVING THE BALANCE OF THE PROJECTS

Certain projects don't reach the economic balance of Direct Life Cycle Cost. However, we didn't include in the calculation of the DLCC the subsidies for building sustainable housing from Europe or any other subsidies from national and local authorities. We would thus in this chapter look at the impact of these financial incentives on the economic impact of the SHE project.

4.3.1 - Subsidy impact on the economic balance of the SHE projects

The SHE projects have benefited from subsidies from Europe. If we take into account these subsidies (plus the local and national subsidies received by Bourgoin project), we get the following balance of DLCC:

New DLCC balance in € / m².year *(Source La Calade)*

Project	Preganziol		Mazzano		Fastiggi		Ozzano		Teramo		Bourgoin		Porto		Aarhus	
SHE Partner	COIPES, Mestre		CONSEDI, Brescia		COPES, Pesaro		COPALC, Bologna		CCICASA, Teramo		OPAC 38, Grenoble		NORBICETA, Porto		RINGAARDEN Aarhus	
	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60
DLCC SHE savings	3.4	8.1	-7.1	0.4	-2.1	11.0	-2.8	6.5	-5.2	- 1.0	1.7	8.3	0.9	5.3	- 3.6	5.7
SHE Subsidies for SB	0.6	0.4	1.2	0.9	9.0	5,0	3.0	2.1	6.0	4.1	4.1	2.2	2.5	2.0	4.0	2.2
DLCC SHE savings with subsidies	4.0	8.5	- 5.9	1.3	6.9	16	0.2	8.6	0.8	3.1	5.8	10.6	3.4	7.3	0.4	7.9

Except for Mazzano project (30 year calculation period), all the SHE projects are beneficial, either for 30 or for 60-year-calculation periods.

4.3.2 - Market price versus subsidies

The debate between market price or rent increase and subsidies from local or national authorities is about: who has to pay for the overcost of investment building sustainable housing? For the most cases if we don't take into account the exceptional European subsidies that are not transferable, the overcost is supported by the social housing/cooperative, except for France for which through a grant it is partly supported by the local authorities.

It is however the tenant or buyer that will benefit from the overcost invested through a reduction of its charges, reduction that will grow with the increase of energy and water prices (while the society at a whole will benefit from a reduction of atmospheric pollution and of CO_2 emissions).

It could thus seem sensible and natural that the tenant would have an increase of rent corresponding to its reduction of charges, thus benefiting of an enhancement of comfort without having to pay for it. However, in France, the raise of rent for social housing is very restricted by law and this reasoning is thus not easy to apply without a change in these rules.

It seems equally natural that the buyer which would also benefit from a reduction of charges linked to a more sustainable house would pay a premium for acquiring this house, as it was the case for the first sales of Ozzano (Bologna) case study whose social dwellings have been sold with a bonus of 12% (a possibility studied in chapter 4.4.6). If the premium reflects the savings enabled par a sustainable building, the resident would indeed still benefit from buying a sustainable house.

This is however not always possible for buyers to have the necessary loan supplement for paying this premium, and in the case of social housing this have to be particularly taken into account. Special financial products, which would be reimbursable each month by to the money saved through the reduction of charges, have to be further developed so as to cover this extra cost. This type of financial product exists already in some banks in France. However, this also still depends on the "readiness" of the market to sell at higher prices sustainable housing. In the meantime, subsidies from local and national authorities could still be necessary.

Thanks to the application of the European directive on the Energy Performance of Building, the energy saving would moreover be clearly labelled for the future tenant or buyer, thus facilitating changes of the real estate market (and in a smaller measure of the house renting market).

We could also discuss of the possibilities that externalities created by more sustainable housing and beneficial to the society would be taken into account by local and national authorities through financial incentives (other than subsidies) like: reduction or temporary exoneration of local housing taxes for sustainable constructions, or reduction of urbanisation cost in Italy ("Taxe Locale de l'Equipement" in France).

CHAPTER 5 – THE INTEREST OF THE SET-SHE MODEL FOR SOCIAL OWNERS AND COOPERATIVES

The interests of the SET-SHE model are several. It underlines for the society the economical and financial stakes of environmental objectives that have to be fulfilled by buildings. The SET-SHE model shows that even in case of familiarisation with new technologies (energy and water low-consuming, use of natural materials…), the sustainable buildings projects are economically profitable on a long-term. They require indeed supplementary investments but the projects result practically all in benefits that in a long-term are superior to the initial investment overcosts.

The SET-SHE model, until now, was used as an assessment model ex-post, the assessment of the costs being made on the basis of the projects (companies' quotes, market prices). The model contains hypothesis on prices (energy; water) that could be used as adjustable parameters, but the model has still not be used ex-ante as a decision aid tool so as to define the technical options.

To use the life cycle costing ex-ante requires an initial knowledge of the techniques and an assessment of their impact on the buildings running. These elements could be modelised as this has been done with the energy retrofitting of buildings (Factor 4 model, a project coordinated by SUDEN, Intelligent Energy Programme for Europe). This prospective aspect of the model could be developed with the Italian cooperatives.

The SET-SHE model was used during the construction phases of buildings. The operating data are estimations stemming from technical studies. The model could then be easily used as a tool for monitoring buildings. It's already the case for the operation of OPAC 38 in Bourgoin for which the data for three running years are available. The real evolution of a building's life cycle cost could be thus monitored and result in possible readjustments. More generally, the life cycle costing makes sense only in the framework of a dialog with the partners. The assessment of the shared overall life cycle cost is based on several hypotheses which have also to be shared between the project's partners. Externalities for example make sense only for those who benefit from them or bear their inconveniences. The value of greenhouse effect gas, estimated either for prevention or reparation is strongly linked with political choices. The value of noise pollution, landscape is very subjective and could be an object of study with the inhabitants…

The SET-SHE model has to remain transparent and easily usable. However, the rules for using the model have to be always respected so as to maintain the coherence of the approaches.

In this aim, the SET-SHE model could gather all the users in a club which would deal with the evolution of the model and the capitalisation of the results. This capitalisation is important as it is the condition for giving a « status » to the approach and a « sense » to the results.

PART 2 – SOCIAL ASPECTS TOWARDS SUSTAINABILITY IN THE SHE PROJECT

CHAPTER 1 – THE METHODOLOGY FOR THE SHE – PROJECT

Speaking **about social aspects in housing** and especially in sustainable housing requires raising many issues:

- **Who are the individuals concerned by social aspects in housing?**

  The inhabitants are obviously concerned, and they are not the only ones. The neighbours are also concerned, as the building of a new housing will change their environment and will create pollutions (building site) and benefits (threshold effect for the construction of new equipments for example).

- **When do social aspects concern the individuals?**

  The individuals are concerned at every moment in the building life cycle, which means that social aspects concern the workers in charge of the building site as well as the inhabitants who will live in the buildings, the employees of management and maintenance of the building and the other users of the neighbourhood equipment.

- **What does the term of social aspects involve?**

  Spontaneously we think about quality, comfort, well-being… but we must also include the social capital, the social development, the social equity… However these words require to be precised in an integrated approach.

The social benefit of sustainable buildings and especially of those of the SHE project has been assessed by means of a **questionnaire.** Then, this questionnaire has been analysed in order to present a synthetic point of view of the social impacts of the SHE projects fir each SHE partner.

The social impact of a building project concerns five topics which correspond to different issues of the sustainable development: social equity, quality of the life, integration in the city, quality of work conditions and negotiated decision.

➢ 1 – Social Equity

The sustainable building must be focussed towards all the population categories. Particularly sustainable buildings must benefit to the low-income households with the reduction of future running charges. New financing rules are often necessary to allow this population having the possibility to get these types of flats. Co-operation with local authorities is also necessary to cover the extra-costs for investment in sustainable construction.

In other terms, the sustainable buildings can contribute to social redistribution. It concerns globally the level of rent and charges of housing. Housing is generally an important part of the inhabitants' revenues and the aim of a sustainable building is to contribute to the reduction of this part. This can be done thanks to many elements as high efficiency of equipment and services as well as common services and equipments in the building.

➢ 2 – The residents' satisfaction.

The objective of the cooperatives and social owners is to provide attractive and quality housings with the best quality – price ratio. The result must be a high satisfaction for the residents.

Three categories of social impacts can be analysed:

- **Welfare and comfort**: It directly concerns the quality of life and the comfort the residents benefit from. This point will be assessed thanks to many precise questions on the quality of housing, of open spaces…
- **Social capital**: The social capital is a factor that measures the quality of the social relations of the residents. This factor can be partly measured thanks to the evaluation of the solidarity actions between the residents.
- **Accessibility**: The accessibility of the buildings especially concerns old people and handicapped persons who require specific equipments for their well-being.

- **3 - The integration of the SHE buildings in the neighbourhood**.

This part regards the integration of the SHE buildings in the neighbourhood. The SHE buildings are part of a neighbourhood, which is part of a town or a village. This feeling of membership is very important, as it contributes to the identification of the inhabitants. In this part, two dimensions of the social aspects will be treated:

- **Integration**: A building continuously interacts with its neighbourhood and the neighbourhood also interacts with its continuous areas and surroundings. This relation creates the feeling of identification, and this feeling is positive if the inhabitants consider that their territory is not excluded from development. This feeling of permeability can be dissected into many elements: the existence of efficient public transportation, the existence of public services…
- **Urban diversity**: The existence of different functions contributes to the dynamism of the neighbourhood and also to the quality of life of the inhabitants. Small traders, leisure, cultural and sportive equipments are usually welcomed by the residents of each neighbourhood.

- **4 - The social aspects during the SHE building sites.**

Social aspects concern two types of population during the building construction phase: the workers, and also the neighbours living in the surroundings during the building sites.

- **The workers**: It concerns the training they have beneficiated during the building sites and consequently the improvement of their quality of work.
- **The neighbours living in the surroundings**: The social dimension treats with the reduction of nuisances for the neighbours during the building sites in terms of noise, air pollution, space occupation…

- **5 – The social impacts for the Cooperatives and Social owners**

The SHE project is innovative for the involved cooperatives and the social owners. So the SHE project has some impacts on the behaviours of the different stakeholders:

- Usual business of all the cooperatives departments are concerned by the project and must move;
- Relations with construction companies, craftsmen and clients can also be modified towards more negotiation;
- Relations with the public authorities must be modified in order to include in the negotiation the environmental, social and economic aspects both.

The proposed questionnaire includes about one hundred questions which can be used by the cooperative or the social owner from the ex ante assessment in order to define the expected results of construction projects.

- **Then, this questionnaire could be used again during the running phase of the buildings.**

Indeed, many questions can be used to really appreciate the residents' satisfaction when they are living in their dwellings.

- **The SHE social approach**

The approach is as following:

1. Working out of a questionnaire (by La Calade) aiming at analysing all the social aspects regarding the building project for the different stakeholders. This questionnaire is to be filled by the cooperative or the social owners but concerns future residents, the owner, the construction companies and the neighbours.
2. This questionnaire is adapted for each SHE project regarding the presence or not of residents in the buildings before the end of the SHE project in the case of rented flats, the questionnaire is completed by a questionnaire directly sent to the residents, which makes possible to get an overview of the social situation. The whole analysis is replicable to other projects of the SHE partners
3. Questionnaire completed by the SHE partners
4. Analysis of the questionnaires by La Calade
5. Working out of a report presenting a synthetic analysis of social aspects relative to each SHE partner

CHAPTER 2 – THE SOCIAL QUESTIONNAIRE

PRELIMINARY QUESTIONS

1. How many flats does the project have?

…………………………………………………………………………………………..

2. How many inhabitants are currently expected to live in?

……………………………………………………………………………………………………..

3. When has the project been finished (in terms of construction)?

…………………………………………………………………………………………………….

1. SOCIAL EQUITY

4. What is / will be the status of the residents?

- ☐ Renters ☐ Owners
- ☐ There are both
- ☐ If both, precise which percentage of each category

5. What is the social status of the residents (various answers possible)?

- ☐ Unemployed workers ☐ Pensioners, retired
- ☐ Workers ☐ Technicians and employees
- ☐ Executives, managers ☐ Students

- ☐ Single person ☐ Young couple
- ☐ Families with children ☐ Old people

6. What is the income of the residents per person and per month? *(income of the household divided by the number of shares with 1 adult = 1 share, 1 child more than 14 years old = 0.5 share, 1 child below 14 years old = 0.3 share).*

- % households less than the poverty threshold :
- % between the poverty threshold and the median income :
- % more than the median income :

7. What is the age of the owners (%)?

- ☐ Less than 18 years ☐ Between 18 and 25 years
- ☐ Between 25 and 35 years ☐ Between 35 and 50 years
- ☐ Between 50 and 65 years ☐ More than 65 years

8. How many families are there with only one parent?

……………………………………………………………………………………………………..

2. RESIDENTS' SATISFACTION

WELFARE

9. What is / will be the charge of the flat inside the residents' income (in percentage) (loan + charges including subsidies)? *Tick the majority or indicate a percentage for each type.*

- ☐ Less than 15% ☐ Between 15% and 25%
- ☐ Between 25% and 35% ☐ More than 35%

10. What is / will be the average amount of the loan in euro per year and per m² living space?

…………………………………………………………………………………………………

11. What is the expected average amount of the charges in euro per year and per m² living space?

……………………………………………………………………………………………………..

12. Is there a common laundry for the buildings of the project?

- ☐ Yes ☐ No

13. Is there a common and safe room to store pushchairs and bicycles for the project?

- ☐ Yes ☐ No

14. Are there open spaces for children?

- ☐ Yes ☐ No

If yes, specify the surface:

……………………………………………………………………………………………...

15. Are there common green spaces?

- ☐ Yes ☐ No

If yes, specify the surface:

……………………………………………………………………………………………...

COMFORT

16. Do the buildings have been built in order to make the temperature being still between 18 and 24 ° C ?

- ☐ Yes ☐ No

If yes, specify what has been done in this sense ?

