Reconsidering the Meaning of Home in the Rehabilitation - Towards a Sustainable Historical Town

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INTRODUCTION

The housing sustainability implies “a better quality of life not just now but for future generations as well as, it should combine protection of the environment, sensible use of natural resources, economic growth and social progress” (Edwards and Turrent, 2000:1). Thus maintaining sustainability in the rehabilitation of historical domestic architecture requires a deep understanding of the inhabitants’ needs, meanings and appropriation of their historical houses. Edgar Morin ascertained the importance of the inhabitant-house relationship, as he explained that “If, between the houses, the streets and the groups of its inhabitants, there were only to be an accidental relationship and one of short duration, men could destroy their home, their neighborhood, and their city and rebuild another, in the same place, following a different design; but should the stones let themselves be transported, it is not equally easy to modify the relations that are established between the stones and men” (Morin :1991,p.137 ; Leite ,2009 :27).

The experience of home environments, the relation of this experience with identity, security, mobility, and place attachment received lately increased attention from scholars in different fields. In this paper the rehabilitation of the historic houses will be discussed and reconsidered in light of the notion of home meaning. This will be obtained by exploring the broad set of associations and meanings that are linked to the physical structure of house, and illustrating the challenges that are facing the conservation theory in order to cope up with the modern society needs. Furthermore, going through different approaches that tackle the inhabitant-house relationship and articulating the required means to implement the meanings of home in the rehabilitation of the historical houses.

MEANINGS OF HOME

Revisions for home literature confirm that home is an indicator of cultural identity, a sign of social status and a catalyst for the expression of individual preferences since it...
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represents functional and monetary values, as well as, aesthetic, symbolic and cultural values. Dovey stated that “the concept of home is of value as it uniquely encompasses the social, psychological and cultural aspects of domestic living including key processes and goal-making, which dwelling does not. Home is difficult to define as it has many attributes and levels of meaning, but at its centre is a ‘highly complex system of ordered relations with place, an order that orients us in space, in time, and in society’” (Dovey, 1985, p. 39).

Fox (2007:138-139) tried to categorize the meanings that the home reflects by divided them to intangible and tangible meanings or values. Since Home = House + x, x factor = the meanings associated with social, psychological, emotional and cultural attachments to home. Intangible meanings of home are concentrated in: home as territory, home as identity, home as a socio-cultural unit. And tangible meanings of home are concentrated in: home as a physical structure, home as a financial asset.

Conceptualizing intangible subject “home” is not simple. Kim Dovey as quoted by Fox (2007:145) suggested that “the most appropriate methodological response to these characteristics is to tailor the functions of home analysis, so that it seeks not to produce specific cause-effect relationships or explanations, it is rather to deepen our understanding of an intrinsically intangible phenomenon”.

On the other hand it is essential to analyze the contextual and synthesis components of the home meanings as it is an unformulated phenomenon. As for Hillier the meaning is embodied in the physical structure, he explained that “Architects should beware of espousing a “natural” philosophy of basic human needs or shared norms and values and particularly in determining a spatial form for such nebulous concepts as those of “community and privacy” (Hillier, 2003:110).

Recently the meaning of home is facing major challenges in surviving in an era of globalism and modernity. Heyen (1999:18-19) wrote dwelling and modernity are opposed to each other, and confirmed that “Dwelling is in the first instance associated with tradition, security, and harmony, with a life situation that guarantees connectedness and meaningfulness”. Moreover Dovey (1985:51-58) illustrated the factors that eroded the sense of home as: rationalism and technology, commoditization, bureaucracy, scale and speed, the erosion of communal space and professionalism. In that regard dwelling in the proper sense is not easy to be reached. Thus this paper will tackle the improvement of the rehabilitation theoretical and methodological framework so as to maintain the meanings of home and to achieve sustainability in historic housing areas.

CONSERVATION THEORY CHALLENGES

In any conservation process the need for change is an essential. This need become crucial for many reasons related to economy, legislations, industry, architectural style and taste. Usually, in conservation practice there are three main questions which require answers. These answers depend on basics founded in the conservation charters and originated from the conservation theory. The main questions that the conservation theory has to answer are (Larkham, 1996:29):

- Who decided what to conserve?
- How is conservation carried out?
- And what are the nature, scale and direction of change?

In General, the conservation theory is facing a major burden to deal with these main issues due to certain gaps. These gaps are caused by different factors; some are power
and politics related factors others are related to the lack of development and research. Following a summary of the main gaps that conservation theory needs to overcome:

- The gap between international conservation charters' aims and different social groups' values and meanings. According to Wells (2007:5) the heritage doctrine is a teleological system consisting of a complex mix of beliefs, biases and excluding meanings. The international charters are an example of power, for example, Athens Charter represents a point of focus, and what comes into view is the antagonism between the West and the Soviet Union (Wells, 2007:8, Deleuze, 1988:25). So these charters imbue the materiality of the object with truth as an absolute rather than the relative truths existing in the realm of cultural meanings and values. Actually these charters and recommendations satisfy the Western patient of Orient and the elite cultural taste. Thus, there is a serious need to discuss the readymade recipes for development and common good principle and set new recommendations that accept the social difference. Lately, the Burra Charter and the Nara document on Authenticity are trying to change the absolute truth and to involve the women and minorities in the cultural heritage conservation process.

- The gap between restoration theory that is funded by classical architectural theories and the contemporary architectural concepts. Thus, the restoration theories associated to the architectural object didn’t observe certain cultural values impregnated within formal and spatial architectural dimension (Amorim and Loureiro, 2007:2). This has its echo in the international conservation charters also, which still concentrating on the materiality of the object and ignoring the immaterial meanings. Lately a movement toward the relativization of materiality trend is obvious which transfers importance from materiality to immaterial aspects of heritage. A clear example of this trend is the move from the concept of monuments to the concept of places (Pereira, 2007:18)

- The gap between international guidelines for the conservation of the historic cities and contemporary development. Since the UNESCO recommendations on urban sites was announced in 1976-more than thirty years ago, while these traditional views toward development and the link with contemporary architecture is in need to be enhanced (Van Oers R., 2007:44). In 2003 The World Heritage Committee called for the organization of a symposium in Paris to discuss how to properly regulate the needs for modernization of historic urban environments, while at the same time preserving their values. In response, the World Heritage Centre in cooperation with ICOMOS and the city of Vienna organized international conference, in May 2005, in which a first outline of principles and guidelines was adopted, the so called Vienna Memorandum, which promoted an integrated approach to contemporary architecture, urban development and integrity of the inherited landscape. But still a new or revised Recommendation on the conservation of historic urban landscape doesn’t exist.

These gaps left its impacts on the practical execution of the theory, thus there is no recipe for a successful intervention. This paper proposes an enhancement of the rehabilitation theoretical framework and methodology in order to find out answers for the three main questions through considering the meanings of home and being more sensitive to the inhabitants’ needs. Consequently it is important to understand the interaction between the inhabitants and their historical houses in order to find the balance between the conservation measurements and the inhabitants’ needs and to maintain the development and sustainability requirements.
INHABITANT-HOUSE RELATIONSHIP

So the human-built environment relationship must be given much more importance to bear on the key problem of the twenty-first century city, that of sustainability. Actually there are three main theoretical streams that tackle this relationship: the phenomenology, Structuralism and post-structuralism. Following a description of these main approaches and their connections to the inhabitant-house relationship:

Heidegger argued that people cannot “be” without having some connection to a particular place, “The way in which you are and I am, the manner in which we humans are on the earth, is Buann, dwelling. To be a human being means to be on the earth as a mortal. It means to dwell, man in so far as he dwells” (Heidegger, 1975). Heidegger’s and Merleau-Ponty’s approach of discussing human-built environment relationship is known as the existential phenomenology, from their point of view the human experience reflects the meanings in the world which is also built and embodied by this experience in absence of science and society. Since according to Hillier (2005:5) “the driving idea of phenomenology is that there exist connections between minds, bodies and worlds which are independent of the conceptual frameworks imposed by society and by science, and which are in fact likely to be obscured by these frameworks”.

Inspired by the phynomenological theories, Dovey proposed the phenomenological approach of home design. He described the design process as a “cycle of lived space”, in this cycle the designer first must understand the clients’ everyday environmental needs or their lived-space. Then the designer should translate those needs to geometry, and finally this geometry will be transformed and constructed to a lived space again. As well to achieve successful translation from the experience or lived space to geometry, Dovey suggested changes in the design process that includes experiential simulation, through conducting piecemeal change and phynomenological evaluation of environments already built.(Dovey, 1993:247-270).

Furthermore, the literature on social structure and its relation to geography and place reveals important perspectives on the human-built environment relationship. After Ferdinand de Saussure significant works on structuralism, Giddens in 1984 introduced the theory of structuration in social science in his book “The Constitution of Society: Outline of the Theory of Structuration” his theory is based on establishing a dynamic perspective of how different elements of a society interact. Such a work is based on a critical understanding of people, organizations, agencies, and the power that each element of a society would have (Giddens, 1984). The introduction of the theory of structuration generated an intensive debate on linking issues that pertain to relationship between the structure of society and the physical environment, namely the concept of place. (Salama, 2007: 68)

Allan Pred in his article titled: “place as Historically Contingent Process: Structuration and the Time-Geography of Becoming Places” introduced a framework that is based on an integration of time-geography (place) and the theory of structuration. He conceptualized place as a human product as well as a set of features visible on the landscape. In essence what is concerning in this regard is the term “human product” (Pred, 1984)

The Structuralism took an important role in architecture and urban planning starting from the 1960’s through the ideas of users’ participation in design or pluralistic
architecture as a reaction against functionalism or rationalism. Consequently Amos Rapoport proposed the “Choice Model” and the “Filter Model”, his theory stated that “depending on the meaning of “good” environment, the images which a people has about the good life and the appropriate setting for it, one would expect to find a variety of places designed always directed towards the making of better places through the application of sets of rules based on the definition of environment quality” (Rapoport, 1977:15)

The structuralist faced major criticize for their deterministic approach that imposes the human behavior on the built environment and deals with the networks as a global locational system without consideration for the syntax. In the Habitus theory Bourdieu described the space as being at once both physical and social. The connections of habitus to architecture lie in the connection of habitus to habitate or in other world the ways in which space frames social practice (Kim Dovey, 2005:285).

Recent efforts to understand the relation between the human and the built environment started to concentrate on the need to deal with the building as a social space or lived space without separation between subject and object. So the space syntax theory was developed by Bill Hillier and Julienne Hanson in 1984, Hillier in his justification of the space syntax theory stated that “space syntax combine social physics and phenomenology into a single theoretical model” (Hillier, 2005:8). Based on the space syntax theory Hanson and Hillier proposed the space decoding approach which was developed later to investigate the inhabitant-house relationship. In such an approach they are trying to connect the physical structure and the socio-cultural meanings. Hanson explained that the houses carry cultural information in their material form and space configuration and in the disposition of household artefacts within their domestic interior (Hanson, 2003: 1).

As well the Space syntax theory has a set of techniques and applications regarding the analysis of spatial configurations of all kinds. The main aim of these applications is to help the architects simulate the likely effects of their designs. The most significant application is the Depthmap software which was developed by Alasdair Turner from UCL.

Finally the previously mentioned theories are considered the most important approaches that tackle the inhabitant-house relationship. In view of that the rehabilitation theoretical framework and methodology has been reviewed in order to be reconsidered in light of a deep insight through the meaning of home and the different approaches to explore the inhabitant-house relationship.

THOUGHTS ON THE REHABILITATION OF THE TRADITIONAL DOMESTIC ARCHITECTURE

According to Feilden and Jokilehto (1998) the rehabilitation means “the physical improvements that are necessary in order to provide an appropriate use to an empty or inappropriately utilized structure”. They added that the rehabilitation shall always involve a use as close as possible to the original function so as to ensure a minimum intervention and minimum loss of cultural values, this also makes sense economically. While in present day modern concern the rehabilitation for domestic reason was defined as “improving the action of dwelling by seeking a point of balance between technical aspects, the preservation of heritage values and criteria of social justice, economic efficiency and preservation of the environment” (RehabiMed, 2005:12). As
showed here, it can be noticed the difference between the two definitions, the first definition is a pure technical definition, while the second is looking for balance between technical aspects and social aspects. This argument shows the main gaps in the rehabilitation practice, which will be discussed in details later.

In general the rehabilitation of traditional architecture has to be set in the framework of a process of revitalization and regeneration of the territory of which it forms part, whether an urban or a rural environment. It has to be understood as an intervention on both the physical environment and on the population it hosts, and the series of cultural, social and economic activities that define the “social environment”. Thus the rehabilitation process of any historical town or area includes planning measures side by side to design measures that can be categorized into four levels:

- The international charters and recommendations.
- The national planning and cultural heritage laws.
- The historical town master planning regulations and measures.
- The rehabilitation in the building level.

Accordingly the concentration on the immaterial aspects of the rehabilitation and the deep understanding for the inhabitants’ needs require developing the theory, the international charters, the national regulations and the intervention methodology as well. Following an overview of the main aspects that are in need for reconsideration within the rehabilitation theoretical framework as well as the rehabilitation methodology:

**Reconsidering the rehabilitation theoretical framework**

On the theoretical level, it is aiming to develop a theoretical frame work for the rehabilitation process which bridges the gaps that are caused by the international charters and conservation theory through considering the following aspects:

- Developing the public participation in the rehabilitation process and give them the opportunity to reflect their meanings and values side by side with the professionals. In order to assert the diverse meanings of the objects and include different social groups in the decision making process, aiming to reach social justice.

- Concentrating on the relation between the rehabilitation of architectural space and the social aspect of space. To parallel the development of modern theories of architecture that connected the architecture field to the social practice.

- Enhancing the rehabilitation process to include the modern notions of sustainability and development. By concentration on the concept of cultural sustainability. And impacts of cultural aspects on the environmental aspects of historical buildings.

Through the mentioned points, a new theoretical approach for the rehabilitation in general will help in setting up rehabilitation methodology for the historical houses, which will cope with the main challenges that the theory face. In this paper the rehabilitation of the historical houses is the main target, so the methodology of the rehabilitation in the building level will be explained and discussed to underline the main issues that must be reconsidered and improved.
Reconsidering the rehabilitation methodology in the building level

Depending on the RehabiMed guide (2005, 66-92); the rehabilitation process includes five main stages, which are:

**Stage I: the knowledge**- this stage includes two main steps which are:
- Preliminary step includes the client’s decision to take action. And followed by a visit by the architect to prepare preliminary report of the building
- Multi-disciplinary studies: includes detailed studies of the social, historical, architectural and construction aspects.

**Stage II: the diagnoses or analysis**- which focuses on using the results of the previous studies so as to grant the ability to explore problems and their causes, and produces an overview of the building’s potentials and deficits

**Stage III: the reflection or project**- which includes proposing design that picks up the client’s ideas for rehabilitation work and seeks to reconcile them with the reality of the building, its heritage values, economic possibilities for investment, etc. At this point the criteria of intervention must be guided by a solid professional ethic and the previously mentioned Charter on the Built Vernacular Heritage, which will decide the answer for three main questions:
- What to keep?
- What to get rid of?
- What to add?
And, finally, on the basis of sound criteria, the outcome of this stage is the drafting of the project document that enables the contracting, constructing and control of rehabilitation.

**Stage IV: the action**- this stage includes execution and site work of the project, in which there are two main principles to take care of:
- The material used
- The techniques of repair work

**Stage V: life span monitoring and maintenance**- this stage comprises minor cleaning work, repairs and renovations carried out according to a timeframe throughout the building’s lifespan until future rehabilitation.

Thus, the implementation of the inhabitant-house relationship should be performed in different stages of rehabilitation methodology. There are main points that are in need to be reconsidered and enhanced, these main censure points are:
- The knowledge stage:
In the preliminary diagnoses, the decision making process is excluded on the dialogue between the client and the architect (RehabiMed, 2005:70), while there is a need for a participatory and pluralistic approach in the rehabilitation of domestic architecture considering different social groups (women, children, elderly, etc...). And to reassess the common good approach which minimize the options and control the decisions. As well, in the multi-disciplinary studies, the following points must be taken into consideration:

a. The social studies are defined as: “sociological survey to detect family units and possible problem situations (overcrowding, marginalization, unemployment, abandonment, etc.)” Besides “Anthropological study that provide us of all the intangible aspects related to the community’s perception of its architecture” (RehabiMed, 2005:73). While it is important to study the social structure and social behavior starting from the relation between society and building, and how building envelops the social structure and behavior and to concentrate on the inhabitants’ preferences and lifestyle.

b. The architectural analysis defined the architectural values as “integration in the place, spatial configuration, singular structure, type of ornamentation, etc.” (RehabiMed, 2005:75). In that regard the architectural analysis concentrate on the building as an artifact object which reflects meanings from outside. There is a need to deal with building as an object with a space that includes meanings and values. So there must be no separation between the architectural analysis and the social content.

c. The architectural analysis suggested investigating the building transformation with recourse to a historical study, in order to understand its present-day configuration (RehabiMed, 2005:76). Although understanding the building transformation is not only related to combine the historical study but the most important is to combine the social study.

At last, the multi-disciplinary studies can be more sensitive towards the inhabitants’ needs by including new methods and techniques, these are:

a. Applying the phenomenological approaches of experiential evaluation of the built environment through performing participant and direct observations to investigate the behavioral patterns and lifestyle. And conducting interviews with key persons from local society and the inhabitants for a deep understanding of their perceptions of the historical houses.

b. Applying the structuralist’s approaches of investigating the environmental choices within the built environment through conducting field surveys and questionnaires to investigate the inhabitants’ evaluation and preferences for their houses.

c. Applying the post-structuralist’s space syntax approaches by implementing the configurational analysis to define the historical houses spatial qualities. As well as using the UCL Depthmap software analysis to simulate the users’ behaviors and pattern of use.

- The reflection stage still unclear and left to the designer ethics, although the RehabiMed method depends on the Charter on the Built Vernacular Heritage as a reference. While through enhancing the analysis phase more deep results
will be attained so as the design phase will be more concrete. As well it is efficient to introduce new techniques and strategies in the design stage such as:

- Applying Dovey's cyclic approach of design which depends on the inhabitants' perceptions of their lived spaces.
- Using the Depthmap software to simulate the inhabitants' behaviours in the proposed designs.

- The execution stage is the main important phase in reality, since most of the time and efforts are concentrated on the execution which turned the rehabilitation to a technical process that focuses on the quality of construction works and materials used. While in this stage it is useful to follow the previously mentioned cyclic approach of design and include experiential simulation techniques as well through:
  - Conducting piecemeal change in the house's environment.
  - Applying the phynomenological evaluation techniques of the already built parts.

- The monitoring stage is concentrated on the physical maintenance and repairing while no mention for investigating the inhabitants and users satisfaction and preferences.

As a final point, it is important to consider applying this methodology based on the difference in the building's (house) architectural and historical values. Thus the different categories of historical houses including monuments, registered houses and ordinary houses should be recognized. In general the aim is common for all categories, which is to consider the inhabitant-house relationship in the rehabilitation process in order to maintain the main meanings of home (identity, territory, socio-cultural unit, monetary and physical structure) and to reach housing sustainability in consequence. In particular the application of the recommended methodology must take into consideration the specialty of each category depending on the conservation international charters and recommendations.

For monuments it will not be proper and simple to conduct physical changes to apply the inhabitants' needs. Any change should be sensitive to protect the house's identity and values. Special solutions are in need to be innovated depending on the circumstances of each individual case; these solutions can be developed based on two main considerations:

- Applying semi-fixed, movable and flexible changes.
- Creating non-fixed changes such as new behavioural patterns.

Regarding the configurational properties such as visibility and permeability there will be a need to define what can be changed without affecting the house's cultural and architectural values.

For registered houses the physical changes is more flexible, while any change should be in light of the conservation measurements and regulations that control the proportions and the characteristics of changes. As well for the change in the configurational properties the limits of intervention is wider than in the case of monuments. The Architect should define the properties which are in need for change and those which should be protected based on the inhabitants' needs.

Regarding the ordinary houses the physical change is easier to be conducted as in the case of the registered buildings moreover in the case of the ordinary houses the additions and destruction process is more flexible. As well as, the configurational
proporties can be altered based on the inhabitants' needs and contemporary perceptions of their houses meanings.

CONCLUSION

This paper gave the opportunity to review the rehabilitation process of the historic domestic architecture in light of the main meanings of home. It was clear through the previous discussion that understanding the inhabitant-house relationship is important to maintain the meanings of home and to reach sustainability. On the other hand, it was found that the conservation theory has certain gaps that caused the rehabilitation to be more technical and materialistic. The paper presented several aspects and methods to enhance the historic houses rehabilitation theoretical framework and methodologies. Particularly, major enhancements were outlined within the knowledge and analysis stage as well as the design and reflection phase.

REFERENCES


Papers


Phytodepuration integrated in flat green roofs. Proposal of grey water management for medium and high density urban districts.

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Summary

The proposal analyzes the water consumption habits and the urban conditions of medium and high density Spanish cities, in order to improve new grey water management policies which take advantage of the large flat roof surfaces existing in these contexts. In these areas, an average citizen consumes in domestic uses, which does not require drinkable water (flushing toilets, irrigation, etc), more than 30% of the total volume (167 liters / person day). This situation brings not only wastage of limited water resources, but also the need to oversize the urban sewage networks and to build large wastewater stations in the urban peripheries; with the resultant environmental, social and economic impacts.

On the other hand, the urban structure of the Spanish districts built since the 60’s is characterized by the lack of private green areas, which difficult developments of naturalized treatments of grey water at ground level. Also, flat roof building typologies have been frequently designed in most of the Spanish medium and high density residential districts. Because of that, the paper proposes to rethink these large and underused roof surfaces, in order to incorporate industrialized phytodepuration systems, which purify grey water produced in domestic uses.

The use of natural purifying systems integrated in urban areas is favored by the relatively low contaminant load of grey water from showers, bide, washbasin and even washing machine. Furthermore, the proposed systems allow the water reuse in non-drinking uses (flushing toilets, urban maintenance, garden irrigation, etc), by using simple construction methods and without the need of using toxic components.

Keywords: Grey water reuse, phytodepuration, urban water management, green roofs

1. Research Framework

The ABIO-UPM research group (Bioclimatic Architecture in a Sustainable Environment), has worked from 2007 to 2010 in the subproject 10-Optimization Systems for Efficient Behaviour in Housing, in the frame of the Strategic and Singular Project INIVISO (Industrialized and Sustainable Housing). The research has been developed in the following four main phases:

1. Cataloguing phase. There have been analysed and classified 166 strategies that currently are used in the sustainable water management scope. These strategies have been organized in the next seven categories: Rainwater, water consumption reduction, irrigation, grey water, waste water and water quality.
2. Selection phase. Each strategy has been detailed described through analytical and graphical parameters, in order to define their level of Sustainability, Innovation and Functionality. As result of the strategies comparison, grey water treatments have been defined as those with the greatest potential for innovation in the field of housing industrialization. By improving their development, it is possible to raise important drinkable water savings with interesting possibilities of spatial innovation and relative easy integration in residential buildings.

3. Development of a phytodepuration system for grey water reuse. Although these systems are normally used in communities with large free country extensions, the proposed strategy tries to adapt the benefits of traditional systems into industrialized modular products, which can be applied in urban building roofs or gardens.

4. Prototype construction and monitoring. A first prototype has been built by the biologist Óscar Domínguez on the Aula de Educación Medioambiental of Pozuelo de Alarcón, near Madrid (Spain). This experimental prototype has been constructed on the ground level. A second prototype is being built on the flat roof of a private house in the village of Tembleque, near Toledo (Spain); and it will be finished at the summer of 2011.

2. Domestic water consumption

2.1 Spanish habits regarding the domestic water consumption

The National Statistic Institute of Spain (INE) estimates that each Spanish inhabitant consumes 167 litres of water per day in domestic uses; of which the most representative are the 60 litres/person day used in personal hygiene and 45 litres/person day by flushing the toilet. These values represent a 60% of the global water consumption.

Taking into account also the low rainfall levels in Mediterranean countries like Spain, it is necessary to develop new water management behaviours that help to reduce the use of drinkable water, specifically in uses that does not require it (flushing toilets, irrigation, urban maintenance, etc).

![Fig. 1 Main domestic uses of water consume](image)

2.2 Grey water reuse

According to the main domestic uses where water is being consumed, the development of strategies of grey water reuse and the change of the conduct habits, represent the most effective methodology to diminish the current high values of drinkable water consumption.
Although grey water concept has become in recent years more and more common, there is still no consensus about the sources which produce this. While some authors define it like the result of all kind of domestic water uses, except flushing toilets [2]; other authors exclude water from kitchen sinks and cleaning with high levels of soap [3].

According to the first hypothesis, Biological Oxygen Demand (BDO) and Phosphorus levels increase considerably because of the organic load from kitchen sinks; and in some cases it reaches similar values as the water from flushing toilets [4]. Also, if this grey water definition is being accepted, the section of the dual grey water pipeline should be greater, the control of discharged chemical products would be more difficult and the solid in suspension levels would be higher; but the volume difference in relation with the second definition supposes less than the 17%.

Because of that, and taking into account the economical and constructive requirements of urban retrofitting actions, there will be only considered as grey water, those from washbasin, shower and bidet. Furthermore, there will be studied the impact of including water from washing machine; because if it is included, the daily volume that is discharged to the network increases to 138 litres/person day, which together represent almost 80% of the global domestic water consumption. However, if this source of water is included, there would be only used organic soaps without chemical components in order to protect the phytodepuration plants.

Although by avoiding water from kitchen sinks implies a considerably reduction of organic load, it should be took into account that one of the main problems of grey water is the highly fluctuation of DBO and Chemical Demand of Oxygen (CDO) levels; mainly produced by the different habits of each inhabitant and by the existence of children in the family.

Table 1 Average water consumption values in Spain (l/person day). Source: INE, National Statistic Institute of Spain. ECODES: Ecology and Development Foundation. *washing machine included as grey water source

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<thead>
<tr>
<th>Water consumption (l/person day)</th>
<th>Water consumption (l/person day)</th>
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<tbody>
<tr>
<td><strong>Shower/bath bidet and washbasin</strong></td>
<td>60/93*</td>
</tr>
<tr>
<td><strong>Toilet</strong></td>
<td>45/16</td>
</tr>
<tr>
<td><strong>Washing machine</strong></td>
<td>33/18</td>
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<tr>
<td><strong>Cooking and drinking</strong></td>
<td>19/13</td>
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<tr>
<td><strong>Cleaning</strong></td>
<td>10/7</td>
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<tr>
<td><strong>Total grey water produced</strong></td>
<td>60/93*</td>
</tr>
<tr>
<td><strong>Total water consumption</strong></td>
<td>167/100</td>
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3. Urban water management proposal

3.1 Characteristics and conditions of Spanish medium and high density districts

The population distribution in Spain differs from most of the Occidental European countries, mainly from these where phytodepuration systems have presented a higher development, like United Kingdom or central Europe. The Spanish population density is about 91,4 inhabitant/km² while in other countries with similar dimensions, it raises the 250 inhabitant/km² of Germany or United Kingdom with 243 inhabitant/km². However, the Spanish population is concentrated in densely populated cities of medium or large size, located either along coastal and valley metropolitan areas or in specific interior metropolitan areas like Madrid, Zaragoza, Córdoba and Valladolid. Thereby, the 45% of the Spanish population is concentrated in only 7 of 50 total provinces.

The metropolitan area of Madrid is the fourth largest of the European Union, after London, Duisburg and Paris, where peripheral cities experienced an important development since the 1960 decade, characterized by urban growth patterns based on complex of tall buildings and lack of green areas.
Respect to the urban water management model, this growth pattern was based on the construction of large and isolated sewage stations, where all consumed water of the city was discharged. Over the years, these facilities have been absorbed by the new residential districts and most of them suffer currently overloaded situations. The lack of water separative networks produces oversized networks and saturation problems of the stations, especially in storm periods. Also, the continuously ground waterproofing in the current cities facilitates that rain, black and grey water mixed in the same net, and discharge more polluted water volumes than the station can purify.

Because of that, it is necessary to consider new strategies to act upon the urban water cycle, in order to establish correct management policies about this limited resource. The proposal of new grey water treatment stations at district scale contributes not only to reduce the current drinkable water consumes in uses that does not require it (flushing toilets, irrigation, etc); but also helps to a better organization that increases the efficiency of the sewage stations at city scale.

The proposal tries to take advantage of the underused spaces in medium and high density cities, where it is possible to rethink new low impact facilities. In this sense, the large flat roof surface existing in most of Spanish cities, suppose an important opportunity to locate controlled phytodepuration stations at district scale. The lack of physical contact between inhabitants and roofs, the low contaminated load of grey water, the return of nature processes to the urban contexts and the hygrothermal behaviour benefits on the buildings indoor comfort, are only examples of the positive impacts that this solution could offer to the contemporary cities.
3.2 Study case

In order to develop this grey water management model, a study case has been selected in a district of the city of Alcalá de Henares, situated in the metropolitan area of Madrid and a good example of the urban growth developed in the sixties and seventies in most of the Spanish cities. The density of the area and the large flat roof surface existing over tertiary sectors, have determined this selection. Also, these characteristics are common in many Spanish cities, so the proposed system could be extrapolated to many other examples.

The studied area was built in the early seventies and it is formed by two residential seven storeys blocks and a central one storey volume with a tertiary use; and is bounded by the Complutense Avenue with the Ribera, Murillo, Juan de Arellano, Caballería Española and Manuel Azaña streets.

According to this typologies and the regional legislation of the Comunidad de Madrid, an average of 3 equivalent inhabitants per dwelling has been estimated; resulting a total amount of 1,680 equivalent inhabitants in the whole area.

In other hand, the central building has a 4,690 m2 flat roof, mainly free and underused.

![Fig. 4 Location of the study case](image)

4. Water management strategy

The possibility of reusing the underused flat roof of the commercial building has been studied, in order to take advantage of the large free surface. In this way, it is possible to win an area where the inhabitant has no physical contact with the phytodepuration treatment system, but at the same time it is possible to build a new urban garden which improves the views from the surrounding buildings.

The proposed system is the following: Grey water from each dwelling is collected by a dual pipeline, prefiltered and stored in a primary tank, one per doorway. There, grey water should be remained no more than 24 hours. Also, the design of the bathrooms of the same owner, which are sharing the same technical wall, helps not only to reduce the length of the grey water and pumping net, but also to minimize rehabilitation works and economic costs.

Water stored in primary tank is pumped daily to the centralized tank, sited in the basement of the commercial building. From there, grey water is again pumped to the roof, where should be at minimum 7 days in the industrialized phytodepuration system. Later, purified water will be stored, waiting to be reused in flushing toilets or garden irrigation.
5. **Industrialized phytodepuration system**

The main innovation has been developed in relation with the phytodepuration area. As traditional wetlands are so large that it is not possible to define the tour wastewater does, the strategy proposes to reduce drastically the required water treatment surface. Because of that, the industrialized tanks have been designed in order to facilitate the control of the water circulations.
Subsurface reed beds have normally a 4.00 m width [1], and are normally disposed linearly. However, the developed strategy will reduce the width to 1.50 m, in order to increase contact between roots, bacteria and water, optimizing the system and reducing the space needed. Also, the tanks length is 10 m, in order to facilitate not only the portability and transport of the system, but also to make easier their placement on the roof.

In relation with the plants, macrophytes in flotation filters (FMF) have been firstly developed by the Grupo de Agroenergética of the Universidad Politécnica de Madrid, leaded by the Professor J. Fernández. The technical consist in combining the benefits of emergent and floating plants. Emergent plants, like Praghmites or Typhas, have an important rhizosphere volume. When they have sufficient growth, they are adapted to the aquatic medium by the used of buoys. As the rhizosphere volume is greater, more aerobic bacteria rise, and the system efficiency increases. Also, roots are floating and the traditional substrate problem of reed beds is avoided.

Respect the first FMF designs, the other important innovation consists in the incorporation of the transitivity platform over the tank. This platform contributes to the macrophytes support, avoiding the necessity of buoys and the danger of displacements caused by wind or storms. It is supported by two lateral tank reinforcements and polypropylene cells transversally disposed, which also contribute to the oxygenation of the water which passes through them. Also, the platform over the tank provides to the system an air chamber which will avoid disgusting smells, and a thin layer of gravel is disposed over this platform, in order to protect the water from exterior pollution components, leaves or insects.

In order to diminish the roots growth in the connection pipelines between industrialized tanks, three different areas have been design in each tank. The central area is the largest and is where the macrophytes float; while the end sides are free of roots, in order to facilitate the water circulation.

![Fig. 7 Detail of an industrialized phytodepuration module](image)

6. Macrophytes selection

The macrophytes selection has been made, taking into account the continental climate of central Spain, where winter and summer have extreme temperature oscillations; and the benefits of the situation on the roof, where plants receive maximal solar radiation. Respect to the roots length, all species can be adapted to the 50 cm channels depth. It has been estimated 10 plants per m² [5].
Table 2. Main characteristics of the plant species selected for the project. Source: [1] J. Fernández. Filtros de macrofitas en flotación. Ayuntamiento Murcia, Murcia, 2005

<table>
<thead>
<tr>
<th>Image</th>
<th>Plant species</th>
<th>Climatic conditions (1)</th>
<th>Morphology and growth (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image.png" alt="image" /></td>
<td>Phragmites australis</td>
<td>- Continental climate</td>
<td>- Flexible stem</td>
</tr>
<tr>
<td>Family: Poaceae</td>
<td>- Optimal temperature of 12-23 °C</td>
<td>- Grey-green leaves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Survive extreme temperatures -5°C</td>
<td>- Leaves length of 50 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Height to 4 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="image" /></td>
<td>Typha latifolia L.</td>
<td>- Semi-arid Mediterranean climate</td>
<td>- Grey-green leaves</td>
</tr>
<tr>
<td>Family: Typhaceae</td>
<td>- Optimal temperature of 20 °C</td>
<td>- Leaves width 8 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Brown flowers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Height &gt; 2 m</td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="image" /></td>
<td>Scirpus Holoschoenus</td>
<td>- Template and sunny Mediterranean climate</td>
<td>- Brown inflorescences</td>
</tr>
<tr>
<td>Family: Cyperaceae</td>
<td>- Optimal temperature 16-27°C</td>
<td></td>
<td>Height to 3 m</td>
</tr>
</tbody>
</table>

7. Discussion. Impacts quantification

7.1 Space saving

The use of the industrialized prototype reduces the surface of treatment required in the traditional reed bed systems. In comparison with the conventional FMF [1], the surface necessary for the industrialized system could be reduced in almost five times.

Table 3. Surface of phytodepuration, according to the industrialized system (left) and the conventional filters of macrophytes in flotation (FMF) (right)

<table>
<thead>
<tr>
<th>Grey water circulation optimized</th>
<th>Macrophytes in flotation filters (FMF) (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume to be depurated (m³)</td>
<td>Total equivalent inhabitants 1.680</td>
</tr>
<tr>
<td>Industrialized tanks high (m)</td>
<td>m² / equivalent inhabitant 5</td>
</tr>
<tr>
<td>Total daily surface need (m²)</td>
<td>total surface need (m²) 8.400</td>
</tr>
<tr>
<td>Evaporation losses (%)</td>
<td></td>
</tr>
<tr>
<td>Phytodepuration period (days)</td>
<td>7</td>
</tr>
<tr>
<td>Total surface need (m²)</td>
<td>1.531.2</td>
</tr>
<tr>
<td>Total surf. (inc. transitivity areas)(m²)</td>
<td>1.840.0</td>
</tr>
</tbody>
</table>

7.2 Economic impact

This industrialized and modular system can be used not only in roofs, but also in gardens or parks. Due to its optimized dimensions, the economic and environmental costs associated to the use of materials are considerably diminished. Also, the industrialization provides important benefits in relation with construction and deconstruction periods. Respect to the economic costs, it has been estimated that a system in a single house with 5 equivalent inhabitants is around 1.200 euros/inhabitant, including installations and construction. But however, the use in a centralized district context diminishes the price per inhabitant, around a 40% less.

7.3 Water saving

Different combinations have been studied, in order to quantify the impact of the proposal. The main study parameters depend on the source of grey water. In the most favorable situations, the drinkable water consumption reduction could be more than 60% respect the current values. The first hypothesis A, has only considered the incorporation of the industrialized phytodepuration system; the hypothesis B, includes also the replacement of low consumption toilets; and the hypothesis C, includes also the use of different strategies of water saving, such as aerated taps,
thermostatic taps, low power washers, etc. Each hypothesis has been studied according to two different sources of grey water. Firstly, it was only included the water produced in showers, baths, bidets and washbasins (Table 4); and then water from washing machines was included (Table 5).

Table 4. Hypothesis of water saving impacts, according to different grey water sources. Water produced in shower, bath, bidet, washbasin (left). Water produce in shower, bath, bidet, washbasin and washing machine (right).