……………………………………………………………………………………………

17. Is there the possibility to regulate individually the heat (for each flat)?

- ☐ Yes ☐ No

18. Do the flats have systems or equipments to protect them from the sun and the heat?

- ☐ Yes ☐ No

19. Has the building been built in order that the humidity of the flats be regulated between 40 and 60%?

- ☐ Yes ☐ No

If yes, specify what have been done in this sense:

………

20. Do the flats have double glazing with a high energy performance?

- ☐ Yes ☐ No

If yes, specify the technology:

……………………………………………………………………………………………………

21. Are the buildings built with natural materials?

- ☐ Yes ☐ No

If yes, specify the kind of materials that has been used and why:

………

22. Have the buildings been built with the awareness of indoor air quality?

- ☐ Yes ☐ No

If yes, specify what have been done in this sense:

………

23. What is the average number of persons per room in the dwellings?

- ☐ less than 0.9 ☐ between 0.9 and 1.1
- ☐ more than 1.1

24. Is there any dwelling with more 1 child per bedroom?

- ☐ Yes ☐ No

If yes, specify where:

…………………………………………………………………………………………

25. What is the surface of the living-room?

For a two-roomed flat:

- ☐ Less than 15 m^2 ☐ Between 15 and 20 m^2 ☐ More than 20 m^2

For a three-roomed and four-roomed flat:

- ☐ Less than 20 m^2 ☐ Between 20 and 25 m^2 ☐ More than 25 m^2

26. Do the rooms have all an opening (window) on the outside (except the toilets)?

- ☐ Yes ☐ No

If no, specify the room(s) that do not have an opening on the outside:

…………………………………………………………………………………………………

27. What is the percentage of flats with double exposure in the buildings?

…………………………………………………………………………………………………..

28. Can the flats be adapted or modified according to the needs?

- ☐ Yes ☐ No

If yes, specify what have been done in this sense:

………

29. How far is the car park from the building(s) entry?

- ☐ Less than 10 meters ☐ Between 10 and 30 m. ☐ More than 30 m.

30. Is the car park subterraneous?

- ☐ Yes ☐ No

31. How many parking places per dwelling?

- …………………………………………………………………………………………

32. Are there green spaces around the buildings (precise if private or public green spaces)?

- ☐ Yes ☐ No

33. Are there usable by children and adults (accessibility)?

- ☐ Yes ☐ No

34. Have the children a space outside the flats to play in security, seen from the dwellings?

- ☐ Yes ☐ No

35. Is this space a green space?

- ☐ Yes ☐ No

36. Are there special equipments for children and young people on or near this space?

- ☐ Yes ☐ No

If yes, specify which they are:

………

37. Are the buildings built near (less than 300 meters) high voltage cables?

- ☐ Yes ☐ No

SOCIAL CAPITAL

38. Is there a common space where the inhabitants could socialize?

- ☐ Yes ☐ No

If yes, specify the surface

…………………………………………………………………………………………………

If yes, specify which type is used

…………………………………………………………………………………………………

39. Is there a room in the building (inside or outside) where the inhabitants could meet each other or organise events?

- ☐ Yes ☐ No

40. How many persons can this room welcome?

- ☐ Until 15 persons ☐ Between 15 and 25 persons
- ☐ Between 25 and 40 persons ☐ More than 40 persons

41. Are collective events organised between the neighbours of the flats and buildings?

- ☐ Yes ☐ No

If yes, specify the type of events organised: (and per whom (associations or others?):

…………………………………………………………………………………………………

If yes, how many events are organised per year?

………………………………………………………………………………………………..

42. Do the residents share the maintenance tasks of the building(s)?

- ☐ Yes ☐ No

If yes, specify these kinds of task:

……

43. Do the buildings have been damaged (voluntarily) by the inhabitants?

- ☐ Yes ☐ No

If yes, specify the type of damages

……

44. Have the inhabitants initiated solidarity actions between them?

- ☐ Yes ☐ No

If yes, specify the type of actions

………

45. Is there an association or a representative of the residents (for the building's management or maintenance)?

- ☐ Yes ☐ No

If yes, specify the actions of the association or the representative:

…………………………………………………………………………………………………

ACCESSIBILITY

46. Have the buildings and the flats been built to welcome old and handicapped persons (beyond the regulation)?

- ☐ Yes ☐ No

If yes, specify what have been done in this sense:

…………………………………………………………………………………………………

47. Are the flats accessible to very low salaries[7] (less than 600 euros for a single person, less than 900 euros for a couple, less than 1300 euros for a couple with two children…)?

…………………………………………………………………………………………………

48. What is the percentage of flats with interior fittings adaptable to handicapped persons?

…………………………………………………………………………………………………..

49. How many levels are there in the buildings? ………………………………………………………………………………………

50. Are there elevators?

- ☐ Yes ☐ No

[7] *These numbers are for France. The level of poverty is the half of the median salary.*

3. INTEGRATION OF THE SHE BUILDINGS IN THE NEIGHBOURHOOD

INTEGRATION

48. Do the residents have the feeling that the building is part of the neighbourhood, and that the neighbourhood is part of the town?

- ☐ Absolutely yes ☐ Yes
- ☐ No ☐ Absolutely no

49. In which percentage do the residents have answered absolutely yes or yes?

- ☐ More than 90 % ☐ Between 70 e 90 %
- ☐ Between 50 and 70 % ☐ Moins de 50 %

50. Do the residents have the feeling to be excluded from the city's life and activities?

- ☐ Yes ☐ No

If yes, specify from where this impression comes

………

51. Do the residents have an easy access to public services as administrative offices, post office, etc. (less than 400 metres by foot)?

- ☐ Yes ☐ No

52. Is the building deserved by public transports?

- ☐ Yes ☐ No

If yes, specify the various types of public transport:

………

53. How far is the public transport station or stop (in meters)?

………………………………………………………………………………………………………..

54. Is public transport satisfying in terms of quality?

Frequency

☐ Yes ☐ No

Punctuality

☐ Yes ☐ No

Comfort

☐ Yes ☐ No

Security

☐ Yes ☐ No

Service road (number of stations)

☐ Yes ☐ No

Accessibility for handicapped persons

☐ Yes ☐ No

55. Are there cycling ways or pedestrian ways close to the project?

- ☐ Yes ☐ No

56. Are these cycling ways and pedestrians ways towards the main equipments (school, post office…) secure?

- ☐ Yes ☐ No

57. Are these cycling ways and pedestrians ways towards and until the city centre?

- ☐ Yes ☐ No

58. Do the residents regularly use public transport?

- ☐ Yes ☐ No

59. For which type of displacements do the residents regularly use public transportation (various answers possible)?

- ☐ Go to work ☐ Go to school

- ☐ Go shopping ☐ Go for a walk
- ☐ Go to sportive or leisure equipments

If there are specific data furnished by the public transportation, specify:

………

URBAN DIVERSITY

60. Is the neighbourhood only made of housing?

- ☐ Yes ☐ No

61. If no, which are the others functions in the neighbourhood (various answers possible)?

- ☐ Schools ☐ Small traders
- ☐ Supermarkets, commercial centre ☐ Public administration
- ☐ Offices ☐ Restaurants and bars
- ☐ Sportive equipment ☐ Leisure and cultural equipments
- ☐ Retirement housing
- ☐ Others:

Specify………………………………………………………………………………….

62. Is the housing in the neighbourhood only constituted of social housing?

- ☐ Yes ☐ No

63. If no, which are the others types of housing (various answers possible)?

- ☐ Private multi-family housings ☐ Individual houses
- ☐ Others (specify)

64. Are there new equipments because of the additional inhabitants (school, high school, a swimming pool, etc.) ?

- ☐ Yes ☐ No

Describe the new equipments and explain why

…………………………………………………………………………………………………

……

4. SOCIAL ASPECTS DURING THE SHE BUILDING SITES

FOR THE WORKERS OF BUILDING COMPANIES

65. Have the workers been trained to realize buildings sites (with a particular concern on energy performance of the envelope, rain water management, waste management, noise reduction and water management) ?

- ☐ Yes ☐ No

If yes, specify who and how:

……

66. Have the building companies increased the workers qualification thanks to their participation to the SHE building sites (with a particular concern on waste management, noise reduction and water management) ?

- ☐ Yes ☐ No

67. If yes, in which area have they enhanced their qualification (various answers possible)?

- ☐ Organisation ☐ Waste management ☐ Energy
- ☐ Noise reduction ☐ Water management
- ☐ Others : Specify……………………………………………………………………………

68. Have the workers increased the quality of their work thanks to their participation to the SHE building sites?

- ☐ Yes ☐ No

If no, specify who and how:

………

69. If yes, in which area have they enhanced the quality of their work (various answers possible)?

- ☐ Use of new technologies ☐ Reduction of visual pollution
- ☐ Reduction of olfactory pollution ☐ Reduction of ground pollution
- ☐ Reduction of the water consumption ☐ Avoid the pollution of rain water
- ☐ Reduction of the energy consumption ☐ Reduction of dust and mud
- ☐ Improvement in waste management

70. Were there accidents during the building sites?

- ☐ Yes ☐ No

If yes, specify the types of accidents and their causes:

………

FOR THE SURROUNDINGS

71. Were there buildings or houses near the building sites?

- ☐ Yes ☐ No

If yes, specify the types of buildings that were already in the surroundings:

………
………………………………………………………………

72. If yes, how far were these buildings or houses from the building sites?

- ☐ Less than 20 meters ☐ Between 20 and 50 m. ☐ More than 50 m.

73. Have the inhabitants and users of the surroundings been regularly informed about the building sites?

- ☐ Yes ☐ No

If yes, specify the information that was given to them:

………

74. Have the given information been respected (delays of the building sites…)?

- ☐ Yes ☐ No

75. Have special measures been taken to reduce the impact of the building sites on the surroundings?

- ☐ Yes ☐ No

If yes, specify what these measures were:

………

76. Were there claims from the inhabitants of the surroundings during the building sites?

- ☐ Yes ☐ No

If yes, specify what the claims were:

………

77. Has the project been the support of environment education actions?

- ☐ Yes ☐ No

If yes, specify what were the characteristics and the partners (schools, universities…)

……

78. Has the project (positive or negative) any impact on the local enviroment (cf. European Directive 2001/42/CE)?

- ☐ Yes ☐ No

If yes, specify what these impacts are?

……

79. Has the project (positive or negative) any impact on the local development?

- ☐ Yes ☐ No

If yes, specify what these impacts are?

………

80. Has the project (positive or negative) impacts for the site neighbours ?

- ☐ Yes ☐ No

If Yes, specify what are the characteristics (parking for example, access to services or equipments…):

…………………………………………………………………………………………………

…………………………………………………………………………………………………

81. Are there other issues that you would like to raise?

………

5. SOCIAL ASPECTS FOR THE SHE SOCIAL OWNERS

82. In the SHE project, what is the most important thing from the point of view of social owners ?

………………………………………………………………………………………………

………

83. What will you do now in all your projects (taken from the SHE project or experience) (Cf. “from extraordinary to ordinary”…)?

………………………………………………………………………………………………

……

84. Are there others questions or issues that you would like to raise ?

……

CHAPTER 3 – RESULTS OF THE SOCIAL QUESTIONNAIRE

The following chapter presents a synthetic analysis of the various SHE projects' social inquiry.

Except the Bourgoin – Jallieu project, the SHE projects do not make it possible a complete assessment in the extent where the flats have not been sold or rented for enough time. The social monitoring is only starting and we need two or three additional years more to have a complete feedback about the buildings and the resident's behaviours.

So, a large part of the information collected directly comes from the cooperatives services.

The assessment comes also from our external point of view.

The questionnaire worked out can be summarised in 23 topics which are focusing on the different fields of the social analysis. For each topic, in regards to the questionnaire, it has been assessed how it has been taken into account:

- in an **exemplary** way
- **well done** : i.e. better than the usual practice
- **minimum** done : i.e. equal to regulation or to the usual practice
- **nothing done** : i.e. that the usual practice consists in to do nothing and the SHE project do modify nothing
- **out of purpose** : i.e. that the SHE project is not concerned by this topic

The next pages are the synthetic social analysis for each project (cooperative or social owner).

Project : PREGANZIOL COOPERATIVE : COIPES			How is the topic taken into account ? :				
			Out of purpose	Nothing done	Minimum done	Well done	Exemplary
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?				■	
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					■
3		Quality of the indoor air and ventilation				■	
4		Available space, surface, adaptation to the needs				■	
5		Reduction of pollution (acoustic, electromagnetic)…				■	
6		Orientation, exposure, visual comfort,					■
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					■
8		Maintenance of the building and surroundings			■		
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…			■		
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					■
11	Car park quality	Balance between the space consumption and the cost…					■
12	Appropriation of the building by its inhabitants	Association of residents, common activities…	■				
13	Accessibility to old and handicapped persons				■		

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

PREGANZIOL project characteristics:

All the flats are not sold. The housing market in the Venice province has now an oversupply of housings but several cooperative employees have wished to buy a flat in this residence, which is a positive indicator.

<u>Main focus</u>

Topic 6 : Visual comfort :

This criteria is particularly important for the residents and Preganziol has a high quality of landscape and of the building environment; there is also a large space with water which contributes to the landscape quality and also to the treatment of the grey water from the building which are cleaned and can be reused.

T. 7 and 8 : Reduction of charges

The cooperative has no information about the real results but the energy objectives should have been reached, according to the present monitoring process. The final energy consumption as well as water consumption depends partly on the residents' behaviour and the cooperative does not manage it. For the SHE project, a guide for the good use of energy and water equipments is given by the cooperative to the new residents.

T.10 : Green spaces:

The SHE project dedicated a large share of the area to green spaces which can be used by the residents. This is partly explained by the underground car park location.

T.20 : Relation between the cooperative and building companies

The SHE project has improved the relations with the building companies: the required innovations have had positive impacts inside these companies: interest questions, training, and research of new abilities… But there is no impact for the local craftsmen.

T.22 : Relation with the local authorities

An important work has been done with the Mestre municipality services. The Construction Code has been modified in order to make possible the installation of solar collectors (thermal or photovoltaic panels) with adapted roof slopes.