<table>
<thead>
<tr>
<th>Hypothesis A_ only phytodepuration</th>
<th>Hypothesis A_ only phytodepuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey water produced (l/inh.eq)</td>
<td>60</td>
</tr>
<tr>
<td>Total litres</td>
<td>100,800</td>
</tr>
<tr>
<td>Total cleaned water</td>
<td>100,00 %</td>
</tr>
<tr>
<td>Wc flushing (l/inhab.eq)</td>
<td>45</td>
</tr>
<tr>
<td>Total litres</td>
<td>75,600</td>
</tr>
<tr>
<td>Need extra water (litres)</td>
<td>-5,040</td>
</tr>
<tr>
<td>Hypothesis B_ included replacement of low consumption toilets</td>
<td>Hypothesis B_ included replacement of low consumption toilets</td>
</tr>
<tr>
<td>Grey water produced (l/inh.eq)</td>
<td>60</td>
</tr>
<tr>
<td>Total litres</td>
<td>100,800</td>
</tr>
<tr>
<td>Total cleaned water</td>
<td>100,00 %</td>
</tr>
<tr>
<td>Wc flushing (l/inhab.eq)</td>
<td>16</td>
</tr>
<tr>
<td>Total litres</td>
<td>28,880</td>
</tr>
<tr>
<td>Extra for irrigation reuse (litres)</td>
<td>43,680</td>
</tr>
<tr>
<td>Hypothesis C_ With strategies of water reduction consumption</td>
<td>Hypothesis C_ With strategies of water reduction consumption</td>
</tr>
<tr>
<td>Grey water produced (l/inh.eq)</td>
<td>46</td>
</tr>
<tr>
<td>Total litres</td>
<td>77,280</td>
</tr>
<tr>
<td>Total cleaned water</td>
<td>100,00 %</td>
</tr>
<tr>
<td>Wc flushing (l/inhab.eq)</td>
<td>16</td>
</tr>
<tr>
<td>Total litres</td>
<td>28,880</td>
</tr>
<tr>
<td>Extra for irrigation reuse (litres)</td>
<td>27,216</td>
</tr>
</tbody>
</table>

Fig. 8 Proposal view
Table 5. Impacts of water saving, according to different hypothesis proposed.

<table>
<thead>
<tr>
<th>Hypothesis A</th>
<th>Only phytodepuration</th>
<th>Hypothesis A</th>
<th>Only the phytodepuration system</th>
</tr>
</thead>
<tbody>
<tr>
<td>The grey water produced is not enough to reuse 100% in flushing toilets, but it is only necessary almost 7% more to cover all the demand.</td>
<td>The strategy will save 39% respect to the actual water consumption.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The system will save 25% respect to the actual water consumption.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis B</td>
<td>Use of phytodepuration system with the replace of existing toilets for others of low consume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The strategy will save 34% respect to the actual water consumption.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The combined strategy will save 27% respect to only replace the toilets for others of low consume.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis C</td>
<td>Use of phytodepuration system, including strategies of water reduction consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The strategy will save 45% respect to the actual water consumption.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The combined strategy will save 32% respect to apply only all the other water reduction consumption strategies.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The use of phytodepuration systems could be combined with other water storage roof systems, improving the hygrothermal regulation and the comfort levels in the building. But these parameters should be more accurately studied in new research lines. Also, the viability of the system is not conditioned to the constructive requirements, but for the lack of specific regulations in the Spanish laws according to the grey water reuse systems.

8. Acknowledgements

The results presented here have been developed in the frame of the INVISO Project (Industrialization of Sustainable Housing), funded by the Spanish Ministry of Science and Technology. The work has been developed with the help of PROSOJARD S.L. and the biologist Óscar Domínguez.

9. References

Abstract

This paper presents briefly the objectives, methodology, actions and results of the work Pilot study to reduce environmental impact: evaluation and assessment of a sustainable refurbishment of an existing residential building in Playa de Palma. The building, object of the study carried out by the Consortium of Platja de Palma1 is among the streets Singladura, Dofi and square Pius IX of Can Pastilla (Block 1). It will be explained by how the environmental impacts of the building can be reduced by 50% or more, according to the objectives listed in the following section, as a result of future refurbishment and subsequent management, referring to both its current situation and refurbishment standards in residential buildings. It also includes an approximated evaluation of the CO2 emission reduction achieved in the building life cycle and the projected costs for the various actions of the refurbishment model proposed by the Consortium, to be carried out in Playa de Palma (hereafter PdP).

Objectives and environmental indicators

- To determine the standards for retrofit and successive building operation (which should be followed in the residential buildings in the area of PdP) through a test case, achieving a reduction of environmental impact of the 50% compared to the current situation and a standard refurbishment. Environmental indicators which should show a reduction of at least 50% in a life cycle of 50 years are:
  a) Energy [MJ/m2]: consumption associated with all processes of the building life cycle.
  b) Water [l/person/day]: domestic consumption, cleaning and irrigation.
  c) Materials [kg/m2]: consumption in retrofit and maintenance.
  d) Construction waste [kg/m2]: production in retrofit and maintenance.
  e) Emissions of greenhouse gases [kgCO2/m2]: associated with energy consumed in all processes of the building life cycle.
- To reach, for the test case building (hereinafter Block 1) the compliance with the preceding paragraph and, additionally, A or B energy rating according to the requirements of RD 47/2007.
- To develop the basis of a standard procedure for evaluation and environmental improvement to be applied in the refurbishment of further buildings, both residential and hotels, of the PdP area.

Synthesis of the used methodology

In summary (more information is available throughout the document), the steps to be made to determine the characteristics of the refurbishment are:

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1 Formed by the Ministry of Industry, Tourism and Trade of Spain, Autonomous Community of the Balearic Islands, the Insular Council of Mallorca and the municipalities of Palma and Llucmajor / www.consorcioplayadepalma.es
1. Collect information of the refurbishing building through documentation and visits: plans, technical building systems and HVAC, resource consumption, activity schedules, management and climate.
2. Performing a computerized profile of the environmental impacts of the building in its actual state (with the support of the building energy simulation programs LIDER, CALENER and others⁴; the program TCQ2000 and the databank BEDEC PR/PCT³ for building material information; a water balance on Excel sheet for water; various calculations by the cited program and databank for materials as well as data sheets and own data for waste.)
3. To identify appropriate strategies and actions to reduce environmental impact for the phases of refurbishment and use, together with technical assessment, economic and regulatory compliance.
4. From the above, perform the computerized profile of the environmental impacts of the building according to the refurbishment project and management: check if it meets a 50% reduction in energy, water and material consumption and the generation of CO2 emissions and construction waste, in comparison with the existing building and a standard refurbishment, in a life cycle of 50 years. The study focuses especially on the phases of extraction and production of materials as well as building operation, since they represent up to 90% of energy consumption and CO2 emissions of the life cycle of a building⁴, as presented in the next figure.

**Objects e hypothesis of study**

There are three objects of study to consider allowing a comparison and thus ensuring compliance with environmental objectives: a) the existing building, Block 1, in its current state, b) the standard refurbishment model, or practice, c) the environmental retrofit model, hereinafter called PdP.

The existing building is the starting point to determine if the refurbishment improvements in energy carriers, water use and waste achieved with the retrofit model PdP, meet the objectives.

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² Additionally, software has been used such as Ecotect, in the study of natural lighting, and Design Builder/Energy Plus in the study of solar energy collecting sunspaces and natural ventilation systems.
³ Institute of Construction Technology of Catalonia www.itec.cat
⁴ According to several studies, including G. Wadel “Sustainability in industrial architecture. The lightweight modular design applied to housing”, PhD thesis, UPC, 2009.
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And the standard refurbishment model is the basis to determine if the retrofit improvements in materials and construction waste reached with the PdP, meet the objectives. Unlike the standard model of refurbishment, environmental retrofit model is not based on existing practice but is formulated in response to environmental objectives. Following the methodology described here, the existing building and the various possible strategies are analyzed from the environmental point of view, so that intervention on the building is determined not only for functional, aesthetic, economic, etc. reasons, but in terms of its contribution to achieving the objectives. Another major issue is the definition of the life cycle. Considering the different stages of the life cycle of buildings, each one with its relative importance, chaining actions is essential to reduce environmental impact. In this way a continuous work in different environmental vectors is determined, where each phase counts in the total.

RESIDENTIAL BUILDING

Existing building

It is a compact block with frontages to street and square on three sides and one dividing wall. It was built in 1977 and has a total gross surface of 1,163 m2, distributed in a commercial ground floor and three upper floors of dwellings. There has been no comprehensive refurbishment since then. The ground floor has 3 stores and also contains the entrance hall houses. The first floor, originally intended also to commercial purposes, is formed by 3 apartments and one office. The second and third floors have 3 dwellings each and from the start of the first floor there is a courtyard for ventilation.

View and floor plan of Block 1, Can Pastilla

Block 1 has three facades of similar treatment (porticos) oriented towards the streets Dofi (where the access to the building is, facing west), Singladura (oriented northwest) and the Plaza Pius IX (facing northeast).

The main construction features of the building are:

- Structure of concrete pillars in the interior and steel columns coated with mortar on the front perimeter.
- Vaulted unidirectional ceramic slabs on reinforced concrete beams.
- Façade walls of ceramic or concrete blocks 20 cm thick, without insulation.
- Interior partitions and walls, separating dwellings or buildings, in sandstone 4.5 to 15 cm thick.
- Interior walls and ceilings finishing of plastering mortar.
- The cladding of external walls is plaster of cement mortar and lime plastering.
- Flat roof consists of, from top to bottom, clay Atobas of 20x20cm, cement, asphalt-waterproof coating, pending formation of lightweight aggregate concrete 10 cm thick, slab of the type already described without insulation.
- External windows: aluminum frame without thermal break, with simple clear glass 8 mm thick, without sunscreen (although some have been added sunshades).
- Interior flooring: terrazzo tile 30x30cm, mounted on cement mortar.
In terms of HVAC systems, heating and cooling and hot water are not connected to the gas urban network (propane-air) present in Can Pastilla. There is a centralized solution for thermal conditioning systems, but each home built point solutions that are described below:

- Heating and cooling electric heat pumps with outdoor units located in terraces.
- Hot water systems with water heaters with and without accumulation.
- Lighting systems with different sources: standard fluorescent in shops and compact fluorescent, incandescent bulbs (less than 25% of total) and halogen lamps in dwellings.
- Water providing and drainage facilities are connected to the network. There is no system for collecting rainwater or separated pipe.
- The cooking facilities consist of butane-gas-cylinder stoves and ovens and, occasionally, electric stoves and ovens.

**Standard refurbishment model**

No document could be found describing standard refurbishment models in housing construction in Spain. However, interviews with various professionals and the conduction of a specific research have drawn some profiles of standard intervention. These profiles, more or less common in refurbishment of buildings similar to the test case in Can Pastilla, have been used to define the standard retrofit model, and are clearly defined into two types of intervention:

- The refurbishment of publicly owned housing and low or middle income population, public promoters, of low retrofit intensity.
- The refurbishment of privately owned dwellings and middle or high income population, private developers, of high retrofit intensity.

The first case (public housing and promoter) may be defined by the following characteristics:

- The maintenance of almost all building systems and facilities, except when conditions present constructive, structural, safety, or functional obsolescence.
- The need to act, almost always, keeping the building occupied, a fact that inhibits or hinders the indoor actions and also requires a complex programming.
- The action almost exclusively restricted to the exterior and common areas, requiring new systems and facilities to overlap the existing building (e.g., refurbishment of facades by adding layers of insulation, waterproofing and finishing on the outside.)
- Almost never updated the building in other regulatory aspects such as adaptation to limiting energy demand, the micro generation of renewable energy, and savings in water use.
In the second case, the refurbishment of private housing by private developers, the standard model of refurbishment may be defined by the following features:

- The action is almost always done completely vacating the building or at least a part.
- The whole building almost will be empty, except for major fixed structures and enclosures.
- Often, consolidation and/or strengthening of structures.
- The addition of new windows, partitions, ceilings, HVAC, finishing, etc.
- The refurbishment and/or renovation of the facades, without necessarily incorporate isolation.
- Often, updating anti fire facilities, air conditioning and hot water, elevators, telecommunications, plumbing and sanitation to the regulations.
- Almost never focusing on the building energy demand, the micro generation of renewable energy, the savings in water use, plant selective separation of waste, etc.

The double reading of the usual refurbishment profile made - for public and private - opens to considering different types of intervention as a standard model of retrofitting, but probably none adjusts to specifically match the expected future actions under environmental targets set by the Consortium of Plata de Palma.

Indeed, there are on the one hand environmental objectives to meet and, secondly, the management PdP model is foreseen to be mixed: interventions on privately owned buildings, mostly, but with management and financing of the public. For this reason and in order to make a balanced and consistent comparison between the two scenarios (needed for environmental analysis and verification of compliance with the objectives), the standard refurbishment model considered in this study refers to the practice, both public and private, but restricted to the same construction elements or installations on considered by the PdP refurbishment model.

Analysis, evaluation, improvement proposals and results

Below follows the analysis of the actual situation, strategies and improvement actions and results achieved in each vector: Energy, Water, Materials and construction Waste.

Energy

- Current situation: We conducted a detailed study of energy demand with the LIDER software, detecting that heating count for 77% of conditioning energy needs, while cooling is at 23%, exceeding the first the limits currently set by regulations (CTE-HE1) by almost 50%. The envelope has no thermal insulation.

Solar incidence analysis carried out with Ecotect can detected that through the openings oriented SE and NO, despite the protection of the balconies, there is an excess of sola gains in summer. In winter, however, large eaves inhibit solar gains, which would be helpful in terms of heating demand.

Functional analysis of the building shows that there is no possibility of cross ventilation, which is desirable to harness the night breeze for cooling built mass. HVAC systems have hardly any energy efficiency feature (not centralized, not adjustable, or complement, or take advantage of residual heat or

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5 The reading of the statistical data of the nearest weather station, Son Sant Joan, showed that the average air temperature in summer nights is around 19 °C.
cold, or use renewable energy). Analysis with the program CALENER in applications for heating, cooling, lighting, DHW and the use of survey data\(^6\) for kitchen and household equipments permitted to define CO2 total emissions regarding the building operation in 81.9 KgCO2/m\(^2\), a value considered to be high.

-Strategies used: a) demand reduction, working out all the possibilities of optimization of the thermal envelope, winter solar gains (incorporating sunspaces) and cross ventilation (incorporating driving plenums) in summer. b) increasing efficiency, from the analysis of the possibilities of HVAC systems and facilities, replacing them with more efficient ones (heat pump with solar support)\(^7\) c) use of local resources evaluating the use of renewable energy offered by the environment (solar thermal and photovoltaic) and d) management from operational patterns and management profiles of the current building and optimization possibilities.

-Actions: With the help of the EnergyPlus/DesignBuilder software and statistical data, solar radiation sunspaces built into the balconies were simulated and a calibrated, active in winter, and a ventilation plenum connecting the indoor, box stairs and interior atrium, acting in the summer. The set of actions is summarized in the following chart.

The combined effect of the actions described, evaluated with the CALENER software and other tools described, allowed achieving a drastic reduction of energy consumption.

The use of air conditioning, lighting, DHW and lighting represent up to 70% of the total energy of the dwellings\(^6\), so that the remaining 30% originates in cooking and other uses, foreseeing this way, according to the best practices experience, actions to reduce up to 50% of consumption\(^8\).

The final results for total operation energy of the building are the following: Current emissions: 81.9 KgCO2/m\(^2\); PdP retrofitting: 30.2 KgCO2/m\(^2\); savings reached: 63%.


\(^7\) Note: the Consortium of Platja de Palma provides for the exclusive use of electricity (which will be provided in the future by a network of renewable primary sources) supported with photovoltaic solar gain in the building.

\(^8\) Among them: a) in kitchen and laundry, replacing conventional dishwashers and washing with bi-thermal machines and conventional refrigerators with energy class A ones (up to 65% savings). Replacing conventional electric cooking plates with induction (up to 35% savings over the conventional ones). b) office automation and audio and television electronic equipment and other conventional replaced by Energy Star certificated (from 30% to 75% savings as appropriate) and cutting out consumption in standby role. c) Changing in consumption habits of the population (between 10 and 15% savings, according to the experience of the contest “The community saves”, organized by the House Lit de Madrid).
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Water
-Current situation: through a building inspection, it was detected that the equipments did not include savings mechanism (9-liter flush toilets, faucet flow between 20 and 17 l/min, etc.) or the use of regenerated water (rainwater, greywater, etc.) in uses where quality is not needed for drinking. Basing on this data, on the number of people and without being able to have access to real consumption data, we conducted a water balance, based on frequency of use deriving from statistical data, consumption was calculated to be about 178 l/p/d, which is considered high.
-Strategies: a) increased efficiency (change to lower consumption taps, showers, tanks, appliances and other equipment) b) use of local resources (capture and use rainwater, not to be used in the building but transferred to municipal use.) c) recycling (greywater from sinks and showers, for use in cleaning and toilet flushing).
-Actions: The following table shows what they are and on what part of total consumption they act.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Approximation of current consumption: 178 l/persona/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of efficiency: faucets, showers, WC tank and not efficient household appliances</td>
<td>22%</td>
</tr>
<tr>
<td>Washing machine</td>
<td>15%</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>11%</td>
</tr>
<tr>
<td>Shower</td>
<td>9%</td>
</tr>
<tr>
<td>Sink</td>
<td>4%</td>
</tr>
<tr>
<td>Others</td>
<td>3%</td>
</tr>
<tr>
<td>Recycling: use of water proceeding from the greywater purification system</td>
<td>5%</td>
</tr>
</tbody>
</table>

-Results: The inclusion of saving mechanisms in all consumption points allowed reaching a 52% reduction, in addition to 13% saving, substituting drinking water with greywater.

The final results for total water use for building operation phase are the following: Current situation, 178 l/p/d; Refurbishment PdP, 60.5 l/p/d; savings reached 65%.

Materials
-Current situation: A building inspection found that the structures and main enclosures presented no great problems for their conservation for a new cycle of use, foreseeing the partial replacement of flooring, cladding, windows and HVAC, as well as the incorporation of thermal insulation coated exterior facades and roofs, renewable energy systems, solar collecting sunspaces, sunscreens, and natural cross ventilation plenums.
-Strategies: a) To preserve as much of the existing materials as possible, valuating or repairing existing construction solutions. b) To reduce the number and impact of the materials to be added to the building, using solutions of low consumption per service unit and renewable or recycled materials. c) Minimize maintenance, selecting low-impact and durable materials.

9 Study of water consumption in buildings in the metropolitan area of Barcelona from the Generalitat of Catalonia, July 2004
-Actions: 100% of foundations and structures are conserved, as well as up to 50% of roofs, walls and fixed partitions, walls and floors and walls and mobile partitions. The rest of the building subsystems had to be replaced. The materials to be renovated and added, in their majority, according to the studies consulted\(^\text{10}\), were of natural basis.

\[
\text{Materials to be conserved} \quad \text{Materials to be added}
\]

-Results: The realization in parallel of two refurbishment budgets with environmental data\(^\text{11}\), based respectively in the standard refurbishment models, and in the described PdP model, enables the calculation in terms of energy and CO2 emissions of extraction and production of the materials used. The same process was used in determining the values of the maintenance phase.

\[
\begin{align*}
\text{PdP refurbishment} & \quad 151 \text{ KgCO}_2/\text{m}^2 & \quad 188 \text{ KgCO}_2/\text{m}^2 & \quad 349 \text{ KgCO}_2/\text{m}^2 \\
\text{Standard refurbishment} & \quad 389 \text{ KgCO}_2/\text{m}^2 & \quad 523 \text{ KgCO}_2/\text{m}^2 & \quad 892 \text{ KgCO}_2/\text{m}^2
\end{align*}
\]

The final results, in terms of materials use for retrofitting and maintenance are: standard refurbishment, 892 kgCO2/m2; refurbishment PdP, 349 kgCO2/m2; savings reached 61%.

Construction Waste

-Current situation: As in the case of materials, also in construction waste two refurbishment models (standard and PdP) are compared, which, basing on constructive solutions, mitigation and different management actions for recycling, achieve very different results. Also the logistics of existing waste management in Mallorca have been studied, with the purposes of determining whether to it is possible to meet the target of 50% reduction, only with design and construction actions or if it is necessary to proposed changes in the external management. Given the difficulty to determine the waste generation in each case (standard scenario and PdP scenario) basing on local reference values, the estimation of quantities and types of waste generated was performed with the help of statistical data\(^\text{12}\), databanks\(^\text{13}\) and calculation sheets\(^\text{14}\).

-Strategies: a) reduce waste generation (e.g. prefabricated solutions - dry assembly), b) recycled waste products (e.g. crushing demolished masonry), c) recycling the waste generated that cannot be reused

\(^\text{10}\) Factor 10. Strategies to reduce CO2 Emissions, SaAS arquitectes
\(^\text{11}\) With the help of the program TCG 2000 and the databank of reference prices for construction and refurbishment BEDEC PR / PCT’s Institute of Construction Technology of Catalonia.
\(^\text{12}\) 98/351 Life Project conducted by the ITec.
\(^\text{13}\) Reference prices databank for construction and refurbishment items BEDEC PR / PCT ITec.
\(^\text{14}\) Technical Consultant Office, Architects Association of Catalonia.
(e.g. metals), d) recovering energy from waste which is not reused or recycled and admits controlled burning (e.g., wood, dirty or mixed plastic) and e) dumping the waste of no value (e.g. glass laminate).

Actions: The following chart shows the main instruments taken into account, the study phase, the construction phase plan and the selective separation and management scenario.

- Results: constructive solutions of low waste generation, selective separation actions, Reuse and Recycling at construction site are not sufficient to achieve the goal (reduction of at least 50% of waste being buried or incinerated compared to the standard refurbishment).

The study of management logistics on the island determined that the current pricing system does not sufficiently promote recycling, as the more demanding the separation is, the higher are the costs of waste management (minimum scenario is composed of stony waste, banal and special, favoring energy recovery compared to recycling). Consequently, in order to enable the level of recycling foreseen by the PdP, it is necessary to change the of waste management logistics island-wide.

Life Cycle

The life cycle has been defined within a period of 50 years starting from the time of refurbishment. The indicator used to perform a comparison of the behavior of both scenarios (the current building refurbished following standard or PdP model) are the carbon dioxide emissions associated with energy production used in the extraction and production of materials, transportation to site, the process of construction, building operation, maintenance and demolition. CO2 emissions, besides being one of the main indicators in all the studies that are undertaken in the area of the Platja de Palma Consortium make up what is called an “indicator of indicators” which allows to measure the energy consumed, consumption of nonrenewable resources, other forms of pollution associated with and impact on global

15 Energy, and therefore CO2 emissions, related to the environmental vectors of water (collection, purification, transportation, evacuation, treatment and disposal) and Waste Management (end of) are not taken into account due to lack of rigorous information on consumption associated with these processes.
climate change, among other factors. To calculate the phases of transport, construction and demolition various statistical studies\textsuperscript{16} have been used, adapted to the specific values of refurbishment models (standard and PDP) as well as the insular location of the building. The following chart presents a summary of the calculation of CO2 emissions on a lifecycle of 50 years.

The breakdown of emissions in each phase to the refurbishment model PDP is as follows:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials production</td>
<td>10% Heating</td>
</tr>
<tr>
<td>Transport</td>
<td>14% Cooling</td>
</tr>
<tr>
<td>Refurbishing</td>
<td>2% Hot Water</td>
</tr>
<tr>
<td>Use (HVAC,HW)</td>
<td>22% Lightning</td>
</tr>
<tr>
<td>Maintenance</td>
<td>10% Kitchen</td>
</tr>
<tr>
<td>Demolition</td>
<td>14% H. appliances</td>
</tr>
<tr>
<td>100% Life Cycle</td>
<td></td>
</tr>
<tr>
<td>Existing building</td>
<td>54.9% HVAC, DHW and Lightning</td>
</tr>
<tr>
<td></td>
<td>Circulation: CALENER and other software</td>
</tr>
<tr>
<td>Refurbished building (PDP model)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>78% Building Operaion</td>
</tr>
<tr>
<td></td>
<td>1.510 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>1.167 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: other software</td>
</tr>
<tr>
<td></td>
<td>23.5% Kitchen, household appliances</td>
</tr>
<tr>
<td></td>
<td>0.483 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: manual and statistical data</td>
</tr>
<tr>
<td></td>
<td>7.4% Construction</td>
</tr>
<tr>
<td></td>
<td>0.549 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: other software</td>
</tr>
<tr>
<td></td>
<td>10.7% Maintenance</td>
</tr>
<tr>
<td></td>
<td>0.20 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: other software</td>
</tr>
<tr>
<td></td>
<td>3% Other phases</td>
</tr>
<tr>
<td></td>
<td>0.04 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: manual and statistical data</td>
</tr>
<tr>
<td></td>
<td>1% Construction process</td>
</tr>
<tr>
<td></td>
<td>0.02 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: manual and statistical data</td>
</tr>
<tr>
<td></td>
<td>2.1% Demolition and waste management</td>
</tr>
<tr>
<td></td>
<td>0.14 kgCO2/m²</td>
</tr>
<tr>
<td></td>
<td>Circulation: manual and statistical data</td>
</tr>
</tbody>
</table>

The CO2 emission savings (of the PDP refurbishment compared to the existing building and to the standard refurbishment) in 50 years are, as it can be calculated from the chart data, 3,138 kgCO2/m². With regard to total the building (1,163 m²) and for the whole life cycle, it represents some 3,650 tons of CO2. The following table compares, in life cycle and CO2 emissions, four scenarios: current building, new building (demolition and rebuilt), PDP refurbishment and standard refurbishment.

\textsuperscript{16} SaAS and others, Analysis of CO2 emission reduction in a housing complex in Tossa de Mar, study, and G. Wadel, Sustainability in industrial architecture. Modular construction applied to housing, PhD thesis, among others.
### CO₂ emissions reduction

If refurbishment of the building in Block 1 was carried forward according to the fulfillment of the objectives of 50% or more reduction of environmental impacts (energy, water, materials, construction waste and operation waste), important energy savings as well as CO₂ emission savings would be achieved. Following is a table showing a summary, representative of the savings achieved during the different refurbishment phases (for once) and subsequent use of the building (annual savings, which can last for about 50 years). Both direct savings (reflected in the energy bills of the building, although in primary energy) and indirect (derived from the potabilization of water because of lower consumption of it, for example) are shown.

<table>
<thead>
<tr>
<th>Demolition (preexistence)</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Operation</td>
<td>4.095 100%</td>
</tr>
<tr>
<td>Material Production</td>
<td>514 100%</td>
</tr>
<tr>
<td>Other Phases</td>
<td>87 100%</td>
</tr>
<tr>
<td>Total Life Cycle</td>
<td>4.696 100%</td>
</tr>
</tbody>
</table>

**Annual savings - lowering consumption in building operation**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity (and gas in current building)</td>
<td>95.2</td>
<td>29.1</td>
</tr>
</tbody>
</table>

**Annual savings - lowering water consumption**

<table>
<thead>
<tr>
<th>Current consum. [m³]</th>
<th>Future consum. [m³]</th>
<th>Savings [l/CO₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.338</td>
<td>1.238</td>
<td>1.10</td>
</tr>
<tr>
<td>Drinkable water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0010876 CO₂/m³ (water potabilization in Mallorca - study ARUP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0010842 CO₂/m³ (purification of greywater - study Bioús)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Savings during refurbishment phase - using materials of lower energy consumption**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refurbishment materials</td>
<td>427</td>
<td>176</td>
</tr>
<tr>
<td>0.369 CO₂/m³ (standard refurbishment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.151 CO₂/m³ (PdP refurbishment)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Savings during refurbishment phase - reducing amount of waste to transport and to treat**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity and diesel</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>0.0608 CO₂/km of road and 15 km of transportation (landfill - study BBDO (TCE))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0147 CO₂/km (waste management - study Ecobin)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The implementation of strategies and actions of improvement on all environmental vectors can achieve higher energy and CO₂ savings than the traditional approach of energy efficiency in only the building operation phase.

If, as it has been said, the use phase represents approximately 60-70% of the energy or total CO₂ emissions, there is another 30-40% left, represented by the management and transport of water, mining and manufacturing of construction materials and management and transport of construction waste, on which it is also necessary to take action.

### Estimate economic evaluation

An estimated economic evaluation of various refurbishment measures taken in the PdP scenario has been realized, with the following observations:

- The development of the project corresponds to an initial state and not the technical definition of a project. Therefore, it was not possible to measure and work according to project budget, but an estimate of the costs of the different actions to take.
- The valuation was based on reference prices considering industrial, work aids, studies and health and safety plans, waste management, and general expenses adjustments.
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-The prices shown are not including taxes, licenses and administrative or financial fees.

<table>
<thead>
<tr>
<th>TOTAL €</th>
<th>€ ENERGY</th>
<th>€ MATERIALS</th>
<th>€ WATER</th>
<th>€ WASTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>651,280</td>
<td>201,897</td>
<td>436,358</td>
<td>13,026</td>
<td>0,00</td>
</tr>
<tr>
<td>€/m²</td>
<td>€/m²</td>
<td>€/m²</td>
<td>€/m²</td>
<td>€/m²</td>
</tr>
<tr>
<td>560</td>
<td>174</td>
<td>375</td>
<td>11</td>
<td>0,00</td>
</tr>
</tbody>
</table>

Conclusions

-Considering the limitations of information (audits of building were not available) and freely available tools used (the official energy simulation programs do not account for several bioclimatic aspects, for example) the methodology has allowed the development of a work with appropriate technical level, thus validating itself.

-In the study phase and the case-test building it was possible to meet the objectives, i.e. reduce by at least 50% consumption of energy, water, materials and the generation of construction and operation waste, and emissions of CO2 compared to the current building and to a standard refurbishment considering a lifecycle of 50 years.

-It was established that, such as it was supposed, refurbishing following strict criteria in order to reduce environmental impacts is an extra financial effort (at least until the market economy begins to reflect the cost of environmental degradation that most goods and services are associated with, if hidden). The difference arising from the economic calculations made for the standard models and PdP refurbishment, measures how much it would take into account to incorporate the externalities of the building sector of into its own sphere, i.e. accepting to load the burden of the environmental impacts, which the whole society sooner or later shall bear.

-The economic or management stress of the administration could focus on the environmental impact actions that currently lack financial support: reducing potable water consumption, less environmental impact materials, management to reduce energy consumption, management for the reduction of construction and operation waste, among others.

Bibliography

(5) Rosselló-Batle, B; Moià, A; Cladera, T; Martínez, V. “Energy use, CO2 emissions and waste throughout the life cycle of a sample of hotels in the Balearic Islands”, Energy and Buildings, 2010.
1. BACKGROUND TO URBAN RENOVATION IN SPAIN

1.1 The indefinite growth crisis

The concept of "urban rehabilitation" is the product of a process of evolution. It sprang from some of the conclusions reached in the International Congresses of Modern Architecture (the mythical CIAM), held in the mid-1950s, where some urban planners, mainly Italian, announced the so-called "crisis of indefinite growth" against the more orthodox postulates of the Modern Movement, whose discourse was constructed on "the new city project", denying not only the "pre-existences" (Le Corbusier's Plan Voisin, 1925, for the centre of Paris saved just a few important monuments), but also ceasing to value the concept of long term: "houses have shorter lives than us, every generation must build its own city", said Sant Ella in Milan in 1914, in his Manifesto of Futurist Architecture, recorded by Valerio Battista in "City, History and Project". At the International Congress of Modern Architecture (CIAM) in 1952, thematically focused on "the heart of the city", Rogers delivered a critical overview that was to have a major impact in the following decades, first in Italy and later in Europe.

The changeover from "the project of the new city", on which the whole experience of the Modern Movement was based, to "the project of the existing city", reveals either an evolution or a deep fracture. Trust in the total permutability of whatever exists, together with its swift obsolescence, was the paradoxical result of a misunderstood transfer to architecture of the philosophy of industrial production, for which the ongoing substitution and updating of products were essential.

1.2 Urban rehabilitation, the result of a process of evolution

As we pointed out earlier, the term "urban rehabilitation" - that was first applied to historical buildings, then to residential buildings, and finally to entire neighbourhoods, is the result of an evolutionary process, from a "culturally enlightened" justification which favoured the conservation of historical and cultural landmarks, and later came to value more complex urban areas, to a later study and appreciation of the Historic Centres as a whole. This brought to light the brutal transformation that historic city centres had undergone, mainly in the second half of the 20th century, and the social, morphological and functional degradation that this had brought with it.
And finally, the tangible proof that such processes could not be corrected exclusively from the perspective of a physical restoration of the buildings and urban environments, has led to a theory of urban rehabilitation as a planning option that focuses its attention on the existing city. This contrasts with the previous "developmentalism", which unfortunately still exists and only conceives the "progress" of cities in terms of expansion and growth in the form of urban peripheries, involving, as often as not, the destruction of old city centres, replaced by buildings that were typologically more suited to the new peripheries and transferable to any contemporary city.

1.3 Rational arguments in favour of new rehabilitation interventions

There were, and there are, arguments other than the aforementioned concerning the preservation of the historical and cultural memory of the cities (until recently these historic centres were "the whole city") - arguments of a social nature, in view of the serious deterioration of living conditions experienced by the traditional residents: an above-average percent of elderly people, low economic resources, a decrease of productive activity, social exclusion, etc. Moreover, there were those who invoked the “waste” involved in many cases in what some urban planners called the neglect of the “fixed capital” of the city (i.e. the infrastructures, the urban facilities, etc.) which led inevitably to a need to provide new services, further away on the periphery. A never-ending process based on a belief in the goodness and unlimited resources of the cities to sustain the “indefinite growth” mentioned above. On top of this, the generalized lack of any culture, methodology or specific technology for the maintenance of old buildings, contributed in those years of “development” to a deterioration of the housing stock.

More recently the arguments have been focused on the unsustainability (social, economic and environmental) of this urban planning model on account of the negative impact of the mobility generated or of the occupation of non-developed farmland or forest, or the energy costs related to the construction of thousands of new dwellings, new urban facilities etc., while at the same time thousands of other dwellings lie unoccupied because they are not suitable: the schools and sports centres are not used because of lack of people and the traditional neighbourhoods languish.

1.4 The social, urban planning and regulatory context (1976-1986).

The social context, urban planning practices and regulations of that period led practically to the destruction of the historic city centres. As Francisco Pol pointed out in 1988, referring in general to Spanish cities of that time: "Property letting legislation that allowed the freezing of old rents and which discouraged repair work, together with a legislation in matters of declaring a building to be in ruins that took no account of other planning values and encouraged property owners to neglect their responsibilities, will, literally, destroy as many, or more, buildings than those destroyed in the wars that the city had undergone".

2
1.5 What we mean by sustainable urban rehabilitation

Sustainable and integrated urban rehabilitation starts from a multidisciplinary diagnosis which will lead to a deep knowledge of the neighbourhood and will go beyond the buildings, infrastructures and public spaces, to involve the different local actors and residents. It is on this basis, then, that the politicians should take decisions and activate the urban management process, the necessary legal instruments and economic resources. In short, the objective of the revitalization of deteriorated zones is to put in place a strategy that would stop the process of deterioration of the urban and social fabric, to preserve its heritage values, reinforce the social cohesion and promote economic activity.

2. STRATEGIES APPLIED IN OLD CITY CENTRES AND FIRST URBAN EXTENSIONS

Further development of this point has been judged unnecessary since it has been the object of considerable research and has been widely published. However we consider it worthwhile to point out the main strategies followed, which where compatible with the regulations of that time which, unfortunately, have not changed much ever since, and which will be summed up later. The following points give a very brief summary of the situation.

- **Special Plans**: The main Spanish cities and some rural towns, notably some which were of particular historical or architectural interest, adopted a variety of models of urban intervention, initiated with the Special Interior Reform Plans (known as PERIs) or the Special Protection and Interior Reform Plans (known as PEPRIs). These were very versatile instruments of the Land Law of that time and tended to stress one or other aspect and were consequently called ‘the norm plan’, ‘the protection plan’, ‘the management plan’, ‘the project plan’ and so on.

- **Integrated Plans**: A little later, various urban planning action plans in combination began to be applied to more complex areas: the renovation of infrastructures and street networks, new building and housing refurbishment, the conservation of buildings of historical and artistic interest, new equipment, aesthetic improvements of one sort or another. Other actions included: employment programmes, health, education, social services, and new economic activities.

3. PROMOTION POLICIES (subventions, subsidized loans, rebates, exemptions)

Another major strategy followed in Spain from 1983 onwards was that which was used at the various levels of the Spanish public administrative system (the Central, the Autonomic, the Local) by the then Ministry of Public Works and Urban Development, the MOPU, whose area of responsibility included housing, though this was already transferred to the newly-formed Autonomous Communities (equivalent to regional governments). Each Autonomous Community quickly developed these new powers, adopting the system of direct non-refundable subsidies, subsidized loans, tax exemptions or tax relief. At a local level they used the Promotion of Rehabilitation ordinances and created Management Offices for the same purpose.
4. EVOLUTION OF THE LEGISLATIVE FRAMEWORK FOR URBAN REHABILITATION

The diagram below sums up the legislative context which at that moment regulated the rehabilitation of buildings and dwellings in Spain, and which is still valid today. There are three main branches from which derive the legislative initiatives of varying ranks and areas of application.

- **Urban legislation**, which basically regulates the following matters:
  - The obligation to conserve buildings, declarations of ruin and enforcement orders.
  - The possibility of approving a catalogue of buildings graded according to their need for protection.
  - The possibility of promoting Special Plans with various objectives but essentially related to conservation.

- **Sectorial legislation**, especially for the promotion of rehabilitation of buildings starting with the approval of R.D. 2329/1983 onwards, applicable both to isolated buildings and to buildings situated in the so-called Areas of Integral Rehabilitation (the ARIs). At a local level they took the form of ordinances for the advancement of urban rehabilitation and the creation of Management Offices. They were very general in their scope in order to favour and impulse policies that were usually focussed on old city centres and the 19th and early 20th century suburbs.