T. 23 : Relation with other cooperatives

The SHE project has accelerated the information exchanges between the various cooperatives of the SHE project and also with the other construction cooperatives in the Venice Region.

Project : MAZZANO - Brescia COOPERATIVE : CONSEDI			How is the topic taken into account ? :				
			Out of purpose	Nothing done	Minimum done	Well done	Exemplary
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?					
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					
3		Quality of the indoor air and ventilation					
4		Available space, surface, adaptation to the needs					
5		Reduction of pollution (acoustic, electromagnetic)…					
6		Orientation, exposure, visual comfort,					
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					
8		Maintenance of the building and surroundings					
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…					
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					
11	Car park quality	Balance between the space consumption and the cost…					
12	Appropriation of the building by its inhabitants	Association of residents, common activities…					
13	Accessibility to old and handicapped persons						

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16		Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17	Quality of the building site	Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19		Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21	Added value of the SHE project	Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

MAZZANO – BRESCIA project characteristics:

Most of the flats are not sold. The housing market in Brescia province has now an oversupply of housings. Notice that four flats have been bought by employees of the construction company.

Main focus :

Topic 6 : Orientation, exposure

The Mazzano project has been studied once more after a first presentation, in order to improve the flats exposure. The SHE project has improved the exposure of the life rooms and almost all the flats benefit of nice view on green spaces.

T. 7 and 8 : Reduction of charges

The cooperative has no information. The final energy consumption as well as water consumption depend partly on the residents' behaviour and the cooperative does not manage it. For the SHE project, a guide for the good use of energy and water equipments is given by the cooperative to the new residents.

T.9 : Accessibility to common spaces

The building has an important area dedicated to common spaces. Particularly there is a large room which is equipped to receive official meetings or to allow the organisation of small events between residents.

T.10 : Accessibility to green spaces

The SHE project residents have a lot of green spaces, both private and with a co-ownership. Close to the building, open spaces have a high quality with a picnic area, a nice lake with trees on the banks. There are also walking paths and cycle tracks which are linked to the cycle track Province network.

T.14 : Accessibility to equipments

The location of the SHE building is favourable for the residents which benefit of the presence of numerous equipments and services as well as of cycle tracks and walking paths

T. 19 : Improvement of cooperative services abilities

The SHE project management by the cooperative has encouraged the development of a new methodological approach for the CONSEDI engineers: these engineers were not used to work together, and the SHE project has required more synergy between them and this allowed them to discover new working methods.

The SHE project has also favoured the choice of a collective central heating system instead of an individual central heating one which is usually installed in Italy.

T. 23 : Relation between the cooperatives

The SHE project has created a high interest and a knowledge exchange with the various local cooperatives, whatever the union membership, and also at the national level, particularly thanks to the CASAQUALITA consortium.

Project : PESARO **COOPERATIVE : COPES**			**How is the topic taken into account ? :**				
			Out of purpose	**Nothing done**	**Minimum done**	**Well done**	**Exemplary**
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?				■	
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					■
3		Quality of the indoor air and ventilation				■	
4		Available space, surface, adaptation to the needs				■	
5		Reduction of pollution (acoustic, electromagnetic)…				■	
6		Orientation, exposure, visual comfort,					■
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					■
8		Maintenance of the building and surroundings			■		
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…				■	
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					■
11	Car park quality	Balance between the space consumption and the cost…			■		
12	Appropriation of the building by its inhabitants	Association of residents, common activities…	■				
13	Accessibility to old and handicapped persons					■	

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

PESARO project characteristics:

All the flats are sold. The SHE project has been the award winner of a competition (organised by the Region and the Province) for the construction of 100 friendly-environmental housings. The site spreads on 15 hectares and includes 360 housings of which 130 are built by ANCAB, 130 by COPES and 100 by various organisations. COPES has won the competition for 100 housings, and has received an award of 35 000 € per flat, i.e. 18 % of the construction price.

Main focus :

T.7 : Reduction of charges

The SHE project aimed at saving water and recoveries rainwater thanks to a valley network leading the water towards a water collecting pond but the regional water Agency has up to now refused to install one kilometre of pipes.

T.14 : Accessibility to equipments and services

The location of the SHE building is favourable for the residents which benefit of the presence of numerous equipments and services as well as cycle tracks and walking paths

T.18 : Contribution to environment education

A work has been implemented with the local schools about the valleys (decoration, pictures…)

T.19 : Improvement if cooperative services abilities

The SHE project has favoured a movement into cooperative services towards quality and innovation. All the cooperative services have been concerned. This action is particularly due to the work done with the « SHE project researchers ».

The cooperative engineers have explained to the cooperative members (new residents) the interest of the collective central heating system compared to the individual central heating one usually installed in Italy. Before, it has been necessary to train the engineers to this technology and then to prepare engineers to work with the inhabitants. The work of the marketing persons had to be modified because they were usually the lone persons to have any contact with inhabitants. This process will be included in the work related to the respect of the ISO 9000 label

T.22 : Relation with local authorities

The SHE project has contributed to the greening of the local Construction Code.

T.23 : Relation with other cooperatives

The SHE project has created a cooperation and innovation movement between the partner cooperatives and also between the two social housing Unions (« red » and « white »). A database upon the high environmental added value products is in project within the cooperatives of the Confcooperative (with a blog).

The project has also led the construction of 347 other similar housings, thanks to the success of the SHE programme.

Project : OZZANO DELL'EMILIA **COOPERATIVE : CONSORZIO COPALC, BOLOGNA**			**How is the topic taken into account ? :**				
			Out of purpose	**Nothing done**	**Minimum done**	**Well done**	**Exemplary**
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?					
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					
3		Quality of the indoor air and ventilation					
4		Available space, surface, adaptation to the needs					
5		Reduction of pollution (acoustic, electromagnetic)…					
6		Orientation, exposure, visual comfort,					
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					
8		Maintenance of the building and surroundings					
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…					
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					
11	Car park quality	Balance between the space consumption and the cost…					
12	Appropriation of the building by its inhabitants	Association of residents, common activities…					
13	Accessibility to old and handicapped persons						

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16		Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17	Quality of the building site	Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19		Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21	Added value of the SHE project	Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

OZZANO Project characteristics:

All the flats are sold, in the framework of a growing market.

<u>Main focus :</u>

Topic 6 : Orientation

The SHE project had no impact on the buildings orientation which had been defined before in the urbanism (land planning) document of the City. But the project has not suffered for this orientation. However a most important empowerment with the City about this matter could have some very positive consequences.

T.7 : Reduction of charges

A monitoring of energy consumptions has been carried out at the beginning of 2008. The results confirm the energy consumption forecasts (cf. SET-SHE model, economic part).

T.8 : Maintenance

The SHE project has chosen a collective boiler that is new for the cooperative which usually sets only individual boilers. The maintenance and the lifetime of the collective central heating system are more interesting for the resident than the usual individual central heating one.

T.11 : Car park quality

A public car park is close to the SHE building and is an important pollution as regarding visual comfort. The project has wished to reduce the place of the car in the landscape by the creation of a car park partly under the building and partly with a closed car park, with a green roof. This car park offers one car place per flat.

The parking on public space or underground is not included in the technical documents which are in the local Construction Code. In fact, the regulation related to the car parking is yet to be done with the local authority.

T.17 : Building site

A Clean Building Site protocol has been developed in the whole Bologna Province (due to the LIFE European VAMP project including QUASCO and ICIE) before to be applied to the Emilia Romagna Region. This protocol favours the building site waste selective sort and collect.

T.18 : Contribution to environment education

Numerous actions have been implemented with schools which visit the building site. Information and awareness actions have been carried out with NUOVO QUASCO towards the small and medium enterprises.

T.19 : Improvement of cooperative services abilities

The cooperative engineers have participated to meetings with inhabitants, that has modified the usual marketing relations linking only the COPALC marketing persons to the future residents (cooperative member).

T.22 : Relation with local authorities

The Emilia Romagna Region has created a new Construction Code which concerns more particularly water and energy. The OZZANO project was the first project in the region to adopt it.

There is also a local protocol upon Sustainable Construction that makes possible a very good dialogue with local authorities. The City was at the origin of the project because this project was the winner of a competition managed by the Municipality. This competition required a high "score" for energy and for sustainable development. To be the winner of such a competition required to create a dialogue between the cooperative engineers and the City ones.

The result is a project which is beyond the requirements of the Regional Code.

T.23 : Relation with other cooperatives

Training and information actions have been implemented with CASA QUALITA.

Project : TERAMO **COOPERATIVE : CONSORZIO CCI-CASA**			**How is the topic taken into account ? :**				
			Out of purpose	**Nothing done**	**Minimum done**	**Well done**	**Exemplary**
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?					■
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter				■	
3		Quality of the indoor air and ventilation				■	
4		Available space, surface, adaptation to the needs				■	
5		Reduction of pollution (acoustic, electromagnetic)…					■
6		Orientation, exposure, visual comfort,					■
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					■
8		Maintenance of the building and surroundings			■		
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…			■		
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					■
11	Car park quality	Balance between the space consumption and the cost…				■	
12	Appropriation of the building by its inhabitants	Association of residents, common activities…	■				
13	Accessibility to old and handicapped persons					■	

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

TERAMO Project characteristics:

All the flats have been sold thanks to the union of three factors:

- a subsidy from the State and the Region of 20 000 € per housing (65 % State, 35 % Region) in the framework of a neighbourhood regeneration project contracted with the State (Contratti di quartieri programme), i.e 18 % of the housing price,
- the good image of the cooperative since 1975,
- the innovations in the flats which have been well understood and agreed by the purchasers (residents).

Main focus :

Topics 1, 14 and 15 : social mix / integration of the SHE building in the neighbourhood

The SHE project has contributed to do this « Contratti di quartieri » which is considered as the best one in Italy.

The integration of the SHE project in the Contratti di quartieri programme allowed CCI-CASA to receive a subsidy of 20 000 € per flat and that makes it possible to favour social mix: numerous households with low incomes have been able to buy this type of housing.

T.15 : Acessibility to equipments

Presence of a nursery school on the area

T.17 : Building site

Building site waste are sorted and collected.

T.22 : Relation with local authorities

The project was the opportunity to undertake an important reform of the urbanism regulation for the city of TERAMO. The land-use Plan has been modified for the SHE project in order to integrate and preserve green spaces and to orientate the buildings in the best way…

The SHE project made the street modified and obliged the electric lines around to be underground.

The SHE project has also favoured a negotiation with the City in order to improve the public transports deserve[92].

These important changes initiated by the cooperative have much contributed to the very good success of the Contratti di quartieri project.

[92] *A model has been worked out showing which would be carried out if the urbanism regulations had not been changed.*

Project : BOURGOIN - JALLIEU COOPERATIVE : OPAC 38			How is the topic taken into account ? :				
			Out of purpose	Nothing done	Minimum done	Well done	Exemplary
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?					
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					
3		Quality of the indoor air and ventilation					
4		Available space, surface, adaptation to the needs					
5		Reduction of pollution (acoustic, electromagnetic)…					
6		Orientation, exposure, visual comfort,					
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					
8		Maintenance of the building and surroundings					
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…					
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					
11	Car park quality	Balance between the space consumption and the cost…					
12	Appropriation of the building by its inhabitants	Association of residents, common activities…					
13	Accessibility to old and handicapped persons						

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

BOURGOIN-JALLIEU Project characteristics:

This is the first building occupied and an enquiry has been sent to tenants and gives the following main results.

Main focus :

Topic 1 : Social Mix

Construction of social housings in the city centre has been possible thanks to the City which has given the land property.

T.4 : Comfort

The layout of the flat, the available space and the rooms size are appreciated by the tenants (however there is a lack of storage space for some tenants)

T.5 : Reduction of pollution

Generally, for tenants, there is too much noise between the flats. Moreover, the flat gives onto the covered passage is noisy (less acoustic insulation of the brick, phonic reverberation).

T.7 and 8 : Reduction of charges

After the corrections due to heating problems the first year, the results in terms of reduction of charges are widely reached.

T.9 : Accessibility to common spaces

The common spaces are accessible and large, except the space for caddies and bicycles which is considered as too small.

T.11 : Car park

The underground car park is appreciated whereas the outside car park is considered as too small.

T.12 : Appropriation of the building by its inhabitants

This appropriation is presently positive and efficient after the corrections brought by the environmental quality management committee (Comité de Gestion HQE) including inhabitants.

T.13 : Accessibility to old and handicapped persons

Only the flats at the first floor are accessible. There is no lift (in order to reduce charges) but a space for a future lift is foreseen.

T.14 and 15 : Integration in the neighbourhood

The SHE project is in the city centre and benefits of all the services and equipments of the city.

T.16 : Building site

The masonry is made with the Monomur brick, that required a specific training for the layers and the sort of building site waste on the site allowed to aware the workers

T.19 : Improvement of social owner services abilities

The SHE project is the first operation with a high environmental quality level (named HQE) managed by OPAC 38. This operation is an example and a reference for the company.

T.21 : Relation with tenants

Creation of an environment quality management committee with inhabitants.

Project : PORTO COOPERATIVE : NORBICETA			How is the topic taken into account ? :				
			Out of purpose	Nothing done	Minimum done	Well done	Exemplary
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?			■		
Residents' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter				■	
3		Quality of the indoor air and ventilation				■	
4		Available space, surface, adaptation to the needs			■		
5		Reduction of pollution (acoustic, electromagnetic)…			■		
6		Orientation, exposure, visual comfort,				■	
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					■
8		Maintenance of the building and surroundings				■	
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…			■		
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					■
11	Car park quality	Balance between the space consumption and the cost…					■
12	Appropriation of the building by its inhabitants	Association of residents, common activities…		■			
13	Accessibility to old and handicapped persons					■	

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

PORTO Project characteristics:

Main focus :

Topic 1 : Social mix

The housings of the Ponte da Pedra building have been sold to the cooperative members. Even if NORBICETA has not received any subsidy from the State (except a financing from the Housing Institute), the sale price of the flats is accessible for all the persons which have done a demand.

T.2 and 3 : Thermal comfort and indoor air quality

From energy data and the results known up to now, in winter, the inhabitants of 4 flats which have been chosen for an energy and environmental monitoring consider that their flat is globally comfortable, with a nice indoor temperature. However a few inhabitants think that the indoor temperature is too low. Most of them affirm that the temperature is relatively stable. The indoor air quality is good, in terms of humidity and odor.

T.5 : Reduction of pollution

According to noise measures carried out by the Minho University, the SHE building respects the regulation rules in most of the measured points (cf. Monitoring study).

T.6 : Orientation

There is no local or national regulation for building orientation and exposure. There are some recommendations from the National Laboratory of Civil Engineering towards the promoters and building constructors. From these recommendations, the SHE project has good results related to the use of natural lighting.

T.7 : Reduction of charges from utilities

Regards to water and energy consumption, the first results of the monitoring show that the consumption is reduced in the flats as well as in common spaces.

T.8 : Reduction of maintenance charges

Even if the operating costs are in the average for new construction (lift, energy consumption for common spaces), a drastic reduction of repair costs is forecasted because the building has been erected with sustainable materials.

T.9 : Accessibility to common spaces

There is a common room where the residents can come and discuss about problems belonging to the building. There is no bicycle storage place nor common laundries.

T.10 : Accessibility to green spaces

The building offers a large and attractive open space : several green spaces, streets, a lake, a multi-purpose place to practice sport, a space for children…

T.11 : Car park

The inhabitants have an underground and private car park for one car per flat as well as an outside public car park. Outside, the spaces dedicated to parking are free and it is relatively easy to park the car outside the building.

T.14 : Quality of public transport

There is one bus line which makes the link between the SHE building and the cities of PORTO and MAIA. However, there is no public transport to the MATOSINHOS city centre (which is the city of the SHE project).

T.15 : Urban diversity

On the other side of the street, in front of the SHE building, there are many services : bakery, butchery, supermarket, pharmacy, bank…

T.17 : Building site

The SHE project contributes to the recycling of waste issued from the building construction.

T.18 : Contribution to environment education

The dissemination activity of NORBICETA has started at the first beginning of the project. Education to environment and local development holds an important place (cf. NORBICETA report).

T.19 : Improvement of cooperative services abilities

The SHE project has improved the abilities of the Technical Department of NORBICETA. The Programmation Department of the Cooperative has also decided that all the new buildings after the SHE project shoud respect the same principles of sustainable construction

T.20 : Relation between the cooperative and the building companies

The cooperative has been more present and demanding towards the construction companies concerning the different criteria of sustainability.

T.21 : Relation with the clients

The relation between the cooperative and the members (residents) is naturally very dynamic and is based on a close and trust relationship. In the case of the SHE project, the Cooperative has implemented specific awareness and training actions towards the residents, in order to take into account the construction specificities (or innovations).

T.22 : Relation with local authorities

From the beginning of the SHE project, the central or local State organisations have accompanied the main steps of the project, participating to all the presentation and dissemination meetings. They have underlined the importance of the SHE project and they support the replication of such sustainable projects, but without any financial support.

T.23 : Relation with other cooperatives

The Housing Cooperatives member of the Union with NORBICETA have been informed and awared about the multi disciplinary approach which is necessary for any sustainable construction.

All the cooperatives have received information from the Federation, above all through the Chart of Quality of the Cooperative Housing.

Project : AARHUS **COOPERATIVE : RINGAARDEN, Aarhus**			**How is the topic taken into account ? :**				
			Out of purpose	**Nothing done**	**Minimum done**	**Well done**	**Exemplary**
1	Social Mix	Is the SHE project accessible to a large part of the population (price attractiveness, reduction of the property charge, subsidies…)?					■
Residents ' satisfaction							
2	Comfort of the flats	Thermal comfort in summer and in winter					■
3		Quality of the indoor air and ventilation				■	
4		Available space, surface, adaptation to the needs				■	
5		Reduction of pollution (acoustic, electromagnetic)…				■	
6		Orientation, exposure, visual comfort,					■
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…					■
8		Maintenance of the building and surroundings				■	
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…					■
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)					■
11	Car park quality	Balance between the space consumption and the cost…					■
12	Appropriation of the building by its inhabitants	Association of residents, common activities…					■
13	Accessibility to old and handicapped persons						■

Integration of the SHE building in its neighbourhood							
14	Quality of the public transports to deserve the city centre, and equipments and public services	Proximity of public transport station or stop to go towards the city centre ; accessibility to public services and equipments by foot or bicycle					
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood					
Social aspects during the SHE building sites							
16	Quality of the building site	Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site					
17		Management of pollutions of the building site for the neighbours					
18		Contribution of the project to environment education and to local development					
Social aspects for the social owners and cooperatives							
19	Added value of the SHE project	Improvement of cooperative services abilities					
20		Relation between the cooperative and the building companies					
21		Relations with the clients (future residents)					
22		Relations with the local authorities					
23		Relations with the other cooperatives or social owners					

RINGAARDEN Project characteristics

<u>Main focus :</u>

Topic 1 : Social mix

The SHE project is a social housing project and thereby accessible for the whole population. The price for renting is lower than for privately rented flats or owner occupied houses and therefore accessible for ordinary people with an ordinary salary or pension. In the SHE project many of the actual residents are retired people which proves the accessibility for the majority of the population

T.2 : Thermal comfort

The SHE project is a low energy housing project with a maximum of approximately 44 kWh per sq meter per year including DHW. All over the year the tenants have the possibility of deciding for themselves the individual use of passive sun heating by a system of removable shutters that also will protect the dwellings for overheating in the hot periods

T.3 : Indoor air quality

There is mechanical exhausting in the kitchen and the bathroom. The indoor climate is improved by the use of healthy materials i.e. wood, sound paintings etc.

T.4 : Available space, surface, adaptation to the needs

The indoor space is abundant minimizing the space for sleeping and maximizing the space for activities in the daytime. Terraces and small garden give the tenants good possibilities for outdoor relaxing and for social contacts

T.5 : Reduction of pollution

The acoustic insulation is following the Danish Building Regulation. The project is placed in a dead end street thereby minimizing the traffic in the area. 80%-85% of the used materials in the project is renewable and all materials are healthy thereby minimizing the pollution from unhealthy materials

T.6 : Orientation

The dwellings are mainly orientated with big window openings to the south thereby maximizing the light and the possibility of passive sun gain. To the cold north the window area is minimized to eliminate cold bridge.

The visual contact to the nature and view of the bay of Aarhus is in the SHE project outstanding and not normal for a social housing project.

T.7 : Reduction of charges from utilities

The energy consumption is planned to be one of the lowest in Denmark. The SHE project is classified as a low energy class 1 project which means that the project is projected to use 50% of the energy for heating as comparable build houses after the standard regulation.

All known water saving systems are used in the project.

The use of LED light in the dwellings diminish the consumption of electricity

T.8 : Reduction of maintenance charges

The surfaces of the houses are made of larch tree which should not be maintained for several years.

The surroundings consist mainly of easily maintained grass areas.

T.9 : Accessibility to common spaces

Every dwelling has its own approximately. 6 m² storage room for bicycles, garden furniture etc.

The project has its own 120 m² community house with kitchen and toilet. The meeting room can contain 70-80 people allowing tenants meeting, birthday parties etc.

In connection to the community house there is a common laundry

T.10 : Accessibility to green spaces

A path system allows the tenants to walk to the city and to enjoy the nature around the project. There's no traffic around the project allowing children to play on the green areas around the dwelling group

T.11 : Car park

There's more than one parking plot per dwelling. The parking places are green made of "green stones"

T.12 : Appropriation of the building by its inhabitants

The tenants have elected their own board then constitute a kind of local leadership of the dwelling group.

It's up to the tenant democracy to decide what kind of common activities they want. At least they have the facility to common activities in form of the community house

T.13 : Accessibility to old and handicapped persons

17 of the dwellings are reserved for seniors

T.14 : Quality of public transport

There is around 600 meter to the nearest bus stop. The area is a closed settlement and thereby relatively free of cars. There are bicycle paths from the SHE-project to the city centre of Lystrup

T.15 : Urban diversity

The project is placed in the outskirts of Lystrup which eliminates the possibility of shops in the neighbourhood

T.16 : Contribution of the SHE project to the improvement of the qualification and of work conditions of workers on the building site

The SHE project was build offsite i.e. inside and therefore improving the building quality and the construction environment considerable

T.17 : Management of pollutions of the building site for the neighbours

The project was build offsite and thereafter constructed in a few weeks. The impact of the neighbours has being nearly not existing and the client has not received one complaint

T.18 : Contribution of the project to environment education and to local development

The offsite building method is new in this country and the project thereby has contributed to a whole new way of production

CHAPTER 4 – SOCIAL ASPECTS SYNTHESIS

The first table summarizes the point of view on the various SHE projects (from the inquiry carried out) from the cooperatives / social owners.

This point of view is mainly given by the engineers who were in charge of the project. It is more rarely the point of view of inhabitants because they have just come to live in their flats (except for the French project).

So these points of view have to be considered as a little bit too optimistic even if they reflect the objectives and the first results issued from the monitoring.

Taking into account the social topics (by cooperatives and social owners)

			Teramo	**Pesaro**	**Ozzano**	**Preganziol**	**Mazzano**	**Bourgoin**	**Porto**	**Aarhus**
1	Social Mix	Is the SHE project accessible to a large part of the population?								
2	Comfort of the flats	Thermal comfort in summer and in winter								
3		Quality of the indoor air and ventilation								
4		Available space, surface, adaptation to the needs								
5		Reduction of pollution (acoustic, electromagnetic)…								
6		Orientation, exposure, visual comfort,								
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…								
8		Maintenance of the building and surroundings								
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…								
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)								
11	Car park quality	Balance between the space consumption and the cost…								

12	Appropriation of the building by its inhabitants	Association of residents, common activities…								
13	Accessibility to old and handicapped persons									
14	Quality of the public transports, equipments and public services	Proximity of public transport, public services and equipments by foot or bicycle								
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood								
16	Quality of the building site	Improvement of the qualification and of work conditions of workers on the building site								
17		Management of pollutions of the building site for the neighbours								
18		Contribution of the project to environment education and to local development								
19	Added value of the SHE project	Improvement of cooperative services abilities								
20		Relation between the cooperative and the building companies								
21		Relations with the clients (future residents)								
22		Relations with the local authorities								
23		Relations with the other cooperatives or social owners								

Code : Topic taken into account ➔

	Exemplary
	Well done
	Minimum done
	Nothing done
	Out of purpose

The analysis underlines **three categories of topics,** according to the answers of cooperatives and social owners.

- **Successful topics**

This first category gathers topics which are well taken into account in the SHE projects with sometimes the definition of performance objectives.

This first category gathers the following topics :

2	Comfort of the flats	Thermal comfort in summer and in winter
3		Quality of the indoor air and ventilation
4		Available space, surface, adaptation to the needs
7	Reduction of charges (utilities & maintenance)	Utilities : energy, water…
10	Accessibility to green spaces	Accessibility to green spaces for children and families (by foot)
19	Added value of the SHE project	Improvement of cooperative services abilities
21		Relations with the clients (future residents)
22		Relations with local authorities
23		Relations with the other cooperatives or social owners

Color code	**Social objectives**
(yellow)	Residents' satisfaction
(purple)	Social aspects for cooperatives & social owners

Globally, the two strong points of the SHE projects in the social field are **the satisfaction of the residents and tenants and the improvement of relations between the different stakeholders** of the project.

The satisfaction of the residents is explained by the improvement of the comfort in the flats and more particularly what is related to thermal comfort, indoor air control and energy consumption (energy charges).

Finally, the main effort focuses on the management of utilities. All SHE partners have focussed on energy, water, ventilation and air control. Cooperatives also remind that energy efficiency depends on the residents' behaviour and that the success story depends both on construction and behaviour.

The second strong point is **the new relationship** that the SHE project obliges **between the owner (cooperative or social owner) and its partners**: the appropriation by residents of their building depends on an initial information and a training of inhabitants ; new relations are also necessary into the cooperatives where engineers and marketing persons must modify their relations and their work in order to work together. Engineers must also work in order to appropriate the technical innovations and the new way to build. Last, **sustainable construction requires a partnership with local authorities**, both to adapt the construction code or the land-use planning and to support the project by financing, information, training… (and so to improve its quality).

- **Topics well taken into account**

These topics correspond to standards or good practices for most of the SHE partners but also sometimes for some minor actions for some other SHE partners.