- In the third place, there are concurrent legislations which include other sectorial and general legislations and bear great weight in the rehabilitation management of buildings and dwellings. Such legislations would include:
  - Law 16/1985, 25 June, concerning Spanish Historical Heritage and other laws passed by Autonomous Communities.
  - Law 49/1960, 21 July, concerning Horizontal Property and subsequent modifications
  - Law 29/1994, 24 November, concerning Urban Tenancies with its subsequent modifications
  - Fiscal Legislation (IRPF [income tax], VAT)
5. THE REHABILITATION OF RESIDENTIAL NEIGHBOURHOODS BUILT BETWEEN 1945-1965

At the beginning of the 21st Century, the Spanish cities, like other similar cities in Europe, are faced with a challenge of far greater dimensions than those mentioned in connection with historic city centres and early suburbs - areas that were the object of reflection and analysis and subsequently of institutional action in the last two decades of the 20th century. This challenge consists in the rehabilitation of a specific urban fabric in our cities - those neighbourhoods of isolated blocks built between 1950 and the late 1970s, usually built all at once as a single development.

Their present situation can be explained by the dire need for housing after the Civil War of the mid-20th century when the building process had to be short, the costs low, when industrialized production was just starting, and the standards of comfort were far from the minimum standards that might be expected today. All this explains why many such houses may be withdrawn from the market or marginalised, with all the planning and social consequences that this entails.

The present situation in these neighbourhoods can be summarized through the analysis of present threats and opportunities, as shown in the comparative study made of various French and Spanish cities within the framework of the Revitasud Project, part of the Interreg European Initiative, over the period 2002-07.

The threats that exist in urban areas of this type are related to their withdrawal from the housing market, which may lead to their marginalization and the planning and social consequences that follow. But the threats are also related to infrastructures and equipments being underused or abandoned, which amounts to an unsustainable use of urban land, socially, economically and environmentally speaking. Moreover, one of the greatest risks involved in concentrating public investments in a given neighbourhood for its rehabilitation is, paradoxically, that such investments set in motion processes of social exclusion and displacements of the residents on account of the appreciation of the properties, a phenomenon known as ‘gentrification’ which has been detected in many rehabilitation of historic centres cases.

However, the present situation together with the experience acquired in these matters suggests a wide range of opportunities recognized by most public administrations, as the Director of Housing of the Generalitat de Catalunya recently remarked (Pedrals 2009), and which can materialize in economic, social and environmental benefits.

Among the economic benefits are the following: the stimulation of business in the subsector of rehabilitation owing to the multiplying effect that public subsidies have, together with the consequent creation of employment, professional formation, innovation, etc. Moreover, the returns in economic terms are very high, as can be seen from the figures quoted in the conference cited above, according to which, of the total subsidies of 85 million Euros in the period under study, the administrations got back 82 million in the form of taxes and reduced costs of unemployment benefits.

The social benefits observed point to an improvement in the quality of urban areas, the consolidation of networks and the improvement in social cohesion, together with a cut in the energy bill in groups with few economic resources.
And finally, the environmental consequences of these policies are all very positive: a reduction in the consumption of land for the purpose of urbanisation and a reduction in the construction of new infrastructures, a reduction in mobility-related needs, in the production of waste materials, in energy consumption, and hence in the emission of CO₂.

To sum up, the revitalization of existing urban areas that is a decisive strategy when it comes to avoiding the need for new growths and the emptying of the existing neighbourhoods and their social, economic and physical deterioration. For this reason, a sustainable urban development can only be attained by renovating that large housing stock and through the revitalization of those neighbourhoods in which they are inserted. It is in the cities that our future will be decided for they will be the battleground for sustainability, in the struggle to slow down or mitigate climate change.

All this reinforces the need to concentrate efforts on the urban rehabilitation of the many neighbourhoods of this kind in Spain, as being the only way to palliate the unsustainability of our urban systems.

5.1. Strategies applied in the rehabilitation of such neighbourhoods in Spain

As we have already explained, over the last two decades in Spain rehabilitation has concentrated mainly on historic city centres with the protection of heritage and cultural values in mind. However, concern for the environmental and social sustainability of our cities together with the context of the economic recession has spotlighted the peripheral neighbourhoods of our cities. For several years now various municipalities have been developing pioneer rehabilitation programmes. Likewise, the public administrations have begun to develop programmes and help to encourage the rehabilitation of these neighbourhoods. A sure sign of their attitude in this matter is the fact that they have included the concept of rehabilitation in the last two nation-wide Housing Plans, as we shall see below.

The following list outlines the main strategies that are being applied, together with some examples.

- **PROMOTION POLICIES**
  Central Government, Autonomous Communities, Town Halls

- **MAINTENANCE/ REHABILITATION**
  Programmes of systematic maintenance and rehabilitation of the housing stock in Catalunya (ADIGSA)

- **REHABILITATION/ RESTRUCTURING OR REMODELLING**
  San Cristóbal de los Ángeles in Madrid, La Mina in Barcelona, The Municipal Programme of Rehabilitation of 21 Urban Developments in Zaragoza (8,000 homes)

- **REMODELLING**
  Reviure els barris (“Revive the Neighbourhoods” Programme of the region of Catalunya)

- **INTEGRATED ACTION PLANS IN NEIGHBOURHOODS**
  Ley de Barris (Neighbourhood Law) in Cataluña, and Baleares; European Union Urban Initiative, or Izartu Programmes in the Basque Country
6. BARRIERS AGAINST SYSTEMATIC AND INTEGRAL REHABILITATION IN THE PERI-URBAN NEIGHBOURHOODS

The analysis of recent experiences and strategies undertaken by various Public Administrations reveals the main barriers that hinder the systematic practice of urban rehabilitation in Spain, since the initiatives taken in this field so far are still experimental and minority practices. The following section describes these barriers, grouped in four categories: legal, economic, social and cultural.

6.1. Legal barriers

Those barriers that need legislative change, particularly at the State level but also at the regional and local levels.

- Urban Planning barriers

Ever since the first Land Law was passed in 1956, Spanish urban planning legislation has been almost exclusively focused on the mechanisms for urban extension, and very little concerned with defining the instruments for intervention on the existing urban fabric (Molina, 2007).

Given the complexity of interventions on urban areas, on account of the physical limitations of the urban fabric, of the involvement of a multitude of property-owners in very diverse situations, and of the need to attend to social problems of all kinds (sections of the population at risk of exclusion, illegal letting, mortgages, unresolved inheritances, access problems etc), such actions are in need of instruments for specific types of planning with an approach that differentiates them from urban extension interventions.

It may well not be necessary to pass new land laws but rather to formulate specific laws that would complement interventions on consolidated urban land, rather along the lines of the Catalan “Neighbourhood Law” or the more recent “Law concerning the Right to a Dwelling”, 2007.

However, at the risk of producing a succession of decrees and partial laws which would only make the problem more complex, it might be best to pass an Urban Revitalization Law, or something similar, following the trend of similar legislations in some European countries.

Next, we include a list of recommendations for overcoming the legislative barriers to be found in the field of urban planning:

- Create simple and efficient instruments for interventions on existing urban areas.
- Extend and deepen the concept of the “obligation to maintain” to matters such as thermal comfort, the adaptation and greater energy efficiency of the installations, updating the criteria to present standards.
- Substantially modify the regulations concerning declarations of ruinous state, omitting the concept of “economic ruin”.
- Facilitate the creation of efficient management bodies adapted to the existing city’s needs with the same legislative support that exists for the management bodies in new areas.
- Develop the social right of the property when the property becomes an obstacle.
to the installation of equipment indispensable in these zones: lifts, installations (business premises at street level, private open spaces)³.
- Adapt the Municipal Ordinances of the General Plans to the demands of urban rehabilitation, not yet included in local planning.

- **Housing policies**

  The housing policies have been excessively centred on new construction, though it must be admitted that there has been a change of direction in the latest Housing Plans at national level. They have been developed with no coordination with urban development legislation or any other concurrent legislation. Their role, essentially, is that of regulating grants for residential rehabilitation and grants for the “re-urbanisation” of surrounding areas that were previously delimited, which required the collaboration of the local governments. These measures are not coercive since they leave it up to the homeowners to set them in motion and to the Autonomous Communities who have the competence, to put them into practice.

  Some recommendations for overcoming the legislative barriers to be found in the ambit of Housing Policies could be:

  - The passing of a Law of Urban Revitalization which would give legal cover to the sectorial policies (housing, energy efficiency, re-urbanization, etc.) and to the modifications in the general legislation (Law of Horizontal Property, of Tenancies, IRPF etc.) and it would impulse the policies, as has been the case in France (Ministry of the City, Law of Cities, National Agency for Urban Renovation)

  - The concentration of economic aid exclusively in those areas with greatest need, obligatorily linked to the existence of management bodies with the participation of the regional and local administrations. The economic aid should also be linked to minimum requirements with regard to energy efficiency, the implantation of renewable energies and the removal of architectural barriers.

  - An extension of economic aid to other uses (commercial premises) and to the re-urbanization of private open spaces for public use. Similarly, economic aid should go to matters related to the social management of subsidies (offices with trained staff), the costs of re-housing, to the administrative management (help for the associations of homeowners), to the implantation of new productive activities which would revitalize the neighbourhood, to the training and jobs related to this type of work.

  - Encouragement and administrative cooperation from the central administration and the Autonomous Communities in integrated programmes of urban rehabilitation, economic and social revitalization of vulnerable neighbourhoods, linked to the existence of public management or mixed entities, where all the actors involved participate in the process: the town hall, the Autonomous Community, public and private companies. There should also be the necessary means to ensure citizen participation in decision making along the process.

  - The procedure for obtaining subsidies should be improved and speeded up, through organs created specifically for this purpose, allowing for partial payments without waiting for the finalization of the operation, which at present forces the homeowners to finance part of the operation, with all the consequent difficulties.
Concurrent Legislation

Horizontal Property Law

It is important to remember here that the main objectives of the urban rehabilitation of peripheral neighbourhoods is the residential buildings, and that much of the aid and subsidies offered by the government are given to Homeowners’ Associations, so it will be necessary to review the regulation of the agreements that these Associations need to reach into in order to have access to these grants.

In this sense it would be desirable to extend the concept of “necessary repairs”, with regard to the majority required to make such a decision, to include thermal comfort and the adaptation of installations to the latest regulations, as was done recently with the installations of lifts. It would also be desirable to endow Homeowners Associations with greater legal weight, thus enabling their incorporation by a qualified majority vote (rather than a unanimous one) into other management entities related to the rehabilitation of buildings and urban areas (Homeowners’ Associations of many buildings and management entities concerned with rehabilitation).

Urban Property Leasing Law

It is very important to ensure the permanence of the resident population, whatever their tenancy regime is. Therefore, an updated regulation is needed, adapted to facilitate various operations concerning the integral refurbishment of neighborhoods, the financing obligations of owners and tenants in the work undertaken and in the re-housing needed in the case of ruin or total renewal of the building.

Fiscal Legislation

Finally, integrated urban rehabilitation might be encouraged in fiscal matters, applying a reduced VAT (8%) for all rehabilitation of buildings, or even by eliminating VAT in certain cases of rehabilitation involving significant energy saving, or applied to low rent public housing. It would also be desirable to abolish the obligation of declaring as income the grants received for rehabilitation work under certain circumstances (low incomes, extent of investment, energy savings)

6.2. Economic barriers

As we have seen, the neighbourhoods that are going to require most attention in the matter of rehabilitation are generally those occupied by a low income population with a high incidence of unemployment and social exclusion. For this reason, even when the cost is not high, rehabilitation needs public financing. It will be necessary, then, to regulate and grade the conditions under which such housing may be sold to prevent the privatising of the capital gains. It will also be necessary to improve and develop the financial products earmarked for rehabilitation: loans to associations, public guarantees, micro-credits, etc.

The financing of and support for the energy-related rehabilitation of buildings
depend on the Autonomous Communities’ willingness and management skills, in spite of the existing lines of support traced by the Ministry of Industry by means of the IDAE (the Institute or the Diversification and Saving of Energy). It is up to the Autonomous Communities, then, to move the process forward and to coordinate the areas of Housing and Industry to this end.

6.3. Social barriers

The main objective of urban rehabilitation should be the improvement in the quality of life of the inhabitants, the local development of the community and in general their stabilisation in the neighbourhood after the rehabilitation process. To achieve this it is fundamental that the public participates in decision-making right through the process, as they should in the launching of training programmes, measures for the creation of employment, the reinforcement of the existing social structures, the integration of marginalised social groups, etc. The socio-economic characteristics of certain groups require a relationship of proximity to the management entities which should be stable and suitably staffed (social workers, mediators, educators).

It is necessary to involve the community in the rehabilitation project through participation of neighbourhood and citizen associations, not only during the early planning phase, but also in the implementation and evaluation of the project. Participation strengthens identification with place, with a sense of belonging and with the community’s sense of social responsibility. This is translated into a commitment to keep the place in good repair, to protect it from physical, social and environmental deterioration. While it is true that these programmes tend to drag out over a long period, it is also true that they need time for the information to spread and for proactive participation.

Likewise, the greatest possible local involvement in the work of rehabilitation should be sought, trying to make it the hub of employment in the area by creating workshop schools, professional training courses specialized in that type of work and installations. The most active local agents must be supported insofar encouraging the initiatives under way (modernisation plans for local commerce, the implantation of new productive activities).

As we have seen, one of the constant problems with urban rehabilitation is that the investment of public funds tends to directly cause an increase in housing prices and rents and this in turn leads to the expulsion of the neighbourhood’s habitual residents who cannot afford the increase in rent or the refurbishment itself. They are then displaced by a new population with greater incomes, and the social networks are dismantled. This process could be avoided by means of a better regulation of aid and limits set to the rent increases, as is the case in Denmark for example.

6.4. Cultural barriers

In Spanish culture there is still the myth that the ideal model for a habitat and sign of social ascent is to be found on the suburbs rather than in the traditional neighbourhoods. This makes it more difficult to appreciate rehabilitation as an improvement in the quality of life. Rehabilitation is still seen merely as an expense related to maintenance or conservation and not as an investment, which prevents the development of a true culture of rehabilitation.
Even from the point of view of the consolidated city, the peripheral
neighbourhoods are seen as less attractive than the urban centres because of the lack
of variety in terms of uses. Consequently uses other than the merely residential should
be encouraged in these peripheral neighbourhoods by installing equipment of the type
found in cities, or by encouraging other commercial uses.

Urban rehabilitation should be associated with innovation with regard to building
construction and in the substitution of neighbourhood infrastructures by the most
modern versions available (free access to wifi, renewable energies, non-polluting
transportation, etc.)

7. CONCLUSIONS: TOWARDS A NEW URBAN REHABILITATION POLICY

Finally, with the present situation in mind, we will set out the main conclusions that
flow from the experiences embarked upon and the different strategies devised by
various public entities, concerning the rehabilitation of peripheral neighbourhoods:

- Urban revitalization has to be placed within the framework of a discussion of the
city as a whole. The most desirable scale is the neighbourhood. Urban
rehabilitation should be concerned not only with the protection and
conservation of buildings, but also with improving the urban environment in all its
aspects: physical, social, functional, environmental and economic. Although
urban planning has proved to be an appropriate framework for analysis and
diagnosis of problems, it has not been enough.

- To rehabilitate the large housing stock built in the decades from 1950 to 1990, it is
necessary to carry out a systematized study according to the typologies
involved. The scale (quantitative and qualitative) of the problems detected
requires coordination of resources from the three levels of public administration,
offering incentives to the private sector and taking the initiative in especially
difficult situations.

- The mere accumulation of sectorial policies (housing, facilities, social action,
planning, etc.) alone is not going to revitalize our neighbourhoods. We need a
profound change in the way the government and the most active agents act.
Coordinated actions are needed in the territory. In those processes of
rehabilitation that involve a marginalized population, stable management
entities and enough resources are required to coordinate the whole public
action.

- The potential, in terms of CO2 emission savings, part and parcel of the
rehabilitation of the existing housing stock, is very high and is proving to be one
of the most efficacious strategies for slowing down climate change and
improving the quality of life of the inhabitants and their neighbourhoods.

- Urban rehabilitation cannot be redirected exclusively in the direction of the
energetic rehabilitation of buildings in general and housing in particular (the
need for which nobody denies) just as the urban rehabilitation of Historic Centres and the early suburban expansions could not be restricted to the exclusive interests of history, architecture, tourism or mere urban scenery.

- It has become necessary to reorient and implement economically the public policies of urban rehabilitation along two lines: concentrate economic and management efforts, and locate and give priority to the action plans in concrete areas.

- Although the processes concerning the management of rehabilitation have not been regulated by law, nor are there specific legal figures that retail them, and although the existing legal instruments are insufficient or unsuitable, we cannot remain inactive. The first steps in the right direction can and should be taken; they would serve as pilot experiences and as a stimulus and example to the residents of the neighbourhoods.

- In Spain we have to move from the theory, or experimental projects, to a general and systematic practice of rehabilitation of the existing building stock including sustainable criteria.

It seems that the social and economic management of rehabilitation are the most difficult parts of the process, for which reason public action should concentrate its efforts in supporting the early stages.

It may be said that there are positive signs of change and today there are new driving forces to stimulate residential rehabilitation: the great potential of energy saving that it involves and the crisis in the sector of new housing construction.

These processes are difficult and complex, but should one not tackle complex problems? There is still a certain tendency in the present administrative and political culture to simplify things that are per se complex and which need periods of time that do not fit neatly within the legislative periods of the administrations and which therefore require a basic political consensus before they start.

We believe that we must cannot stop just because not all the instruments are ready and they are still insufficient. We must continue in our reflexions and propose ways of eliminating the various barriers that still exist.

Today, the rehabilitation of large urban areas is an objective that cannot be postponed in Spain. This is the challenge. The technical solutions, though improvable, are there and have been tried. The problem with rehabilitation is the management: economic, social and administrative, and there are still many obstacles that make things difficult. We will continue along this path: acting and reflecting.
NOTES

1 Article by Valerio di Battista “Métodos y procesos en la recuperación de la edificación residencial en Italia”, in Ciudad, Historia, Proyecto 1989, ed. UIMP y el MOPU.

2 Article by Francisco Pol “La recuperación de los centros históricos” in Arquitectura y Urbanismo en las Ciudades Históricas. 1988, ed. UIMP & MOPU.

3 The cities that took part in the study are: Vitoria, Pamplona, Zaragoza, Huesca, Lérida and Barcelona in Spain, and Toulouse, Tarbes and Bayonne in France.

4 Gentrification is a process of urban transformation whereby the original population of a deteriorated neighbourhood is progressively displaced by another group with greater acquisitive power; this is the result of an increase in the prices of houses and commercial premises after a neighbourhood has been renovated.


6 MOLINA COSTA, Patricia (2007): La intervención urbanística en suelo urbano. Análisis de instrumentos. Research Project overseen by Agustín HERNÁNDEZ AJA, within the doctoral programme “Periferias, sostenibilidad y vitalidad urbana” in the Department of Urbanism and Regional Planning, School of Architecture, Polytechnic University of Madrid.