In fact there are always some constraints which prevent a cooperative to have a real performance on these topics:

- The building orientation has been already decided in the land-use plan and cannot be modified: Note that the TERAMO project made the land-use plan modified in order to respect the SHE objectives.
- The visual comfort also depends on the location of the building and it is necessary to have a property policy of the City to allow social housings being in a nice landscape. It is the same question related to the access to equipments, services and public transport which depend on the City policy.
- The maintenance of the buildings is a major target for Ozzano but it has been very difficult to involve the management actors into the design phase
- The car park quality is a balance between the necessity to reduce the car place in public space and the cost of underground car park. The SHE projects have generally limited the number of car places per housing to 1/flat whereas the social demand often is over this level…
- The intervention of the SHE partners in order to improve the quality of the building sites has appeared as linked to the local, regional or national regulations. Generally, the SHE projects adopt the best existing regulations ongoing in their territory.
- The relations between the cooperatives or social owners and the building companies

This second category gathers the following topics:

5	Comfort of the flats	Reduction of pollution (acoustic, electromagnetic)…
6		Orientation, exposure, visual comfort
11	Car park quality	Balance between the space consumption and the cost…
14	Quality of the public transports, equipments and public services	Proximity of public transport, public services and equipments by foot or bicycle
15	Urban diversity of functions in the neighbourhood	Presence of small traders, green spaces, equipments and services in the neighbourhood
17	Quality of the building site	Management of pollutions of the building site for the neighbours
20	Added value of the SHE project	Relation between the cooperative and the building companies

SOCIAL ASPECTS

Color code	**Social objectives**
(yellow)	Residents' satisfaction
(cyan)	Integration of the SHE building in its neighbourhood
(orange)	Social aspects during the building sites
(purple)	Social aspects for cooperatives & social owners

- **Topics to be improved**

The third category gathers the topics which are a little bit taken into account in the SHE project and which should be improved in the future projects of the SHE partners. This category gathers the following topics:

1	Social Mix	Is the SHE project accessible to a large part of the population
8	Reduction of charges (utilities & maintenance)	Maintenance of the building and surroundings
9	Accessibility to common spaces	Presence of bicycle storage spaces, laundry, common rooms…
12	Appropriation of the building by its inhabitants	Association of residents, common activities…
13	Accessibility to old and handicapped persons	
16	Quality of the building site	Improvement of the qualification and of work conditions of workers on the building site
18	Quality of the building site	Contribution of the project to environment education and to local development

Color code	**Social objectives**
(green)	Social Mix
(yellow)	Residents' satisfaction
(orange)	Social aspects during the building sites

To improve social mix is a major social topic in order to ensure social cohesion in the city. However, when we speak only about one or two buildings, it is clear that the social impact is relatively limited. The purpose of social mix is a major topic in the Bourgoin-Jallieu project mainly because the project is located in the city centre. This is generally very difficult to ensure because the property cost is often too high and prevents to propose rents accessible for low income families. In this case, the land has been free of charge for the social owner, the City having taking in charge the property cost.

The accessibility to common spaces has been well taken into account by four projects and not enough in three projects. A sustainable construction must take into account that the bicycle and the walk are going to increase their share in the households' displacements and, consequently, the buildings must include in their programme secure and attractive places to store bicycle and caddies. We can note that this point is not foreseen in land-use plans in Italy; so, the cooperatives are not motivated to set large and secure bicycle storage places if the city does not create bicycle tracks.

Note that Bourgoin Jallieu project has created places to store bicycles but the first enquiry shows that 90 % of the households are not satisfied because the space is too small.

CONCLUSION

1 – SYNTHESIS ON THE SOCIOECONOMIC AND ENVIRONMENTAL (I. E. SUSTAINABILITY) ASSESSMENT OF THE SHE PROJECTS OR OF FURTHER BUILDING PROJECTS

A sustainable development approach deals together (due to a cross-cutting or integrated approach) with:

- environmental, social and economic issues[93] (as shown with the famous figure with the 3 pillars of the sustainable development concept) but also with
- sustainable development objectives and sustainable development principles.

So the SHE approach or methodological framework has dealt with these various issues and not only with environmental ones as it is done in most of the best practices supported by public administration, local authorities and even by the European Commission.

Social aspects analysis is relevant from the programming phase in order to analyse the coherence between the project and the site or the neighbourhood in which it is located. Then social analysis is useful to show the impact of the project on the work conditions on the building site and in taking into account the pollutions. Last the social analysis must include the satisfaction of residents and their appropriation of the building.

Economic analysis is relevant from the project programming in order to discuss about the economic impacts of various technology choices and also to take into account postpone costs in the dialogue with the architect.

The LCC analysis can be also used as an assessment tool in order to enhance the costs and the benefits of the project and so it is an interesting tool both for social owners and for their financial partners (especially in case of public support).

1.1. THE SOCIAL ANALYSIS

The social analysis is part of a life cycle cost analysis, as well as the environmental one and the economic one.

As regarding social aspects, the focus must be on the quality of the dialogue with stakeholders (residents, local authorities, internal relations inside the cooperatives, relations between social owners organisations) and on the quality of the answers/ treatment of the questions or requests. For the SHE project, a questionnaire has been carried out which focuses on the following points:

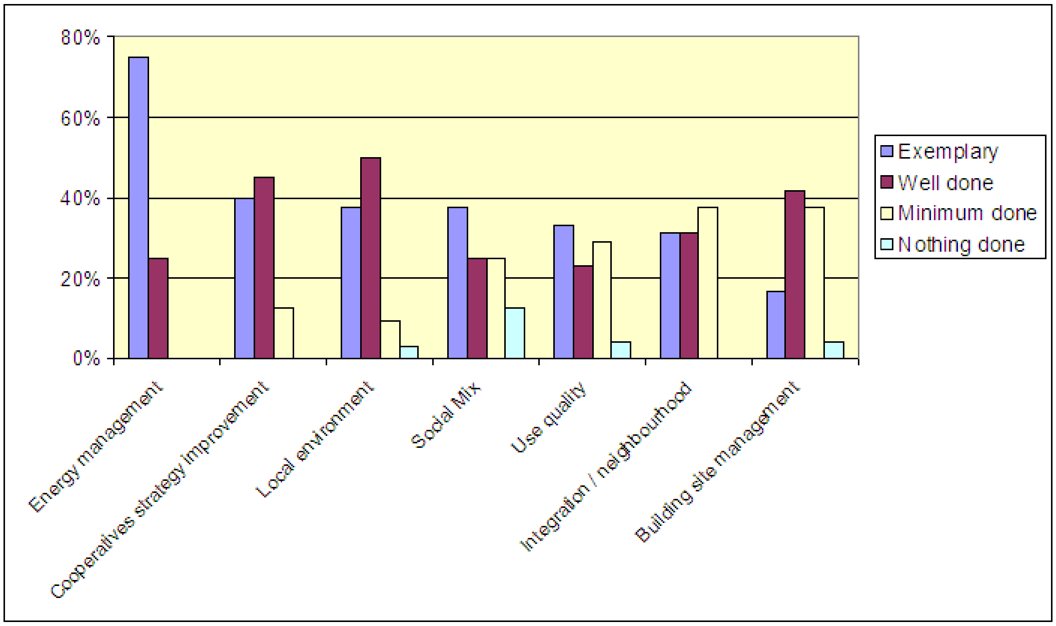
- social equity brought by the project
- residents' satisfaction as regarding comfort, charges reduction, accessibility, space, etc.
- integration of the residents and of the project in the neighbourhood as well as in the city or conurbation (equipments and services)
- the social issues during the construction phase
- the added value for the cooperative

Social aspects do not only concern residents. Neighbours, workers on the building site are also concerned. The overall objective of social analysis of a construction project is to contribute to the improvement of the quality of life or work of every person concerned by the project.

[93] and not only with the analysis of the social and economic impacts of the selected environmental issues as it is still too often done because it is much more simple

All these items are dealt within 23 themes for which an appreciation has been given: exemplary, well managed or done, just managed (or minimum done), non dealt with (nothing done), not concerned. The following graphics shows how the different fields of the social dimension have been taken into account in the various SHE project

Social analysis of the SHE projects



Source La Calade

	Exemplary
	Well done
	Minimum done
	Non dealt with
	Out of purpose

			TER	PES	OZZ	PRE	MAZ	BOU	POR	AAR
1	**Social Mix**	Is the SHE project accessible to a large part of the population?	Exemplary	Well done	Non dealt with	Well done	Minimum done	Exemplary	Minimum done	Exemplary
2	**Comfort of the Flats**	Thermal comfort in summer and in winter	Well done	Exemplary	Exemplary	Exemplary	Well done	Well done	Well done	Exemplary
3		Quality of the indoor air and ventilation	Well done	Well done	Exemplary	Well done	Exemplary	Well done	Well done	Well done
4		Available space, surface, adaptation to the needs	Well done	Well done	Exemplary	Well done	Exemplary	Exemplary	Minimum done	Well done
5		Reduction of pollution (acoustic, electromagnetic)…	Exemplary	Well done	Exemplary	Well done	Exemplary	Minimum done	Minimum done	Well done
6		Orientation, exposure, visual comfort,	Exemplary	Exemplary	Non dealt with	Exemplary	Well done	Well done	Well done	Exemplary
7	**Reduction of charges (utilities & maintenance)**	Utilities : energy, water…	Exemplary	Exemplary	Exemplary	Exemplary	Exemplary	Exemplary	Exemplary	Exemplary
8		Maintenance of the building and surroundings	Minimum done	Minimum done	Exemplary	Minimum done	Minimum done	Minimum done	Well done	Well done
9	**Accessibility to common spaces**	Presence of bicycle storage spaces, laundry, common rooms…	Minimum done	Well done	Non dealt with	Minimum done	Exemplary	Minimum done	Minimum done	Exemplary
10	**Accessibility to green spaces**	Accessibility to green spaces for children and families (by foot)	Exemplary	Exemplary	Well done	Exemplary	Exemplary	Well done	Exemplary	Exemplary
11	**Car park quality**	Balance between the space consumption and the cost…	Well done	Minimum done	Exemplary	Exemplary	Minimum done	Well done	Exemplary	Exemplary

12	**Appropriation**	Association of residents, common activities…								
13	**Accessibility**									
14	**Public transports, equipment & services**	Proximity of public transport, public services and equipments by foot or bicycle								
15	**Urban diversity**	Presence of small traders, green spaces, equipments and services in the neighbourhood								
16	**Quality of the building site**	Improvement of the qualification and of work conditions of workers on the building site								
17		Management of pollutions of the building site for the neighbours								
18		Contribution of the project to environment education and to local development								
19	**Added value of the SHE project**	Improvement of cooperative services abilities								
20		Relation between the cooperative and the building companies								
21		Relations with the clients (future residents)								
22		Relations with the local authorities								
23		Relations with the other cooperatives or social owners								

Source La Calade

1.2. THE ECONOMIC ANALYSIS TOWARDS SUSTAINABILITY

The analysis has been made with the SET-SHE model (Sustainable Economic Tool for the SHE project) worked out by La Calade for the SHE building projects. The SET-SHE model is a Life Cycle Cost model including externalities whose interest is to be:

- a decision aid tool (for social owners as well as for local authorities),
- a tool for improving the dialogue with the various cooperatives' (or social owners') partners,
- a tool for improving the building quality or performances (towards sustainability),
- a monitoring tool,
- an assessment tool,
- a tool giving guaranties on the building quality and so which should facilitate the selling or renting of the dwellings.

This SET-SHE model has been worked out for:

- improving the liveable overall quality of the area, in the preliminary phase (with the location choice and equipments, including public transport);
- improving the housing overall quality (efficiency), during the design and programming phases;
- assessing the buildings in order to underline its performances or overall quality, when the building is ready to be used (end of the construction phase, before the operation phase);
- assessing the various performances of the building during the operation phase in order to validate or not the decision criteria as regarding the choice of some equipments (such as solar heating systems or mechanical controlled ventilation for example);
- assessing the impact of some municipal actions or externalities in order to improve the dialogue with the municipality or local authority as regarding planning regulation on the one hand and public services (transports and equipments) as well as public areas with a good quality (and including green spaces) on the other hand;
- assessing the impact of specific requirements such as regarding energy performance or the reduction of greenhouse effect gas emission in order to justify the need for specific additional subsidies, financial support or financial incentive measures;

- going towards eco-buildings (by dealing with environmental issues) and, if possible, due to the various partnerships improvement (including participation of tenants or residents) on the one hand and to the economic and social analyses on the other hand, towards sustainable buildings.

During the various phases of the building projects, the SET-SHE model allowed various information, decisions and improvements of the housing:

1.- Preliminary phase:

In this first phase the SET-SHE model is useful especially as regarding the location of the building (especially when the location is chosen by the local authority), in order to avoid a location too far from public transport allowing to go to the city centre or to other neighbourhoods, to far from equipments (including open spaces and green areas), too noisy or without social mix.

2.- First design phase[94]:

a) to assess the construction programme and so to improve it.

b) to compare various construction programmes in case of any competition for selecting the best programme (architect or cooperative). In this case it can be used by local authorities.

c) to assess the quality of the construction programme in case of a dialogue focussed on a potential financial support (with the local authority, the local environment agency, the Region or other financial partners). This was done for some SHE projects.

d) to improve the dialogue with local authorities and especially as regarding local planning regulation, public transport, public open spaces, public equipments, etc. A first step has been managed for improving this dialogue during the SHE project and we can assess that this dialogue will still be improved in the next years by the cooperatives because the SHE project has underlined how important it is.

e) to reduce charges for tenants / residents by reducing energy needs and water consumption. It is important to think about this issue at the first beginning of the project in order to be as much efficient as possible.

f) to take into account environmental issues, the EPBD implementation… as for eco-buildings, in order to reduce the environmental impact of the building project (and of the building itself of course), but moreover to measure the socioeconomic impact of the environmental performances of the building(s).

g) to measure the economic and financial impact (over cost) of specific performance requirements of the local authority as well as of tenants or residents.

3.- Second design phase

h) to assess the various performances of the building and to check if the required performances will be reached.

i) to assess the quality of the building.

j) to improve the dialogue with local authorities, financial partners and residents.

k) to build eco-buildings and if possible sustainable buildings

4. Building in use (or operation) phase

l) to test and justify the rent (or rent increase) or the cost (or over cost of the dwellings if they are sold).

m) to assess the building quality and its various performances as well as their economic and social impacts as an ex post assessment tool.

n) to improve the model itself by introducing the equipment cost evolution and other cost or price increase (such as energy price for example).

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[94] This could not been done during the SHE project because the design phase was finished when the SET-SHE model was ready to be used but it is possible

o) to improve the decision criteria of each social owner as regarding some equipments (such as mechanical controlled ventilation for example).

At least the SET-SHE model shows the economic, social and environmental result or performances due to the technical choices, to each technical choice or equipment, and so it should be very useful for going towards efficient or sustainable buildings.

So it should be used by each owner for improving his technical choices and by local authorities and the building companies for identifying the sustainable technologies which will or should be developed at each local level and for improving the know how of the local building actors / companies and craft men in order to improve at least the local economic development…

2 - ADDED VALUE OF THE SHE PROJECT(S) AS REGARDING ECONOMIC AND SOCIAL ISSUES

The SHE projects

As regarding the SHE projects, we must not focus only on the building performances because the proposal has been written 5 years ago and the design phase has been managed also some years ago. The main SHE projects' result concerns:

- the improvement of the dialogue and of the partnerships, especially with local authorities;
- the awareness of various actors - including social owners (and not only those involved in SHE) - as regarding the interest of a cross cutting analysis on the one hand and, on the other hand, the need of training and further experimentations for closing the gap between research and practice and for improving the business as usual practices and ways of working.

The SHE European project

Some issues or questions managed in the SHE project were new, unusual and sometimes rather difficult to understand and so to manage and the SHE result must be seen on the new habits and way of working, the partnerships, the project management and at least policies more than only as it is too often the case as regarding the best practices (or building performances).

The main results (or strong points) of the SHE project are:

- **the dwellings' comfort**: summer comfort, winter comfort, indoor air quality, available space and design…
- **the reduction of charges**: for energy and water
- **the accessibility to nearby green open spaces**,
- **the improvement of**:
  - **the know how and abilities of the cooperatives departments**: for example:
    - CONSEDI has improved the way of working, cross cutting actions and cooperation between its departments,
    - all the COPES departments were involved in the SHE project in order to improve its quality and the engineers have worked with the future residents in order to convince them about the interest of a collective heating system,
    - the NORBICETA technical department has improved its know how and this will now improve the quality of all the dwellings and buildings built,
  - **relationships with (future) residents:** for example:
    - the COPALC engineers participated to the residents meetings and so they modified and improved their marketing strategy,
    - OPAC 38 initiated an *environmental quality comity* gathering all the residents in order to make them appropriate their building and its surroundings (and not only their dwelling) on the one hand and, on the other hand, to make them use the innovative equipments as well as their verandas in the best possible way;
    - NORBICETA has managed information and awareness campaigns for residents.

- **relationships and partnerships with local authorities**: for example:
  - COIPES could obtain the land planning modification in order to allow solar panels on their SHE buildings
  - The COPES SHE project allowed friendly environmental modifications of the building rules/code of the Pesaro municipality
  - Emilia Romagna has modificated its building code with a better management of energy and water and the OZZANO project was the first one to use it
  - The COPALC project won a concourse on sustainable buildings managed by the OZZANO municipality with the SHE project and this was the first step of a new partnership between COPALC engineers and the municipal services
  - NORBICETA could involve the municipality in the project and its monitoring.
- **relationships with other cooperatives or social owners:** for example:
  - COIPES has engaged a new partnership with the other regional (Venitia) cooperatives,
  - new partnerships and links between cooperatives emerged among the CASAQUALITA network
  - a data base with products and equipments with a high environmental added value is on going at the Confcooperative.
  - a new partnership was initiated between the 2 Italian social housing associations
  - NORBICETA has informed and aware all the other cooperatives in his country on the SHE project and its results

And at least there was **a first innovative use of a life cycle cost analysis for new social housing**, due to the sustainable objective of the SHE project **and the SET-SHE model** which is a tool for:

- improving the dialogue between social owners and their institutional partners,
- the analysis of the various impacts of each potential technical solution and so for optimizing the building design towards sustainability
- monitoring the building projects.

3 – ADDED VALUE OF THE SHE SOCIOECONOMIC ANALYSIS TOWARDS SUSTAINABILITY

A life cycle cost (LCC) analysis in new building projects such as the analysis managed with the SET-SHE model in the SHE project allows to choose the best techniques and to optimise the building/housing towards sustainability. It allows getting sustainable housings/buildings.

This rational model is a decision aid tool at the pre-designing and designing phases of the building which allows to:

- take the prices evolution into account: energy prices, taxes, new financial market products and subsidies;
- take into account the further maintenance costs of the building and its equipments;
- take into account the ecological aspects of the climate change and of the green house effect;
- compare the costs and the economic but also social and environmental advantages of each project for the various actors concerned: social owner or promoter, inhabitant, community, State, society…

A Life Cycle cost model such as the SET SHE model is an important decision aid tool for cooperatives as well as social owners and their partners because it allows:

- to better understand the interest of the various additional criteria or technique for each of the actors concerned
- to choose the most efficient techniques and equipments
- to anticipate and better know the future maintenance costs

- to better know the environmental and social impacts of any choice
- to improve the dialogue with the financial partners
- to improve the dialogue with the municipality (including on the location of the building itself)

Reminder on Life Cycle Costing (LCC)

What is usually named LCC is the sum of purchase (or investment) costs and maintenance (and refurbishing) costs during the whole life of the building (and so including the demolition costs). But some experts call this the "Direct LCC" and an "enlarged or overall LCC"(OLCC) is including externalities.

An overall LCC (OLCC) model is an economic tool which is both more complex (including a lot of hypotheses which must be discussed first among the users and the financial partners) and less technical, and which takes into account projects' costs on the one hand and social and environmental benefits on the other hand. So an overall LCC takes into account:

- all the various project's costs throughout the building life (from the conception up to the demolition phase) (which is the usual LCC or direct LCC),

- all the various environmental and social project's impacts (named externalities) (which is the OLCC).

A shared LCC analysis done with a model such as SET-SHE can also show the advantages and profitability for each type of the concerned actors (social owner, inhabitant, local authority, State)

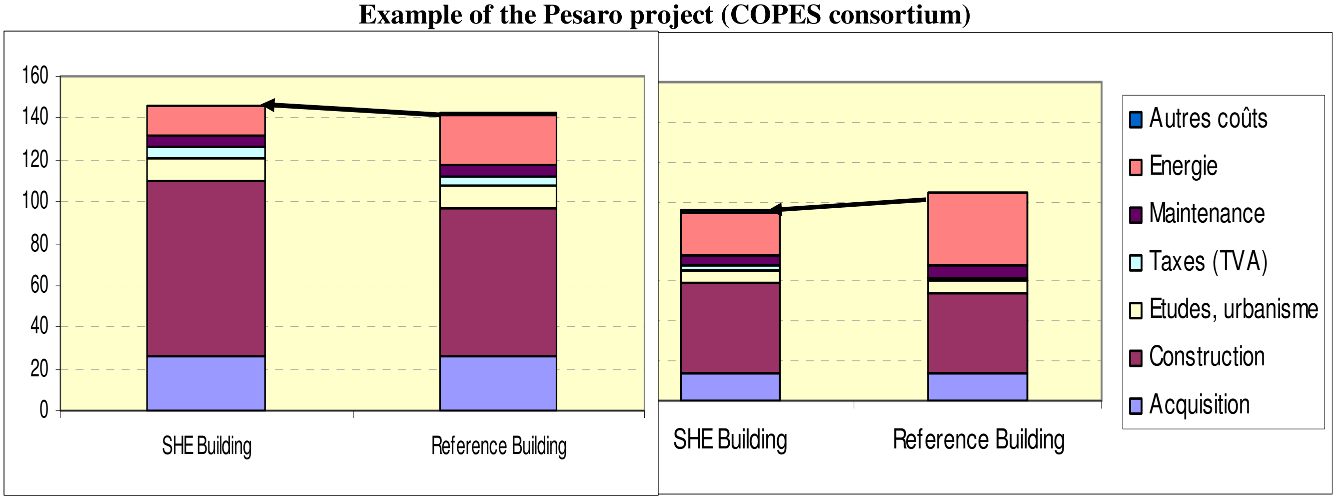
A LCC analysis can be used as an assessment tool in order to enhance the costs and the benefits of any project and so it is an interesting tool both for social owners and for their financial partners (especially in case of public support).

Of course there are uncertainties but it is not a reason for forgetting the profitability or economic efficiency criteria.

The main results of the LCC analysis with the SET-SHE model are summarised below about one of the SHE projects:

Direct LCC for a 30 years and a 60 years period

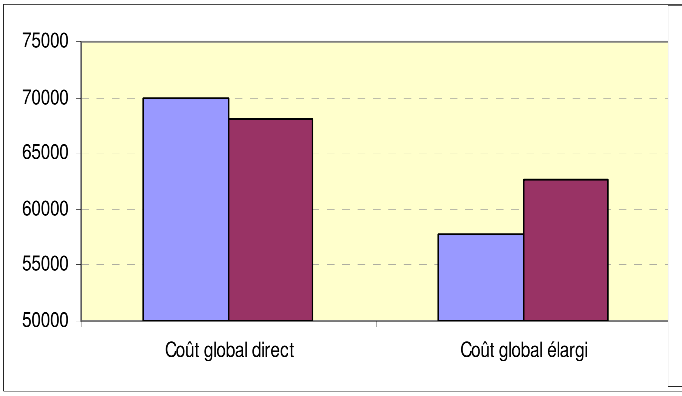
Example of the Pesaro project (COPES consortium)

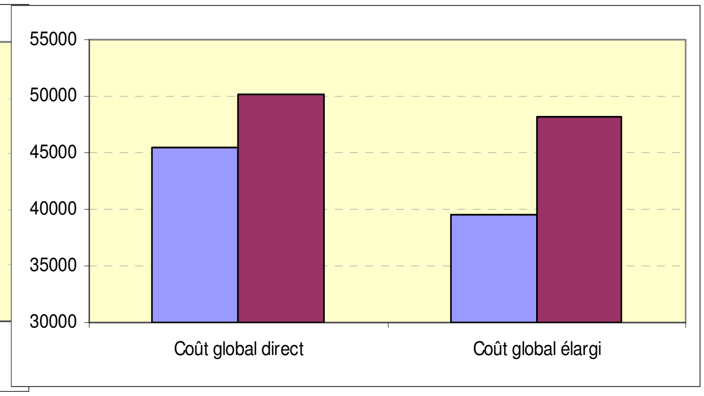


Direct Life-Cycle cost = 30 year-period 60 year-period

146 €/m².year 142 € / m².year 95 €/m².year 105 €/m².year

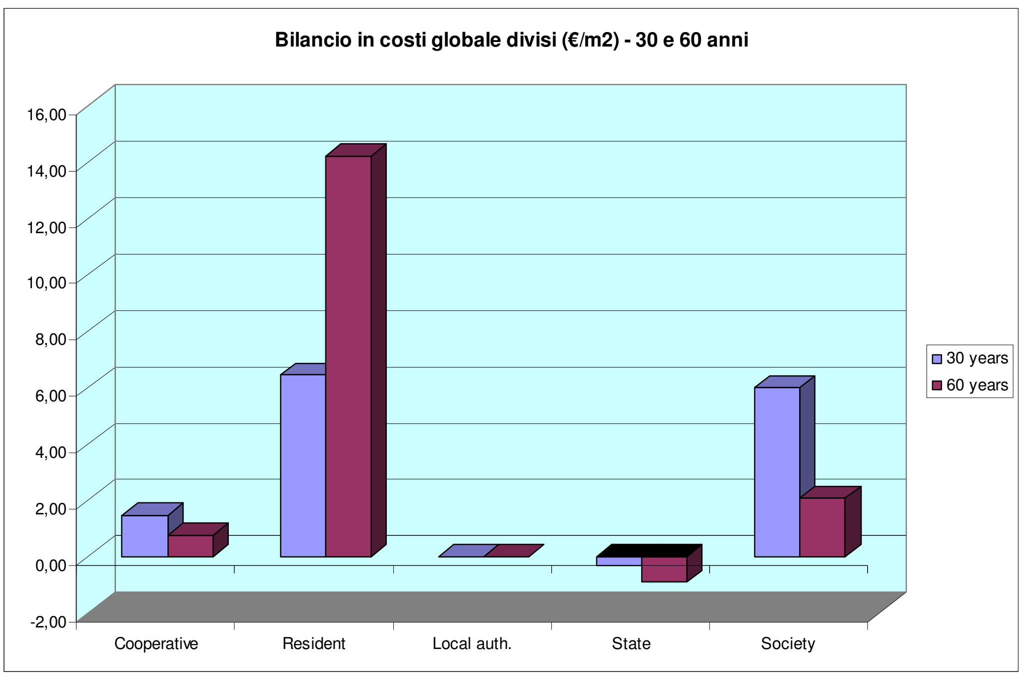
Direct and overall LCC for a 30 years and a 60 years period
Exemple of the Pesaro project (COPES consortium)



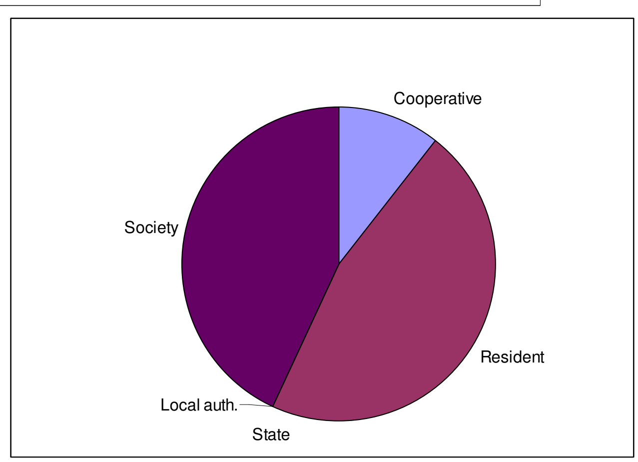


Overall Life-Cycle cost =	*30 year-period*		*60 year-period*	
	SHE	*Reference*	*SHE*	*Reference*
	121 €/m².year	*131 € / m².year*	*83 €/m².year*	*101 €/m².year*

Shared LCC - Exemple of the Pesaro project (COPES consortium)



Profitability
for residents, the cooperative
and society



4 – MAIN RESULTS AND RECOMMENDATIONS FOR SOCIAL OWNERS AND THEIR PARTNERS TOWARDS SUSTAINABLE SOCIAL HOUSINGS AND BUILDINGS

The main elements to be taken in account for the social analysis are:

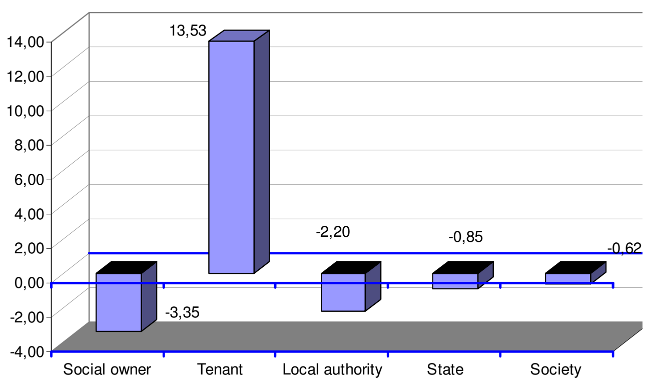
- **social equity** and especially as regarding future running charges
- **the residents' satisfaction**: welfare and comfort, social capital, accessibility
- **the integration of the building in the neighbourhood** with wishes or demands from neighbours (including economic actors such as local shopkeepers) as well as for architecture or urban development) and urban diversity
- **social aspects on the building sites**: taking into account workers of the building companies, as regarding security and safety during the building site but also during the building's life because of maintenance and retrofitting works, as well as the neighbours needs (noise, traffic…)
- **social impacts for the cooperative(s) or social owner(s)**: partnerships and relations with building companies, financial partners and especially the local authority (municipality).