7 Like the “Law for solidarity and urban renovation” (Loi Solidarité et Renouvellement Urbains) passed in France, 2000.

8 The local administration may declare a building to be in a state of ruin, and therefore to be demolished, if the repairs to the building would be more that 50% of the value of the building (not the land). This tends to reward neglect and carelessness on the part of the landlords who simply relinquish their obligation to maintain the building. This becomes more dangerous when there is permission to increase the volume of the new building that is to come.

9 When a lift cannot be installed in an old building, or in the central patio, or in any common area, or on public land, it should be possible to expropriate the necessary private space in favour of the homeowners association. The Sustainable Economy Bill mentions this, but this is possible even now with the present Law of Expropriation, if the municipal governments wanted to make use of it; in fact San Sebastian City Hall is doing this systematically at the request of the homeowners’ associations.

10 In this sense it is worth mentioning the “Integral programme of housing rehabilitation for disadvantaged groups” put into action in Vilafraanca del Penedés (Barcelona). This programme was awarded a “Best” rating in the United Nations International Competition of Good Practices, 1998.

11 In Denmark there are specific financing systems so that the tenants will not be expelled as a result of the rent increase – whereby the State and the owner take on the expenses of the process. Each year Parliament approves the budget for urban rehabilitation, and the General Plans should include the zones to be rehabilitated in order for them to benefit from these subsidies. It is the town halls that approve of the budgets for housing rehabilitation and for a rise in rents. If it is necessary to re-house tenants temporarily, the interim rent should be similar to the original rent, and to the final rent when they return to the rehabilitated building; if this is not the case, the tenants have a right to a subsidy for up to 10 years.
A tool and an approach for setting sustainable energy retrofitting strategies for territories (neighbourhood, city…) or building stocks

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THE 2010 EUROPEAN DIRECTIVE ON ENERGY EFFICIENCY IN BUILDINGS

Since the 2010 European directive on energy efficiency in buildings, the focus is on the technico-economic optimisation of energy retrofitting programmes in order to take care of the households’ purchasing power. So a whole life cycle energy cost is needed for each retrofitting programme at the building scale and of course for any territorial or building stock strategy.

For such a purpose we use the SEC model worked out due to a European SAVE project, the Factor 4 project on energy retrofitting of social housing (cf. www.suden.org/factor4).

SUSTAINABLE RENOVATION OF NEIGHBOURHOODS: BEST POLICIES INSTEAD OF ONLY BEST PRACTICES

1. The Factor 4 approach and models origins: a European project focussed on social housing

The Factor 4 approach and models have been first worked out due to the Factor 4 European SAVE project (2006-2008) coordinated by the SUDEN (Sustainable Urban Development European Network) non profit association whose aim is the promotion of sustainable urban development (cf. www.suden.org/Factor4/).

In 2 countries social owners which were not Factor 4 partners were associated to the project for being sure that the tools (Factor 4 approach and models) fit to their needs: 10 social owners in France and around 10 cooperatives in Italy.

As technologies and costs are different in each country, various versions of the Factor 4 model were worked out: ASCOT in Denmark (where 94% of dwellings are connected to a district heating plant with gas) by Cenergia, BREA in Italy by Ricerca & Progetto, VROM (focussed

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1 All the results or deliverables are available on the web site except the models. For the models you must contact directly their author (1)
only on insulation) in Germany by Volkswohnung (a social owner) and SEC in France by La Calade.
These models are not the same ones and we focus on this document on the French SEC model.

2. The Factor 4 objectives
The Factor 4 objective is to set out a sustainable energy retrofitting strategy for a whole building stock (of a social owner or on a neighbourhood).

3. Other new versions of the French SEC model
Due to specific studies for social owners or local authorities, the SEC model has been regularly improved by La Calade and various versions are in use (some social owners wanted their specific version with their own building stock typology for example).
Further more, due to subsidies from the French ministry (PUCA through PREBAT, the national research program on energy in buildings), La Calade has improved the initial version of the SEC model: SEC can deal now with more technologies and is adapted to the private sector (which has not the same financing rules nor the same costs data base) and another new version of the SEC model is now available for single family houses.
A lot of social owners and some local authorities are now using the SEC model.

4. The Factor 4 approach and the uses of the SEC model
The Factor 4 approach has various steps:
1.- to work out a building typology (of the building stock) in order to select representative ones on which the analysis will be focussed on
2.- an energy diagnosis with the SEC model (with both Energy and Climate labels) and the collection and the analysis of available energy consumption data: EPBD, data from the collective heating plants…
3.- various energy retrofitting simulations or scenarii for each representative building with the SEC model, first without any subsidies and then with various potential ones in order to show and better understand their impacts (on energy consumption but also on CO₂ emissions and on charges for renters, etc.)
4.- extrapolation of the results on the representative buildings to the building stock or to the territorial scale (neighbourhood, city…).
5.- recommendations and setting out a sustainable energy retrofitting strategy.
These simulations (scenarios) also help for identifying the buildings to be demolished and those for which an important energy retrofitting programme is needed.

5. A life cycle energy cost model
The SEC model is a life cycle energy cost model. It allows setting up a lot of simulations in order to optimise the energy retrofitting programme of each building.
These simulations allow a selection of the best technologies regarding their economic efficiency or, if needed in specific cases, their energy efficiency. The SEC model allows to take into account simultaneously all the environmental (reduction of energy consumption), ecological (reduction of CO₂ emissions), social (reduction

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2 Plan Urbanisme Construction et Architecture
of charges for tenants or owners) and economic (investments optimisation, taking into account energy price increase) issues in order to help all the actors concerned (social owners, private owners, local authorities, banks…) to make the best choice (fig.1).

Fig 1 - Simultaneous integration of environmental, ecological, social and economic issues for setting out a sustainable energy retrofitting strategy for a whole building stock (with the SEC model)

Source La Calade for the Factor 4 European project, 2007 (1)

6. A decision aid tool as well as a dialogue tool
So the SEC model is a decision aid tool:

- for local authorities in/for dealing with private housing in sustainable energy retrofitting strategies, in coherency with their regulation documents as regarding both housing and land planning.
- for social owners for setting up the energy retrofitting strategy of their whole building stock,
- for all the actors involved in a neighbourhood regeneration project including retrofitting of existing buildings;
- for local authorities in their fight against energy poverty.
At least the SEC model contributes to the dialogue between actors (such as local authorities and social owners) and especially with financial ones such as banks.

7. The SEC model hypotheses

A lot of hypotheses have been validated with the Caisse des Depots et Consignations (the official French bank for local authorities and social owners), Ademe and various public administration services, such as:

- an energy prices data base and energy price increase,
- an equipments and techniques data base with their life duration, cost and maintenance cost,
- a degree days data base,
- carbon tax and other energy certificates,
- a discount rate level,
- the duration of the evaluation,
- …

And all these hypotheses can be changed if needed.

8. The energy diagnosis with the SEC model

The SEC model allows calculating the energy consumption of any housing building and comparing this estimation to the real data when they are available, for heating, sanitary hot water (SHW) and electricity.

This comparison allows adjusting the technical parameters describing the building and is a sort of guarantee on the results quality of the further simulations (this is not possible with the EPBD diagnosis in France).

At least, if you can’t get the data, the SEC model calculates them, even if it is not the objective of the model (there are other sophisticated models dedicated to that).

The following example illustrates this comparison between the real data and the calculated ones given by the SEC model. So if there is an important difference (over 10 % or 15 %) you must try to understand why (perhaps you did not describe well the building or the climate conditions or the residents’ behaviour is not usual…). (Tab 1).

<table>
<thead>
<tr>
<th>Tab. 1 - Final consumption - heating and HSW - in kWh / m²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>169</strong> data difference</td>
</tr>
<tr>
<td>Heating</td>
</tr>
<tr>
<td>SHW</td>
</tr>
<tr>
<td>Electricity common lighting and auxiliaries</td>
</tr>
</tbody>
</table>

Energy and Climate labelling (in blue in the following Tab 3) are also given.

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3 electricity with is not included in the EPBD diagnosis but which is an important expense for house keepers
Tab 2 - Energy diagnosis results presentation

<table>
<thead>
<tr>
<th>1. In ratios</th>
<th>2. Results per dwelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating + SHW in kWh per m².year (Cep)</td>
<td>Heating + SHW in kWh per year (Cep)</td>
</tr>
<tr>
<td>CO₂ emission in kg per m².year</td>
<td>CO₂ emissions in kg per year</td>
</tr>
<tr>
<td>Expenses Heating + HSW in €/m².year</td>
<td>Expenses for Heating + SHW in € per year</td>
</tr>
<tr>
<td>Expenses for Electricity in the dwellings in €/m².year</td>
<td>Expenses for electricity in dwellings in € per year</td>
</tr>
<tr>
<td>Expenses for cold water in €/m².year</td>
<td>Expenses cold water in € per year</td>
</tr>
<tr>
<td>244,7</td>
<td>16 650</td>
</tr>
<tr>
<td>73,4</td>
<td>5,0</td>
</tr>
<tr>
<td>14,8</td>
<td>1 006</td>
</tr>
<tr>
<td>4,65</td>
<td>317</td>
</tr>
<tr>
<td>3,98</td>
<td>271</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Results for the building</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating + SHW in MWh / year (Cep)</td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions in tons / year</td>
<td></td>
</tr>
<tr>
<td>Expenses for Heating + SHW in € / year</td>
<td></td>
</tr>
<tr>
<td>Expenses for electricity in the dwellings in € / year</td>
<td></td>
</tr>
<tr>
<td>Expenses for cold water in € / year</td>
<td></td>
</tr>
<tr>
<td>Expenses electricity in common areas in € / year</td>
<td></td>
</tr>
<tr>
<td>333</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>20 113</td>
<td></td>
</tr>
<tr>
<td>6 332</td>
<td></td>
</tr>
<tr>
<td>5 411</td>
<td></td>
</tr>
<tr>
<td>733</td>
<td></td>
</tr>
</tbody>
</table>
Tab. 3 - Consumption of the building in kWh per m²
(with electricity in yellow, sanitary hot water in red and heating in blue)

<table>
<thead>
<tr>
<th></th>
<th>Electricité commun</th>
<th>Eau chaude</th>
<th>Chauffage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>244.7</td>
<td>79.4</td>
<td>165.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Marges calculées</th>
<th>Calculés</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chauffage</td>
<td>165.3 10%</td>
<td>181</td>
</tr>
<tr>
<td>ECS</td>
<td>79.4 -14%</td>
<td>68</td>
</tr>
<tr>
<td>Electricité pc et aux.</td>
<td>5,0</td>
<td></td>
</tr>
</tbody>
</table>

9. Scenarios / simulations

Various energy retrofitting scenarios can be set out by or with the various actors concerned, such as for example (cf. Tab. 4):

- an optimisation in life cycle cost (so, based on economic efficiency) (called « Optimum scenario »);
- a « Grenelle scenario », according to the prescriptions of the Grenelle Law 1, which consists in going towards an energy consumption under 150 kWh/m² pe (primary energy) per year for heating and hot sanitary water;
- an « Eco-prêt scenario », which consists in a reduction of at least 80 kWh/m² for energy consumption as well as going under 195 kWh/m² (for primary energy);
- a « BBC scenario » (BBC means low energy building), which is a scenario allowing to reduce energy consumption until about 80 kWh/m² and per year.¹

¹ exactly: 80 (a+b) where a is a ratio depending on the area and b a ratio depending on altitude
Tab. 4 – Energy characteristics for each scenario

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Energy characteristics for each scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Prêt scenario</td>
<td>cep &lt; 195 kWh/m² and minimum reduction of 80 kWh/m²</td>
</tr>
<tr>
<td>Grenelle scenario</td>
<td>cep &lt; 150 kWh/m²</td>
</tr>
<tr>
<td>BBC scenario</td>
<td>cep &lt; 80 kWh/m² (approx.)</td>
</tr>
<tr>
<td>Optimum scenario</td>
<td>where cep minimises the life cycle energy cost of the building</td>
</tr>
</tbody>
</table>

Cep = consumption in primary energy for heating and SHW

The end results for each housing building give ratios per m² of heated area and per dwelling. They gives also the Energy and Climate labels.

10. The technics hierarchisation

The SEC model can use a lot of technologies for improving energy consumption in buildings. These technics are upon:
- the envelope,
- the improvement of energy efficiency of energy equipments
- renewable energy
- alternative energy sources
- residents behaviour.

For each technology, the SEC model gives an investment cost, a maintenance cost, an usual technical life duration and the impacts of the technology on energy consumption and CO₂ emission (cf. Tab 5.).

Tab 5. Analysis component per component

<table>
<thead>
<tr>
<th>Tab 5. Analysis component per component</th>
<th>Energy consumption (Cep)</th>
<th>Cost for the social owner (€/m².year)</th>
<th>Charges (€/m².year)</th>
<th>Life cycle cost (€/m².year)</th>
<th>Inv./dwelling (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial situation</td>
<td>244.67</td>
<td>21.50</td>
<td>21.50</td>
<td>244.67</td>
<td></td>
</tr>
<tr>
<td>Hygro ventilation type B</td>
<td>231.64</td>
<td>1.10</td>
<td>21.17</td>
<td>22.28</td>
<td>91.00</td>
</tr>
<tr>
<td>Central gas boiler with condensation</td>
<td>223.87</td>
<td>1.66</td>
<td>19.81</td>
<td>21.47</td>
<td>1.837</td>
</tr>
<tr>
<td>From fuel oil to gas for condensation</td>
<td>244.67</td>
<td>0.90</td>
<td>21.50</td>
<td>22.41</td>
<td>1.000</td>
</tr>
<tr>
<td>External walls insulation - 10 cm</td>
<td>185.37</td>
<td>3.25</td>
<td>16.29</td>
<td>19.54</td>
<td>4.296</td>
</tr>
<tr>
<td>Roof insulation</td>
<td>232.77</td>
<td>2.04</td>
<td>20.46</td>
<td>22.50</td>
<td>2.255</td>
</tr>
<tr>
<td>Heating system balance</td>
<td>223.08</td>
<td>0.35</td>
<td>18.51</td>
<td>18.86</td>
<td>272.00</td>
</tr>
<tr>
<td>Changes in behaviours</td>
<td>233.72</td>
<td>0.69</td>
<td>20.54</td>
<td>21.24</td>
<td>136.00</td>
</tr>
<tr>
<td>Pipes insulation</td>
<td>238.72</td>
<td>0.07</td>
<td>20.98</td>
<td>21.05</td>
<td>68.00</td>
</tr>
<tr>
<td>Centralised HSW replaced by an independent system</td>
<td>244.67</td>
<td>1.56</td>
<td>21.59</td>
<td>23.15</td>
<td>1.225</td>
</tr>
<tr>
<td>Energy saving due to hot water saving</td>
<td>232.77</td>
<td>0.16</td>
<td>19.93</td>
<td>19.99</td>
<td>68.00</td>
</tr>
</tbody>
</table>

So the results are shown for each scenario in such a following table (table 6):
Tab 6 - Summary of the results for all the scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Energy label</th>
<th>Climate label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial situation</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>Heating system balance</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>Energy saving due to hot water saving</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>External walls insulation - 10 cm</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>Pipes insulation</td>
<td>Grenelle</td>
<td>C</td>
</tr>
<tr>
<td>Central gas heating with condensation</td>
<td>Optimum</td>
<td>C</td>
</tr>
<tr>
<td>Changes in behaviours</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Solar heat water</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Hygro ventilation type B</td>
<td>BBC</td>
<td>C</td>
</tr>
<tr>
<td>Roof insulation</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>

In this example, the 4 scenarios require different investment cost from 4 636 € / dwelling up to 12 884 €. The optimum is reached for a 7 541 € investment/dwelling.

These results can be illustrated by the following schema n°1 showing the **evolution of the life cycle cost in €/m².year** technique (work) after technique (the red curve in the life cycle cost, the pink one is for charges and the blue one for the social owner’s cost):
The following schema n°2 is showing the evolution of investment (in € per dwelling on the right part of the schema) on the one hand and of primary energy consumption on the other hand.

So energy consumption can be compared for each scenario as in the following schema n°3.

**Schema 3 - Comparison of energy consumption and investments needed for each scenario with the initial situation of the building (before works)**

And we can also see for whom are the costs and benefits as shown in the following schema n°4.
Schema 4 - Cost and benefits for the various actors (the tenant, the social owner and society) for the Grenelle scenario

So for each scenario the results are presented as following in the tab 7

Tab 7 - Results of the life cycle energy cost analysis for one scenario

<table>
<thead>
<tr>
<th></th>
<th>€ / m².year</th>
<th>€ / dwelling</th>
<th>€ / building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charges for tenants (initial situation)</td>
<td>21.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment in actualised € per year (1)</td>
<td>6.40</td>
<td>435</td>
<td>8 704</td>
</tr>
<tr>
<td>Yearly maintenance (2)</td>
<td>0.26</td>
<td>17</td>
<td>347</td>
</tr>
<tr>
<td>Energy savings with constant energy prices (3)</td>
<td>-8.98</td>
<td>-611</td>
<td>-12 221</td>
</tr>
<tr>
<td>Energy savings due to energy price increase (4)</td>
<td>-3.85</td>
<td>-262</td>
<td>-5 242</td>
</tr>
<tr>
<td>PV panels gains (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsidies (for solar heating) (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life cycle cost evolution in present € per m² and per year</td>
<td>- 6.18</td>
<td>- 4.21</td>
<td>- 8413</td>
</tr>
<tr>
<td>Sum from (1) to (6) -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property taxes exoneration (7)</td>
<td>-1.25</td>
<td>- 85</td>
<td>-1 696</td>
</tr>
<tr>
<td>White energy certificate (8)</td>
<td>- 0.87</td>
<td>- 59</td>
<td>-1 187</td>
</tr>
<tr>
<td>Average life cycle cost after retrofitting works for the whole period – Sum from (0) to (8)</td>
<td><strong>13.21</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial participation of the renters</td>
<td>2.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charges for tenants after retrofitting works</td>
<td>11.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual cost for the social owner</td>
<td>1.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual cost for society</td>
<td>2.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ factor</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Such a life cycle cost analysis can be done for private residential buildings at the city scale or for social housing at the regional scale or for the building stock of a social owner for example.
Such a life cycle energy cost analysis has shown already that:
- the most efficient techniques are different according to each building technical specificities and the same technologies must not be decided for all the buildings;
- the energy retrofitting costs are sometimes very different according to:
  - the energy source,
  - the building typology,
  - the initial level of energy consumption,
  - the scenario (the objectives and the way for reaching the objectives)
  - …

For example energy retrofitting costs for buildings with an Energy label E or F are very different according to:
- the typology: single housing buildings with electricity heating systems cost much more than buildings with a lot of dwellings as shown in the schema 5.
- The objective of energy savings as shown with the schema 6.