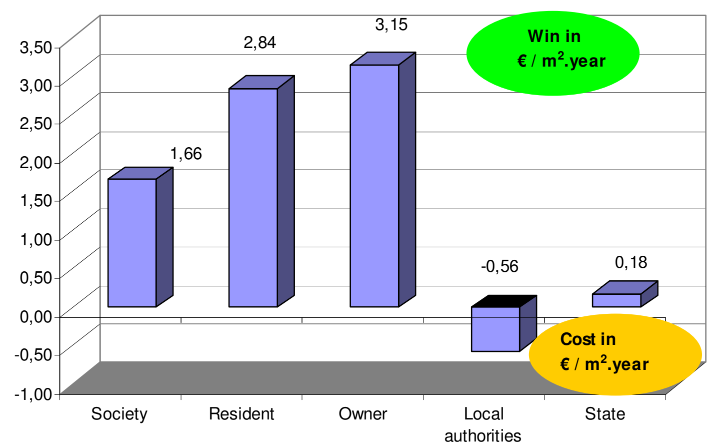
The Life cycle Cost analysis interest

The main obstacle to LCC analysis is the choice of assumptions in regards to the evolution of the prices of utilities, the discount rate, the analysis time period, the difficulties to know the maintenance cost and the lifetime of equipments. These questions can close eyes to decision makers to focus only on short term analysis. The main recommendation would be to create dialogue and partnership with the local authorities in order to define the more sustainable (long term) economic and social solutions and to find the best way to finance them.

As mentioned for the SET-SHE model, **such an analysis allows**:

- **improving the dialogue between social owners and their institutional partners**, as shown on the following figures on **the shared LCC for social housing**:

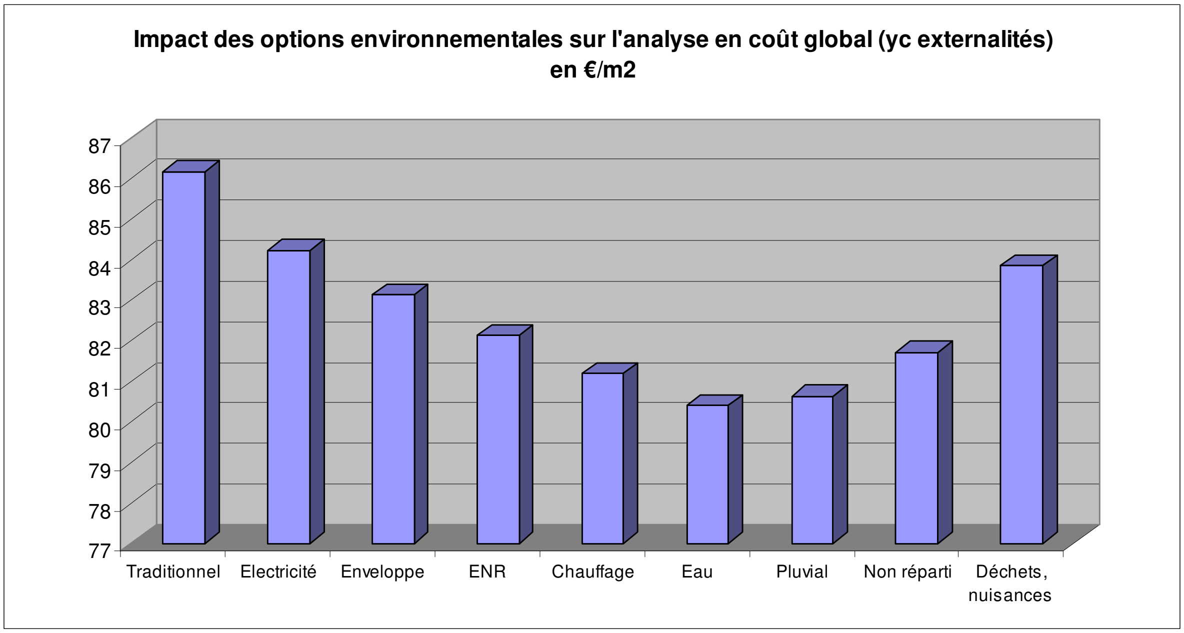




In the left case the higher rent does not allow any economic equilibrium for the social owner and the main profitability is for the tenant. On the right side profitability is better shared among all the actors. This can be a criteria in case of public subsidies (according to the local context).

- **the analysis of the various impacts of each potential technical solution and so for optimizing the building design towards sustainability**

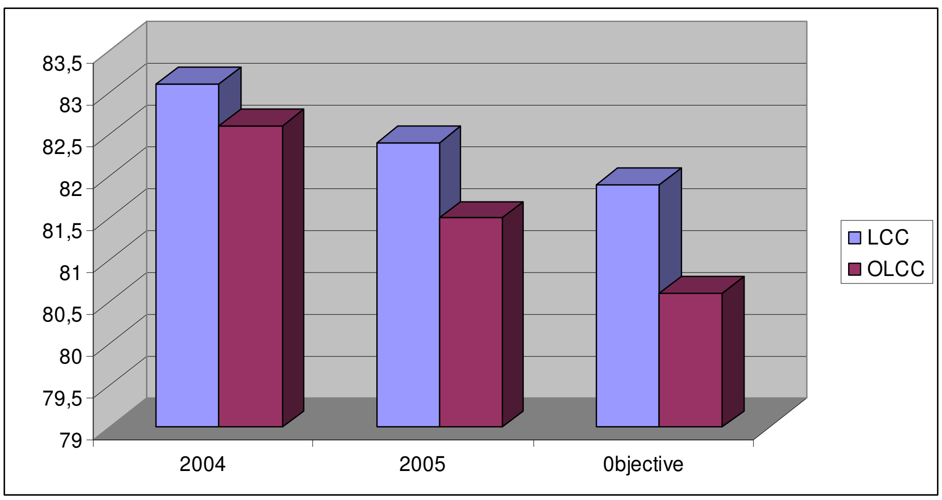
In case of an analysis per equipment/technology according to the life cycle cost of the building allows to optimise the building design as shown in the following figure. In the following figure the optimum is reached with the water equipment, "further" equipments are not profitable.



Source La Calade for OPAC 38, SHE project

- **monitoring the building projects**.

It is possible to see if the initial objectives are reached, as shown in the following figure:



Source La Calade for the SHE project

The needed data for using a LCC model

In order to use the sustainable SET-SHE model, after the discussion on the hypotheses and the main selection to manage (duration of the analysis, discount rate, energy price increase and so on), all the following costs have to be collected:

- **initial costs**: acquisition of the ground, demolition cost, construction cost (including structural works, finishing, sustainable equipments and others), contribution to the implementation of open spaces and technical networks ("secondary urbanisation"), contribution to urbanisation ("primary urbanisation"), technical abilities, financing costs
- **postponed/running costs**: running maintenance and repair costs, operation costs (utilities and maintenance costs such as heating, sanitary hot water, self-production of electricity, self-production of thermal energy, electricity consumption for common and open spaces, electricity consumption in dwellings, sanitary water, water consumption for common and open spaces, specific maintenance) for a reference year.

The importance of the programming phase

The most important phase is the programming one because it is during this phase that several elements which will not be able to be modified in the following phases are defined. So a LCC analysis is very interesting to do even if we do not get every figure and if the translation in euro is sometimes very difficult to do. Several aspects could be analysed in this phase and a LCC analysis could be useful to discuss with local authorities and / or land owners, such as on the choice of the location of the building, which gives the building environment and surroundings quality to the project, with as an objective to ensure the best quality of life as possible.

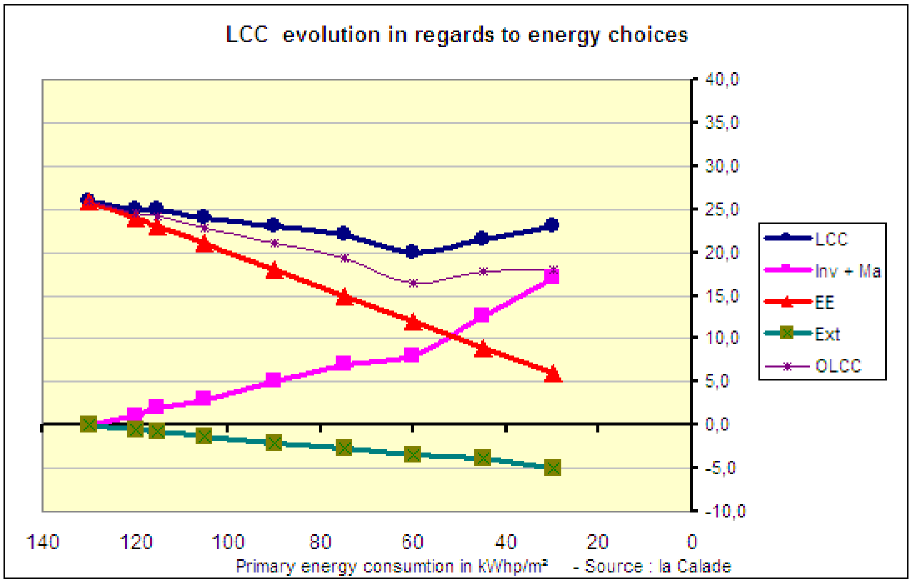
This phase is also the phase with all the needed **surveys** on:

- potential energy sources, particularly the available renewable energy sources and the opportunities or not to develop a district heating,
- the accessibility to the transport means,
- the various potential local pollutions,
- the landscape quality and its potential preservation and improvement,
- participation rules, if it is possible with tenants / residents (if they are already known)
- …

A LCC analysis can be used for selecting the most efficient techniques and equipments by comparing the LCC of the sustainable project/building to a reference one and by managing as many scenarii as necessary when new ideas are coming.

So at this stage, by using the SET SHE model, it should be possible **to carry out an optimization of the building efficiency/productivity** by choosing construction techniques, components and equipments.

For example the following schema suggests until what energy options the contracting authority can go for improving the economic balance of the project. The starting point is the national regulation and then various options can be used for improving the economic LCC. Then from a limit, the profitability decreases whereas available technologies make it possible to go further in energy savings. The LCC allows discussing about these various options: economic optimum versus (or not) ecological optimum? It can be used for justifying a financial support in case of a political objective due to a local Climate action plan for example.



Source La Calade for SHE

LCC: Life cycle cost of the project (€/m².year); Inv + Ma: net present value of investment and maintenance; EE: annual energy expenses ; Ext: externalities, OLCC: overall life cycle cost (€/m².year)

The interest of a LCC analysis during the management and maintenance phase

A LCC analysis can be useful during the management and maintenance phase for several reasons:

- a project assessment to put into relation the relevance of public subsidies.
- a project monitoring of the real costs for the residents. LCC could be used as an economic monitoring board for the project.
- Cooperatives sell the flats to households which become cooperative's members. So even if the cooperatives do not own the buildings, they are directly concerned in order to improve the quality of life of their members. Moreover, cooperatives sometimes are required to be the manager of the building (charges management).

5 – RECOMMENDATIONS FOR FURTHER NATIONAL OR EUROPEAN RESEARCHES OR PILOT SUSTAINABLE BUILDINGS/HOUSINGS

We focus below on what has still to be improved towards sustainable housing in Europe as well as in each European country:

1. The modification of the usual rules or criteria for any public financial support:

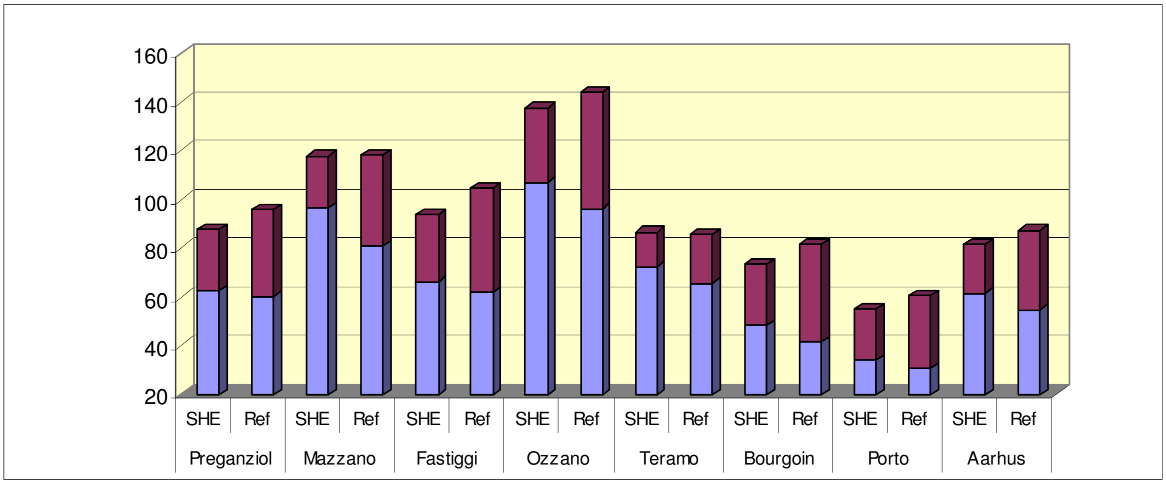
The LCC analysis shows that more often the main criteria is based on "over investments" (or costs) and not at all on the expected performances of the building. So, there is a crucial need for going to a results obligation, especially if we want to reach for example the 3x20 European objectives (on energy and climate change issues).