**Schema 5 - Energy retrofitting costs (according to the Grenelle scenario) for buildings with a E or F Energy label according to the building typology**

*Source: analysis of 22 000 social housings in the Picardie region with the SEC model*
Schema 6 - Energy retrofitting costs for multifamily buildings with an E or F Energy label according to the energy consumption objective after works

Source: analysis of 22,000 social housings in the Picardie region with the SEC model

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PROPOSAL FOR A BUILDING RENOVATION PLAN BASED ON ENERGY PERFORMANCE CRITERIA

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For many years housing policies in Spain have favored purchase over renting, inefficient buildings over energy efficiency, scattered and extensive urban developments over compact ones and access to housing by citizens with highest income. The lack of specific regulation, wrong fiscal policies and incomplete signaling of energy prices have contributed to a situation that most of Spanish society regrets about today.

Besides, new building has been more promoted than renovation, for instance, only 5% of public spending in housing is invested in renovation, and it has nevertheless employed around 345,000 workers. A 180 degrees turn in housing policies was necessary.

All these issues are of great significance for trade unions, because of the importance of access to decent housing, the high number of jobs the sector represents (some 2.7 million workers, not including associated industrial jobs) and because of their influence on environmental and energy issues. In June 2008, the Environmental Department of the Trade Union Confederation (CC.OO.) submitted a proposal for Energy Efficient Refurbishment of Existing Buildings. It was a joint proposal that shared views and criteria of similar plans developed by other groups of experts.

Later that year the Spanish government adopted the Housing and Building Renovation Plan for the period 2009-2012 that includes measures that are relevant to the issue but remain poorly funded. Other fiscal measures recently adopted by the government that might be complementary to promote building refurbishment within the package of measures to abate the effects of the economic crisis. Those measures are basically focused on income tax deduction for renovation projects of homes with income rates up to € 53,000 with an estimated cost of €1.4 billion, and a reduced VAT (8% starting in June) in billing related to such projects.

All debates about the Spanish economy, solutions to the economy crisis and issues regarding energy models regard renovation as an adequate, coherent and necessary policy within the current economic circumstances. The issue is to determine whether the measures implemented by the government will prove sufficient to grant the expected results.

Even though data on the execution of the plan are practically non-existent, it would not be wrong to consider that government measures are insufficient. In our view, a set of more ambitious and conclusive measures must be implemented, especially those that reinforce existing regulation:
1. Private home owners cannot base massive home and buildings energy renovation and refurbishment projects solely on economic and fiscal incentives, especially in those communities where reaching collective decisions is still a complex issue. Obligations in energy renovation must be approached in a progressive way. The goal for 2020 (with some intermediate objectives to be met by 2015) is to adapt most buildings to a standard maximum energy consumption by unit of surface (in Kwh/m²) to be established by regulation and in all cases in compliance with Building Technical Code (CTE). Adaptation must be focused on limitation to energy demands for heating and air conditioning systems, on the performance of thermal facilities and the predominance of renewable energies for thermal uses in buildings. Such requirements must also be adjusted by regulation to the type of building (homes, service or industrial facility) and to the climate zones those buildings are located in, with the obvious exceptions for technical or social causes.

2. CC.OO. along with other social institutions submitted a proposal in 2008 for an energy saving and efficiency bill that includes elements for a change in regulation to promote the modernization of existing buildings, based on Directive 2002/91/CE on the energy performance of buildings, among other aspects. The Directive is being modified with the introduction of the concept “near zero energy buildings” for new construction projects: buildings with high energy efficiency in which the necessary energy is produced by “on site” renewable sources. This will definitely modify building technical codes in all EU countries. However in spite of the demands of some social organizations there will be requirements for Member States in terms of retrofit goals, only a promotion of such activity.

3. City councils and regional authorities will play a significant role in the development of specific comprehensive programmes for neighborhood renovation, especially in those neighborhoods with predominance of buildings from the period 1940-1980 (around 5 million homes). That is period of more inefficient building techniques, especially regarding thermal insulation. Those comprehensive programmes should cover houses energy retrofit and in many cases works to improve their façades, introduce renewable energies actions for urban re-arrangement. Actions should also cover public buildings and equipment. Such programmes could be conducted through “municipal renovation agencies” and include active citizens’ participation in their design and development. These measures have been compared to the those implemented in socially and architectonically impoverished neighborhoods and suggest the introduction of the concept “energy ruin”, when energy standards show high inefficiency levels.

4. The application of renewable energies is of special importance to achieve optimal energy indicators. These projects will basically focus on solar thermal, geothermal and biomass. Technologies for solar and geothermal energies can grant both heating and refrigeration. It is unacceptable for Spain to have a poor development of such technology. To this regard the Plan for the Promotion of Renewable Energies 1999-2010 has been a complete failure. Namely solar thermal energy, a sector that employs some 8,000 workers in Spain, did not experience the expected growth in spite of its compulsory introduction in new building projects according to the Building Technical Code. 75% of solar panels installed nowadays comply with this requirement and 20% are funded by regional programmes. The sector is studying the need to improve existing support programmes in terms of official announcements and other requirements, control of better compliance with the Building Technical Code and development of special programmes for industry and major consumers by linking them to possible energy savings.

5. Finally, we consider that state energy renovation plans must be more ambitious, as we stated above. The following proposal was submitted in 2008 and it shares common goals with similar projects of the same period.

Different authorities are studying the suitability of implementing a Renovation Plan to improve the condition of existing buildings to make them more inhabitable and help the construction sector partially overcome unemployment caused by the current readjustment.
LECTURES

If this plan is developed according to energy efficiency criteria the benefits could extend to aspects like the reduction of greenhouse and other polluting emissions in the sector, the reduction of users’ energy bills and also the reduction of Spain’s foreign energy dependence. It is important to bear in mind that most of the energy used for building consumption, including electricity, comes from fossil fuels.

Substitution and improvement of heating and air conditioning systems in offices and other workplaces might imply a further improvement of workers’ health and safety conditions.

The EU Directive 2002/91/CE on the energy performance of buildings establishes that Member States shall lay down the necessary measures to establish a system of certification of the energy performance of buildings, including the currently existing ones. The Spanish Royal Decree 47/2007 transfers that requirement to new buildings and renovation projects of certain magnitude. A renovation plan that includes such requirement for all buildings would prove useful to test the results of full implementation.

The goals of the BUILDINGS RENOVATION PLAN BASED ON ENERGY PERFORMANCE CRITERIA would be:

- Reducing CO2 and other greenhouse gases
- Reducing users’ and companies’ energy expenses
- Creating jobs and partially assimilating unemployment in the sector
- Reducing Spain’s energy dependence
- Improving health and living conditions in houses and workplaces

SCOPE OF IMPLEMENTATION

He plan must cover at all types of buildings, home, industrial and service facilities (commercial, sport centers, hospitality, and offices). The first type (homes) of building would include private owned houses / communities of home owners and the second type would cover all sorts of companies and local administration buildings.

The renovation plan is particularly necessary in the case of buildings located within cities’ historical centers which require a more structural renovation and in the case of buildings of the last four decades; further insulation measures would be required

The central government adopted in 2007 a Plan for Energy Saving and Efficiency focused primarily on the optimization of energy consumption in big renovation and refurbishment works. These projects should also be funded by National Budget.

This plan would also give some consistency, shape and funding for measures included in the “Spanish Strategy for Climate Change and Clean Energy 2007-2012-2020”. This plan covers residential, commercial and institutional buildings (paragraph 3.3.7.2).

Budgetary funds assigned to this type of action are clearly insufficient so far. A qualitative leap in budget terms to implement measures that imply social, economic and environmental benefits as stated above in this document.

FUNDING AND MANAGEMENT

The plan would be developed for a four-year period 2009-2012, i.e. to cover the full government term. It must be promoted, coordinated and funded by the Ministry of Housing, the Ministry of Environment and the Ministry of Commerce, Industry and Tourism, with full involvement of local and regional authorities. The Ministry of Public Works would also participate in aspects relevant to its activity.
Funding would be provided by direct support or subsidies, as well as credit lines. Funding by third parties could be introduced in cases of equipment that would grant significant savings of energy expenses.

The plan would affect around 1,260,000 houses and 140,000 industrial or service sector buildings during a four-year period with 1,400,000 actions. There are around 25,000,000 houses and 1,400,000 industrial or service facilities. Subsidies would benefit private home owners’ communities in the residential sector and companies in the industry and service sectors. Building renovation would be partially funded by National Budgets.

The estimate amount of the funding would be 25.2 billion Euros of which one third would be allocated through direct subsidies (5.8 billion from government funds and 2.8 billion from regional funds) and two thirds through private investment and funding with some kind of public warranty or through the Spanish Credit Agency (ICO) (16.8 billion Euros).

The implementation of the plan is expected to develop gradually in four years. The expected investment figure for the fist year is 800 million Euros, 1.2 billion for the second year, 1.6 billion for the third year and 2.0 for the last year. The remaining funds (regional and public/private) as well as the actions to be performed would be distributed proportionally according to those figures.

Regional authorities would be responsible for the management of funds and for controlling project execution and companies involved in it, ensuring compliance with required energy performance parameters. This requires the implementation of the previously mentioned energy performance certificates.

**ENERGY EFFICIENCY MEASURES AND RENEWABLE ENERGIES TO BE INTRODUCED**

Technical requirements to be introduced must be aimed at achieving high levels of environmental and climate comfort using the minimum possible external energy and introducing sustainability criteria in the used material and in the management of works. To this regard it would be important to consider:

- **Acoustic and thermal insulation** measures such as the introduction of insulating materials in façades, covering surfaces and floors, substitution of windows or introduction of double glazed windows or metal profiles in wooden balconies or windows, introduction of awning, blinds or any other protecting or insulating elements.
- **Introduction of more energy efficient air conditioning, air conditioning and kitchen equipment and systems.**
- **Introduction of renewable energies, especially:**
  - Solar thermal for Basic hot water needs, for floor heating systems and refrigeration
  - Biomass boilers, especially for heating
- **Introduction of new environmental materials in refurbishment works (pipes, floors) and used of certain building techniques:**
  - Low-impact foundations
  - Easily reversible precast elements (especially for service buildings)
  - Easy-access, readaptable, demolishable or changeable facilities
  - Promoting building deconstruction. Choosing extensive demolition in the case of partial demolitions
  - Use of low water consumption appliances and taps.
  - Exploring the possibilities of introducing reservoirs to gather rain water for later use in watering, lavatories, cleaning.
LECTURES

Energy saving measures must focus primarily on:

SAVING: Measures to ensure energy saving, especially through actions on the enveloping surface and on building design.

- Exploring the possibilities of implementing measures of passive solar capture: south oriented windows, greenhouses. In certain constructions zenithal systems perform well (skylights, large windows).
- Complementing capture systems with measures to accumulate solar radiation: use of materials with high solar inertia in floors, walls or partitions
- Adapting the distribution of spaces to thermal performance whenever possible. Introducing solar protection measures in glass openings (especially those on west, south and east oriented façades)
- Exploring the possibility of crossed natural ventilation in rooms. Introduction of abatable internal elements and forced ventilation through solar chimneys.
- Using vegetation as solar protection and natural cooling elements (combined with bodies of water). Environmental covering of roofs with a few inches of vegetable land to ensure cooling during the summer.
- Recover internal yards as a bioclimatic element
- Improving thermal insulation in enveloping surfaces. Referring to specific thickness required by the technical building code. Placing insulation on the external part of bolting to grant thermal inertia in the rooms
- Exploring the possibilities of using ventilated elements: façades and covers.

EFFICIENCY: Measures aimed at achieving higher energy efficiency.

- Substitution of elements (window frames) to improve energy performance of external surfaces
- Use of high energy efficiency glass: solar control, low or mixed emissivity, depending on the location.
- Use of central boilers instead of single ones.
- Use of low temperature and/or condensation boilers.
- Use of low temperature heat emitters: radiating floors or oversized radiators
- Use of energy efficiency measures for lighting systems: low consumption lamps. Use (in service buildings) of domotics (automation): distribution of spaces by uses, timing devices, presence awareness systems
- Use of energy saving and efficiency measures in taps and appliances that operate on hot water: cold opening, thermostatic and timed taps.

Required energy performance parameters must be established by the Technical Building Code, the Rule for thermal installations in buildings (RITE) and by the Royal Decree (Law) 47/2007 on basic procedures of energy performance certificates for new buildings, whenever applicable until a more specific regulation is adopted, and by existing regional regulation if it is in force or is more exacting.

JOB CREATION AND PROFESSIONAL TRAINING

Job estimates are of some 350,000 jobs per year as average, considering 1 job/ per year/per renovated hose, building. These are conservative estimates and will depend on the type of renovation project. It is important to note that job/invested capital ratios are higher in renovation compared to new constructions and especially public works.

The plan would also promote innovation in building projects, particularly in the development of new materials and equipment, as well as in the integration of renewable energies with construction. Job creation, social and industrial development are expected to diversify and reach extensive rural areas.
LECTURES

Special attention should be conferred to professional training and adaptation of workers in the sector by providing them (at different professional levels) with the necessary training on aspects like insulating systems, materials, specific solar thermal and biomass energy installations, or disposal of construction and demolition wastes and their possible reuse, which are significant aspects in renovation projects. Such training activity could be developed with unemployed workers in the first stage.

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Sustainability assessment tools for urban design at neighbourhood scale

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ABSTRACT

In an increasingly urbanized world, the path that cities follow and the way in which they tackle the defining challenges of social inequities and sustainability will be key to shape the future of the planet. This research explores where does urban design stands to face these challenges. Urban integrated regeneration at neighbourhood scale will play a relevant role in the process. The urgent and necessary urban transition may be facilitated by practical tools to compare scenarios taking into account sustainability criteria in the decision making process. In this sense this research explores how the tools to assess and measure the impact of urban interventions may contribute to improving their sustainability and achieving low GHG emissions targets.

We assume that integrating quantitative as well as qualitative assessment in urban design may contribute to recognise if a mayor breakthrough in urban sustainable regeneration is in fact taking place and afterwards if the results meet expectations. There has been a significant development of tools to assess the sustainability –or more precisely the energy efficiency– of the building industry, like BREAM but most do not consider the neighbourhood scale. LEED, that has indeed developed an application for assessing neighbourhoods, is focussed in new developments. There is consequently a lack of accessible and practical tools to compare scenarios taking into account sustainability criteria in the decision making process. At the same time different agencies, institutions and local governments develop ad hoc tools to assess urban sustainability, with hardly any chance of being applicable in other locations.

This paper presents the conclusions after the review of assessment tools available in the European context. To select the tools to be analyzed three sources were checked: the PETUS (Practical Evaluation Tools for Urban Sustainability) project, led by the University of Cardiff, the thematic Program “Energy, Environment and Sustainable Development” and the database of the Construction and City Related Sustainability Indicators CRISP project, both developed within the Fifth Framework Program. The tools are systematically analyzed and classified according to their application scale and stage, the type of tool and the nature of issues considered.

There is a great general concern about the role of cities in reducing unsustainability and, although there is a lot of work that has been done in the frame of European programs, they have focussed mainly on delivering reports and guidelines, list of indicators and best practices; besides those reports, also some methodologies and specific technologies have been developed. Nevertheless there is a lack of practical, useful and open source (adaptable) tools to assess urban sustainability of small scale interventions. This project aims to contribute to fill the gap.

MOTIVATION

Sustainability challenges in an urbanized World
PONENCIAS

By 2008 the United Nation Report on World’s Cities [1] announced that, for the first time in history, more than half the global population lives in cities. In an increasingly urbanized world, the path that cities follow and the way in which they tackle the defining challenges of social inequities and sustainability will be key to shape the future of the planet. Although it is important that new urban developments adopt the principles of sustainable urbanism, the transformations that existing urban areas undertake will be more relevant [2]. In most European countries the first basic criteria should question if further urban expansion is necessary or not.

One of the most notorious consequences of the current unsustainability is climate change, which now ranks high in the political agenda. This awareness has lead to more focussed strategies oriented to technical innovation and efficiency improvements, considered key factors to mitigate or adapt to global warming.

In this urbanized context, cities have to shift from being part of the problem, to become part of the solution. They should lead the process and take initiatives of mitigation and prevention –providing low emission alternatives and disconnection from carbon– and adaptation to climate change –anticipating to its consequences and answering to the new climate conditions and their associated risks like droughts or floods. Urban regeneration programs and projects should play a relevant role in this path towards a more sustainable urban future.

Urbanism: combining social and technical perspectives

The concept of sustainability entails three complementary dimensions: environmental, social and economic. It entails more complexity than other top challenging concept: climate change. The statement that urban regeneration may contribute to cope with climate change does not equal to consider urban intervention as a mere technical problem. Neighbourhood regeneration implies necessarily a social component. Unfortunately there has too often been a dichotomy between social and urban planning-design issues, with responsibilities assigned to different and insufficiently coordinated departments. The trend is changing and the traditional approach of urban planning that stressed the spatial upgrading is now changing to take into account more complex processes that open new opportunities to the citizens. In that sense the program PEGASUS states that whereas in the past urban regeneration in Europe focussed mainly on physical upgrading, nowadays they are conceived following more multidimensional perspectives [3]. According to this new vision, urban integrated regeneration initiatives try to push forward incentives to local economy, they seek social cohesion and a better quality of life as well as rehabilitation of buildings and improving public spaces, and all those actions are supported by new urban policies and governance.

The neighbourhood scale

This research explores where does urban design –understood as effective problem solving and/or the processes of delivering or organising development [4]– stands to face these challenges. We strongly advocate the neighbourhood as a critical scale for urban intervention. The neighbourhood is a unit large enough to undertake consistent transformations and, at the same time, limited enough to enable its citizens to get involved in those transformations [5]. In its area, the diversity of economic activities, mix of uses and appropriable space foster social relationships. The huge potential of relationships and connections in a context of social, cultural and professional diversity offer one of the basic qualities of the complex city: creativity [5] and as a consequence, resilience.

Quantitative and qualitative assessment

The urgent and necessary urban regeneration at local scale may be facilitated by practical tools to compare scenarios taking into account sustainability criteria in the decision making process. In this sense this research explores how the tools to assess and measure the impact of urban intervention may contribute to improving their sustainability and achieving low GHG emissions targets. We understand that integrating quantitative as well as qualitative assessment in urban design improves the evaluation
of urban regeneration effectiveness. There has been a significant development of tools to assess the sustainability—or more precisely the energy efficiency—of the building industry, like BREAM but mostly do not consider the neighbourhood scale. LEED, that has indeed developed an application for assessing neighbourhoods, is focussed in new developments. At the same time diverse agencies, institutions and local governments develop ad hoc tools to assess urban sustainability, with hardly any perspective of being replicable in other locations. This paper presents the conclusions of the review of assessment tools available in the European context.

Our research initiative has been greatly inspired by the tools for supporting urban design developed by the Chair of Technical Ecology and Methods (TEAM) of the Department of Urban Design at the Delft University of Technology [4]. These tools consist of a set of spreadsheets to exercise numerical simulations of the impact on design of different parameters and standards concerning sun, plantation, wind, noise, water, traffic, earth, ecology, density, economy and distribution of green areas. [5] The TEAM tools are a building block for our research initiative. We envisage enhancing these tools in two directions: i) broadening the assessment scope to encompass not only physical impact but also socio-economic performance of urban interventions; and ii) enabling its application at neighbourhood level to existing built environments. The future adaptation work will be feed by the conclusions from the state of art, which are translated into still pending challenges.