2. Official regional or national building reference/standards

Nowadays the "over costs" are estimated by the owner itself and this is more often never controlled. More over such a standard building would avoid too important differences as it can be shown with the following table on the SHE projects.

An official local, regional or national building reference should be

The SHE results after a LCC analysis – we can see how various are the reference buildings



Results for a 60 years period   Blue : initial costs   Red : postponed costs
Source La Calade

3. Common calculation rules

There is an important need for common/shared calculation rules on:

- the evolution of energy prices,
- lifetime of equipments
- calculation periods,
- time value (in €)
- …

This could be defined in a European standard but these rules have also to be flexible and so a common rule for European projects could be a first step…

4. Multicriteria best practices and for best policies illustrated by some best practices (instead of only best practices)

Not any criteria, nor energy nor environmental ones, can be selected alone for best practices. Best practices must deal with social and economic issues as well as with environmental ones.

Further more if we want to reach some European objectives (such as the 3x20 for energy issues) we must move our bracket and go from best practices to best policies, both for building stocks or portfolios and for territorial areas.

5. More cross cutting approaches

The LCC analysis needs coherency between actions and practices/analyses and it improves the cross cutting way of working towards urban sustainability. Such analyses are still too complicated for most of the practitioners and so they have to be supported by the European Commission as well as by public administration.

ANNEXES

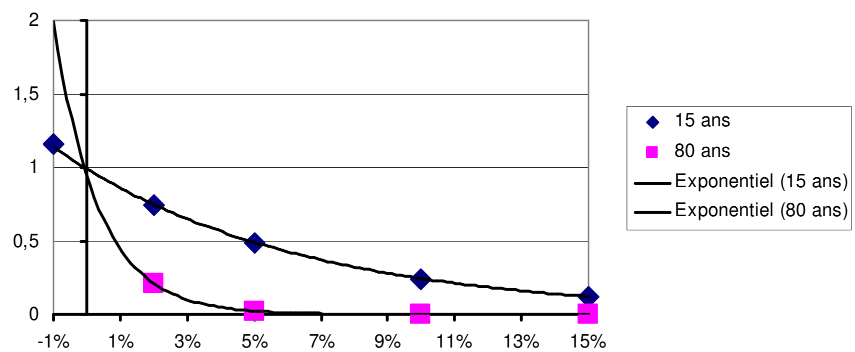
ANNEX I: HOW TO TAKE INTO ACCOUNT THE TIME VALUE ?

An important element of life cycle costing is the discount rate's value. This is the parameter which measures time's value:

"The discount rate is a substitution rate between future and present; it expresses time's value for an enterprise or a community: in a way it is the "price of time". The discount is one of the elements of any inter-temporal economic calculation as it makes possible to answer both fundamental questions: how to measure the profitability of an investment and how to choose between several profitable investments? The economic calculation is therefore a favoured tool for helping decision-making for all the deciders, whether they are private or public."

It is defined as the rate, which measures the preference for the present: which value is now given to one euro available in 10 years, 30 years? This rate greatly influences the value of future savings. With a constant discount rate of 8%, one euro available in 30 years is now worth 0.10 euro, with a rate of 4% the present value is worth 0.31 euro, and with a rate of 2% the present value is worth 0.55 euro.

Present value of one euro available in 15 and 80 years



(*Source : La Calade)*

The diagram indicates the present value of one euro available in 15 years and of one euro available in 80 years. For this horizon, discount rates superior to 3% make the impact totally ineffective.

The discount rate is a subjective element in the calculation and raises many theoretical problems. That is why the concept of life cycle costing is often ignored in favour of strictly financial calculations. This financial calculation identifies the discount rate with the bank interest rate. We can also calculate the return rate of the project which equalises the invest and working costs and the future revenues/benefits: if this return rate is superior to the interest rate, the investment is profitable and we can look for the project which maximises the return rate.

What differentiates these tools of financial calculation from a discount rate calculation is the reduction / limitation of the investment to the only micro-economic aspect.

On the contrary, the discount rate introduces and raises a reflection about time with its different components, taking into account the uncertainty about growth in particular but also about contradictory components:

- a high discount rate will take into account the immediate needs and favour the future integration of innovations,
- a very low discount rate will better protect the interests of future generations and the saving of rare resources…

The discount rate “a” can be valued as follows :

$$a = \frac{(1 + i)(1 + \delta)}{(1 + p)} - 1$$

Where i is the long-term interest rate, p the inflation rate and δ the factor that expresses the preference for the present.

For low values, $a = I + \delta - p$

Presently the value i – p is for France about 2%. According to the economic theory, the discount rate should tend towards the long-term interest rate, which is itself close to the long-term economic growth rate.

The contents of the discount rate for a sustainable development

The discount rate is the sum of several factors:

a) The preference for the present δ: it can be measured by the interest rate which would be demanded by households to defer / postpone / put off their consumption. This rate is about 1 or 2% per year at the individual level. At the collective level and if we consider the analysis of choice implying several generations, it is more difficult to accept this point of impatience.

b) The growth rate of consumption per person μ and the *elasticity of the marginal utility* of the consumption γ.

In order to maximise the collective *utility*, we can demonstrate that the discount rate at the temporal horizon t, a is equal to :

$$a_t = \delta + \gamma \times \mu_t$$

Consumption’s marginal utility varies with the wealth level. One of the basic hypothesis is that a good value is greater that the value of this same good for the future generations thanks to the technical progress. In the same way, one euro of the present time has more value than one euro of tomorrow in a society with economical growth.

The high uncertainty of the long-term growth rate means a high uncertainty on the product of γ x μ, which according to econometric studies varies indeed from 3 to 10.

An other interesting point about this “γ x μ” is that it tends to decrease with time because of the diminution of the marginal utility when taking into account the impact of wealth.

In the private sector, the discount rate corresponds to the net rate of the marginal productivity of the capital (all risk bonus deduced) theoretically equivalent to the pure long-term rate, itself closed to the tendancial growth rate of the economy.

On the other hand, contrarily to the several traditional definitions and practice, the discount rate doesn’t take into account the risk and uncertainty.

It is however necessary to distinguish between the project specific risk and the conjectural risk (e.g. uncertainty on the growth, costs, supply).

The risk specific to the project has to be taken into account at the investment phase as well as in the future exploitation. It isn’t comprised in the discount rate.

For the conjectural risks, it is necessary to do a risk analysis and to consider “risk bonus”, eventually “uncertainty bonus” if the project depends on a certain information level. In other words, the risk has to be disconnected of the discount rate.

Discount rate’s value

This value has to be based on a prospect of economical growth (by inhabitant). In a fifty year perspective, considering the population ageing in Europe, the growth rate by inhabitant is low: according to the evidence base, between 0 and 1.5% per year.

The consumption’s marginal utility value varies depending on the studies and the econometric models between 0.5 and 2.

Based on this estimation, the product of γ x μ will be roughly comprised between 2 and 3%.

(with γ = 1,5 and μ = 1,3 to 2).

For calculation on period of time of less than 30 years, a rate of 1% could also be retained as the rate of pure preference (hypothesis of INSEE, French Statistic Institute).

For longer period of time (60 years) of if we consider the discount rate as a mirror of the society choice, this rate has to be set at the value 0.

The discount rate could thus be modified depending on the period of time considered, knowing that the discount rate could become close to the long-term interest rate. For the SHE project, we will set the discount rate at 2.5% for a 30-year-calculation period and at 1.5% for a 60-year-calculation-period.

Comparison of real interest rate – discount rate of some European countries

	Long-term Interest Rate (30 years)	Price Index (2004)	Real Interest Rates	Discount Rate
France	4,06 %	2,1 %	2 %	4 %
United Kingdom	4,71 %	1,6 %	3,1 %	3,5 %
Italy	4,24 %	2,4 %	1,8 %	5 %
Germany	4,08 %	1,9 %	2,7 %	3 %
Portugal				3 %
Denmark				6 %
European Union	Long-term economical growth rate : 2,5 to 3 %			5 %

Source: La Calade

Weitzman and Gollier established that the uncertainty on the future economical growth has the tendency of reducing the discount rate by introducing a precaution effect antagonist to the wealth effect. The discount rate reduction could happen in 25 to 30 years, when the economical growth rate are particularly uncertain in Europe. In France indeed, the “Commissariat Général au Plan” has made hypothesis of the reduction of the rate to 3.5% in 50 years, 3% in 100 years and 2% in 500 years.

Precisions

The risk bonus was not included in the discount rate calculation. This factor must not be integrated through an implied augmentation of the discount rate. The risk has to be dealt with in each project’s assessment for the quantity previsions as well as for the price previsions.

Moreover, the discount system consist of the discount rate and of a system of goods’ relative prices where the value of environment and non renewable resources could increase more than the others value.

The discount rate is also a real discount rate and has thus to be used in calculations made in constant currency (without inflation).

ANNEX 2: NECESSARY DATA FOR THE GREENHOUSE EFFECT GAS ASSESSMENT

Energy consumption

Two approaches are possible.

- **Results of the direct emissions**

The first approach consists in assessing the emissions on the spot: chimneys, exhaust pipes… In this case, the emissions relative to electricity are equal to 0. For combined power heat, the emissions are those of the boiler room (boiler, turbine or motor). For urban heating, the emissions are those of the boiler if it is on the community area (if it is not, the emissions of the boiler must be taken into account in the results according to the community opinion). These results are called results of the direct or local emissions.

- **Results of the emissions life cycle assessment**

These second results assess the life cycle emissions, taking into account energy consumption relative to production and distribution of energy. The emissions of CO_2 results stem thus from a **life cycle analysis** of the energy considered.

For fossil fuels, the life cycle analysis raises of about 10% the direct emissions. For electricity, it deals with average emissions per year of the whole country electric park which could integrate the life cycle analysis of the different ways of energy distribution. For the wood, the emissions are reduced to 0 by convention, if we consider the hypothesis that the combustion of wood is compensated by the initial stocking/storage of carbon (forest balance).

For the combined power heat, we integrate the life cycle analysis of the fuel entering in the system:

- If the electricity produced is self-consumed, the results keep only the direct and indirect emission linked to the gas bought.
- If the electricity produced is resold to the grid, it is necessary to subtract the emissions that would have been produced by the production by the grid of this same quantity of energy.
- Finally, if the heat is resold (outside the area studied), we must also subtract the emissions which would have been made with classic and equivalent means of heating.

Example of emissions with Life Cycle Assessment (LCA) of a combined power gas heat which resells electricity to the Grid

Gas → 100 kWh → Electricity = 40 kWh ←→ 40 kWh = Grid Electricity
→ Heating = 30 kWh

Emission = 201
Gas Production = 23
(Plant and Distribution)
Total of Rough Emissions = 224 g CO_2

Direct Emission = 0
LCA = 38,4 g CO_2

Total of Net Emissions = 224 – 38,4 = 185,6 g CO_2

These results are called **life cycle emissions**.

The factors of direct or local CO_2 emissions:

In this particular case where CO_2 comes from the combustion of fossil energy, the factors of emission are calculated from the following equation:

Factor of CO_2 emission (t CO_2 /10^3 toe) = Coefficient of carbon emission (tC / TJ)* Factor of conversion in toe (41.868 TJ / 10^3 toe) * (44/12), with 44/12 corresponding to $M[CO_2]/M[C]$

The factors of direct and life cycle emissions:

The tables below indicate the factors of CO_2 emission retained.

Factors of CO_2 emission (t CO_2 / toe)

	Direct Emissions	Life Cycle Emissions
Coal Gas	4.38	4.77
Heavy Oil Fuel	3.27	3.67
Heating Fuel	3.09	3.53
LP Gas	2.69	3.17
Gasoline	3.03	3.65
Diesel Fuel	3.09	3.53
Kerosene	3.09	3.51
Natural Gas	2.61	2.91
Wood and Wood wastes	0	0.12
Electricity French Average Italian Average Portuguese Average Danish Average	 0 0 0	 2.01 for heating, 0.47for other uses 5.80 2.67 for heating, 1.66 for other uses

Source : La Calade based on data from EDF, MIES, ADEME, ENEL and IEA for electricity profiles

Factors of CO_2 emission (gCO_2 / kWh)

	Direct Emissions	Total Emissions
Coal Gas	377	410
Heavy Oil Fuel	281	316
Heating Fuel	266	304
LP Gas	231	273
Gasoline	261	314
Diesel Fuel	266	304
Kerosene	266	302
Natural Gas	201	224
Wood and wood wastes	0 by convention (394)	10
Electricity French Average Italian Average Portuguese Average Danish Average	 0 0 0	 180 for heating, 40 for other uses 500 231 for heating, 143 for other uses

Source : La Calade based on data from EDF, MIES, ADEME, ENEL and IEA for electricity profiles

GLOSSARY

Environmental assessment of life cycle costing or Life Cycle Assessment (LCA) assessment of the environmental impact of a product or an equipment, from its manufacturing to its life end.

Life Cycle Costing (LCC) or Whole Life Costing (WLC): assessment of the economic and perhaps even the social impacts of products or equipments, from their manufacturing to the end of the assessment period / time (LCC) or to their life ends (WLC)

Direct life cycle cost or DLCC: corresponds to the total cost of a project, including the initial or investment costs and the expected postponed or running costs.

Overall life cycle cost or OLCC: sum of direct cost and externalities:
- the direct life cycle costing assessment
- the externalities' assessment
- the indirect effects' assessment

Shared life cycle cost: the breakdown of costs and profits of a project life cycle cost between the project's stakeholders

Externality: all various environmental and social project's impacts which correspond to non market project's effects or which are borne by actors external to the project

Net Present Value of an equipment: Gross value discounted on the equipment's lifespan

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