RESEARCH METHODOLOGY

The research started with an exhaustive analysis of the tools to assess urban sustainability that have been developed by local/national institutions or as part of European research programs with public funding. It was the preliminary work to explore if tools that contribute to incorporate sustainability criteria in urban design and urban policies at local scale are effectively available and applicable by different stakeholders involved in urban regeneration at neighbourhood scale. The selection of tools is based on the compilation of the Practical Evaluation Tools for Urban Sustainability project (PETUS) led by the University of Cardiff, on those developed within the thematic Program “Energy, Environment and Sustainable Development” and those included in the database of the Construction and City Related Sustainability Indicators project (CRISP), both developed within the Fifth Framework Program. From November 2009 until February 2010 there was a thorough review of the corresponding websites.

Tools were analyzed and classified according to the following criteria:

1) The application scale: building, blocks, neighbourhoods, city, region, country
2) The application stage: ex-ante design and ex-post assessment
3) The type of tool: guidelines/methodological recommendations, check-list, indicators system, models, GIS
4) The natures of issues considered: here we distinguished between physical aspects linked to urban metabolism (air, land, water, energy and climate, noise levels, transport, waste, natural spaces and green areas, building systems and materials), from those related to social issues (community, sense of place, identity, governance) and those economic topics (job opportunities, local production, economic development).

1), 2) and 3) topics are summarized in table 1. The fourth criteria is represented in a “rose of sustainability” illustrated in figure 1. Together enable us to visualize the orientation and the relative weighting of each one.
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RESEARCH SOURCES

Measuring urban sustainability in the European context

As early as 1991, the European Commission set up an expert group on urban environment, and has since then been advocated to incorporate environmental goals in urban policies. Therefore projects promoted and funded by the European Commission seemed like a very natural start point in our search for sources of sustainability assessment tools. Early undertakings and initiatives such as guides on reallocating road space in cities and on cycling promotion, the Handbook on Green Public Procurement, Car Free Day, Urban Green Days, and the Mobility Week placed little emphasis on measurement so they were not considered in this review.

There were 131 research projects on Urban Management, Cultural Heritage, Sustainable Built Environment and Urban Transport undertaken following key action 4 "City of Tomorrow and Cultural Heritage" of the Environment and Sustainable Development program included in the Fifth Framework Programme (1999-2002). Not all of these research projects included sustainability assessment tools. Those that did include such tools comprise the first block of tools examined in our review. Projects focused on building knowledge networks or disseminating best practices, developing and testing very specific technologies -e.g. drainage, waste management, cybercars, hydrogen buses, etc.- lacking impact measurement tools were excluded from this review. Also discarded were those projects developing decision support tools absent of specific assessment features, despite the fact that they were extremely interesting in terms of their proposed approaches and procedures1.

The CRISP project, an European Thematic Network on Construction and City Related Sustainability Indicators, was funded by the Fifth Framework Programme. Given that it was highly relevant for our research, this project was considered as a source in its own right. We therefore refer to it as the second source of our review of sustainability assessment tools.

PETUS (Practical Evaluation Tools for Urban Sustainability) is a project led by the University of Cardiff which has compiled a comprehensive list of assessment tools used in Europe. This list was our third source of tools to review.

ASSESSMENT TOOLS REVIEW

Lost threads

PETUS Project information is split into four sections. The section concerning “Building and land use” included 57 tools to assess sustainability. Too often the webpages are not available any longer and it is not possible to find relevant information about the Project. That was the case for 51% of the tools, therefore only the remaining 49% have been analyzed. Through the links provided by the PETUS website we accessed to 20 of the tools, for another 8 tools the links were broken but it was possible to find enough material through specific searches. Some of the tools were either too high level, comparing countries through statistics at national level, or documents on multicriteria approaches for decision making process without any specific application; or too simple ones (matrix to select a location depending on water availability). Tools were also discarded whenever the information available was insufficient to clarify its content and application.

1 In the Sixth Framework Programme (2002-2006) priority was given to transport, efficiency and reduction of GHG emissions. STATUS, SENSOR, TISSUE and RAISE were analyzed.
There were also problems with some of the tools available. 4 of them are not accessible for the general public, as they are internal tools from institutions or private consultancies, 2 of them implied a language problem as were only in Bulgarian; other 2 were normative (French Code of Urbanism, and EIA from the EU) and did not fit well with the approach of the research. There are still other 3 that provide an email address to request further information, but our request had no answer. At the end only 17 out of the 57 tools were considered for deepen analysis.

For about the tools coming from the Key Action 4 City of Tomorrow & Cultural Heritage, developed within the Fifth Framework Program, we checked 77 projects (only those under the topic Integrating Cultural Assets into the Urban Setting from the Cultural Assets mainstream were analyzed). At this point it is remarkable the high rate of research projects “vanished” although they were developed under public funding from European research programs. Once could expect them to be more transparent and permanent, having a projection and application in the future; unfortunately 33 out of the 77 research’s webpages are not working any longer. It seems that, once the project is over –and the budget – the research stops. Therefore the resources and the knowledge built are lost, can not be reused and it is not possible to evaluate their relevance.

**Design and evaluation**

Tools identified have been classified according to three basic criteria: application stage, application scale and type of tool.

Regarding application stage, we distinguished between tools applied at design and planning stages, and those tools used to evaluate existing realities searching for ways to improve their sustainability. The former we refer to as ex-ante tools, the latter we term ex-post tools. Scales distinguished were territorial (e.g. countries), city, neighbourhood and building. Type of tools classification included groupings such as concepts, models, indicators, benchmarks, checklists, guides and GIS. Our classification is illustrated in Table 1 below.
### Table 1. Classification of assessment Tools from PETUS database

<table>
<thead>
<tr>
<th>Tools for Design Stages</th>
<th>APPLICATION SCALE</th>
<th>Region/nation</th>
<th>City</th>
<th>Neighbourhood</th>
<th>Building</th>
</tr>
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<tbody>
<tr>
<td><strong>Name</strong></td>
<td><strong>ECOBOXX</strong></td>
<td><strong>EUROGISE</strong></td>
<td><strong>BRE Checklist</strong></td>
<td><strong>ECOBOXX</strong></td>
<td></td>
</tr>
<tr>
<td>Applied at</td>
<td>Finnish strategy resp. consumption-production</td>
<td>New developments</td>
<td>Existing Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sort of tool</td>
<td>Model</td>
<td>GIS, Indicators, monitoring Local/Regional Agencies</td>
<td>Checklist + Benchmarks</td>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Developed by</td>
<td>Research Centre</td>
<td>Public agency + Consultancy</td>
<td>Research centre</td>
<td></td>
<td></td>
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<tr>
<th><strong>Name</strong></th>
<th><strong>SLA</strong></th>
<th><strong>COUNTRYSIDE</strong></th>
<th><strong>HQE Process [9]</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied at</td>
<td>Development plans</td>
<td>urban-rural interface</td>
<td>New or refurbish.</td>
</tr>
<tr>
<td>Sort of tool</td>
<td>Governance approach Concepts</td>
<td>Guide</td>
<td>Criteria, Indicators, Evaluation methods</td>
</tr>
<tr>
<td>Developed by</td>
<td>National Agency</td>
<td>University</td>
<td>Assoc. enterprises</td>
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<tr>
<th>Tools for Assessment Stages</th>
<th>APPLICATION SCALE</th>
<th>Region/nation</th>
<th>City</th>
<th>Neighbourhood</th>
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<tr>
<td><strong>Name</strong></td>
<td><strong>CSED Framework</strong></td>
<td><strong>Ä–KOSTADT 2000</strong></td>
<td><strong>EMCP</strong></td>
<td><strong>MOLAND-EUROPEAN COMMON INDICATORS</strong></td>
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</tr>
<tr>
<td>Sort of tool</td>
<td>Indicators</td>
<td>Indicators, goals</td>
<td>Indicators + benchmark Educ. inst. + Assoc Enterprises</td>
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<td></td>
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<tr>
<td>Developed by</td>
<td>UN Agency</td>
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<tr>
<th><strong>Name</strong></th>
<th><strong>HUD Framework [10]</strong></th>
<th><strong>Spatial territorial indicators</strong></th>
<th><strong>ISTAT Environmental Indicators Set</strong></th>
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<tr>
<td>Applied at</td>
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<td>Policies Indicators GIS</td>
<td>Urban environment Indicators National agency</td>
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<td>US Agency</td>
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<tr>
<td>Developed by</td>
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<th><strong>Name</strong></th>
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<tr>
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<tr>
<td>Sort of tool</td>
<td>Development by</td>
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<tr>
<th></th>
<th>Info not available</th>
<th>Guia</th>
<th>Check-list</th>
<th>Indicators</th>
<th>Model</th>
</tr>
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PONENCIAS

As can be observed in Table 1, tools to be applied at the design stage usually comprise guidelines and check-list, and they are mostly applied in small spatial scales (building mainly). It is remarkable that indicators –and therefore measurements and benchmarks- are not explicit in the design process. On the contrary almost all the tools to be applied to evaluate or monitor the projects include a set of indicators, and in once case, also a model. Some of the tools are designed to assess policies or urban conditions at larger scales (national, regional, urban-metropolitan areas). There is indeed a deficit of tools to evaluate urban sustainability at neighbourhood scale.

It is also remarkable that those projects that provide guidelines, check-list and indicators are generally available. Unfortunately when dealing with models or more complex tools, usually only derived secondary sources are available, in the form of reports or papers. Therefore one can only have indirect knowledge about the tool.

Key issues

By analyzing the way in which the three dimensions of sustainability are dealt with in the different tools it becomes clear that they are not equally considered (see figure 1). The circle is divided into 13 sectors. The area coloured in each one indicates the proportion of tools that include indicators on the topic. Physical conditions –linked to environmental dimension-, is by and large receiving most attention. The issues related to urban metabolism (air, land, water, energy and climate, noise levels, transport, waste, natural spaces and green areas, building systems and materials) are profusely measured or considered, unlike the social topics (community, sense of place, identity, governance) and the economic ones (job opportunities, local production, economic development). It is certainly easier to measure the impact that urban design has on the physical conditions such as energy or water flows, materials and waste. Social and economic aspects are more complex to measure, real durable and positive impacts are to be consolidated on the long term and they are under the influence of many other external factors beyond the urbanism scope.

Figure 1. Urban metabolism, society and economy in the sustainability evaluation tools

The chart on the right side presents the tools compiled by the CRISP project, specifically meant to assess urban interventions at the neighbourhood scale. Issues related to the physical conditions have still a considerable weight. The CRISP project described each tool following a classification which differs from
PONENCIAS

ours. Some issues like air or noise are classified as “social indicators” because of their impact on the quality of life and human health. Although acknowledging these connections, we prefer to stick to the concept of society for those indicators that consider social interactions. Noise and quality of air remain within the physical conditions section. In fact most indicators about the physical conditions are related also with quality of life.

Three differences between both charts are especially worth noting. Materials are given less attention – probably because the issue is likely to be asóciate to the building scale not to the neighbourhood one__. The same happens to transport, which in this case might be linked to a larger scale: city or metropolitan area. All the tools include two issues: Land use changes and energy -climate change. It is probably the consequence of European Union and global agencies ranking them high into the research and political agenda. At the European Union there is a general concern about the unsustainability of land use changes’ trends; it is a recurring theme in many UE programs, Corine Land Cover being a noteworthy example. The second omnipresent issue is energy and climate. Again it is evidence that energy dependence and climate change are key topics in European agenda.

Although not represented in the charts, we note that some of the tools to be applied at neighbourhood regeneration processes include costs considerations –reducing consumption will lead to reducing costs-

CONCLUDING REMARKS

Assessment tools based on scenarios

There is a lack of accessible and practical tools to compare scenarios at the neighbourhood scale, taking into account sustainability criteria in the decision making process. GREENSCOM Project suggests that, considering that urbanism deals with social issues that are extraordinary complex and dependant on specific local context, research programs should focus on dissemination of good practices and meetings to exchange knowledge. They conclude that trying to develop tools to be applied in different context is not realistic [12]. We, on the contrary, defend the possibility of measuring, anticipating and evaluating also quantitatively urban design proposals. In this sense, assessment tools based on scenarios would help the designer to find less probable but possible and indeed desirable futures and make explicit the different possibilities [8]. Thanks to them, the impact of the proposal may be better communicated and discussed with the different stakeholders, and afterwards reoriented and adapted according to quantitative factors. It can be argued that there are key elements that can not be quantified, for example if it is stated that “cultural activities act as incubators for economic development”, how can it be evaluated upfront? Well, if not measured, at least they should be connected to complementary indicators.

Dealing with neighbourhood regeneration’s constraints

There is a lot of research done, with cases studies, best practices’ compilations, development of methodologies and specific technologies on which the tools to be developed can be built on. However this research has proven that there is a lack of accessible and practical tools to compare scenarios taking into account sustainability criteria in the decision making process at the neighbourhood scale. We propose two basic criteria to be considered when assessing sustainability: Impact on Human health (physical and psychological) and on Biodiversity (local, global) [7]. The urban design or actions to be assessed may involve changes on the physical environment, on the regulatory frame and/or on the cognitive environment. The tool is planned to be applied to assess sustainability on existing neighbourhoods, where the possibilities to shift conditions and performance is limited. The changes affecting non-material aspects, like shifting spatial regulation or distribution of uses are easier to be applied than those transforming massive structures. Tools intending to evaluate impacts beyond
physical condition have to face an added difficulty derived from dealing with the neighbourhood as a complex social system.

Additionally we should not forget that any design or urban policy proposal has to deal with different constraints, such as cost effectiveness, financial and technical feasibility, social acceptance and legal limitations. Governments at different scales should incorporate convenient prescriptions and regulations, should set and control limits and should also forbid specific substances and practices. But that would not be enough for the necessary transition into a sustainable development in which quality of life and social wellbeing of society together with biodiversity preservation are sought. It is also essential to construct creative processes at local scale that reinforce natural and social ecosystems [13].

Building on previous findings

There are already good tools to assess green areas, both ex ante and ex-post (BUGS, GREENSPACE, RUROS or partially URGE), building renewal (SHE o SUREURO) brownfield development and land use changes (RESCUE o SELMA) and traffic management (PROPOLIS). Tools to be developed could be connected to their methods and indicators in order to evaluate achievements in sustainability and low emissions neighbourhoods. To make further progress in such developments, it would be highly recommendable that at least all the related research projects public funded within European Framework made their results permanently available. Having a repository on their works would facilitate the exchange of knowledge. It would also be very useful to have public and direct access to the tools developed, instead of disseminating only reports about them. It would also be helpful if those tools were developed using compatible programs of universal accessibility, so that it enables further open source developments.

Future implementation

One of the practical limitations of assessment tools to be applied at neighbourhood scale arises from the scarce data available. Quite often the problem of working at smaller scales is that data and statistics are produced for larger units and there are no disaggregated data. Nevertheless connections can be found and measured, both upwards between the neighbourhood an the city, and downwards between the neighbourhood and the buildings –as illustrated by the IANUS Project points out-. It is recommended to evaluate the impacts of urban design at neighbourhoods in the other scales.

One final remark is necessary. When developing the assessment tool, we must bear in mind that it has to be practical and useful. That implies avoiding large amounts of time to collect data and translate them into the model. Large cities and urban networks do have their specific departments on urban sustainability. But the task of shifting our urban-social environments is not limited to the bigger metropolitan areas. Medium and small cities as well as villages do also have a responsibility in this process, and they can not afford large budgets and professional teams. They are our target public for a practical, useful and open source (adaptable) tool to assess urban sustainability of urban interventions at neighbourhood scale.


PONENCIAS


Other references. Tools acronyms

<table>
<thead>
<tr>
<th>TOOLS FROM THE PETUS DATABASE</th>
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<tbody>
<tr>
<td>BRE</td>
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<tr>
<td><a href="http://southeast.sustainabilitychecklist.co.uk/checklist">http://southeast.sustainabilitychecklist.co.uk/checklist</a></td>
</tr>
<tr>
<td>CSD FRAMEWORK</td>
</tr>
<tr>
<td>MCP</td>
</tr>
<tr>
<td>European Common Indicators: <a href="http://ec.europa.eu/environment/urban/common_indicators.htm">http://ec.europa.eu/environment/urban/common_indicators.htm</a></td>
</tr>
<tr>
<td>HQE PROCESS</td>
</tr>
<tr>
<td>HUD Housing and Urban Development</td>
</tr>
<tr>
<td>ISTAT Environmental Indicators Set. Istituto nazionale di statistica Italia.</td>
</tr>
<tr>
<td>MEMPD</td>
</tr>
<tr>
<td>PASTILLE Promoting Action for Sustainability at the Local Level in Europe</td>
</tr>
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<td>SLA Sustainable Livelihoods Approach</td>
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<tr>
<th>TOOLS FROM THE 5FP</th>
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<tbody>
<tr>
<td>IANUS Indicators system to Assess New Urban Services</td>
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</table>
### PONENCIAS

| PEGASUS Planning, Environment, Governance and Sustainability PLUS Participation, leadership and urban sustainability  |
| SELMA Spatial Deconcentration of Economic Land Use and Quality of Life in European Metropolitan Areas http://selma.rtdproject.net/  |
| SHE Sustainable Housing in Europe http://www.she.coop/  |
| SURE Time oriented model for sustainable urban regeneration  |
| SUREURO Sustainable Refurbishment Europe http://www.sureuro.com/  |

### TOOLS FROM THE FP6

| STATUS, Sustainability Tools and Targets for the Urban Thematic Strategy http://status-tool.iclei.org/content.php/frontpage/?p=1  |
| TISSUE, Trends and indicators for monitoring the EU thematic strategy on sustainable development of urban environment http://cic.vtt.fi/projects/tissue/index2.html  |
The ecodesign and planning of sustainable neighbourhoods: the Vallbona case study (Barcelona)

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INTRODUCTION

Urban areas and environments are expanding worldwide as statistics for urban population share reach figures of 70% in Europe, America and Oceania and even 50% on a global level [1]. This ever-increasing urban population is likely to become even larger still [2-4]. This unprecedented growth in urbanisation, will lead to important but as of yet poorly understood impacts on the Earth’s environment [5]. Despite representing only 2.7% of the world’s surface area [6], the world’s cities are responsible for 75% of the world’s energy consumption and 80% of greenhouse gas emissions [7]. Therefore, global sustainability is increasingly an issue of urban sustainability, being essential to encourage more benign trajectories of urbanisation [8].

The model for sustainable planning places the concern for environmental issues on an equal footing with its traditional economic and social objectives [9]. Therefore, the goal of sustainability in urban areas could be defined as a reduction in their use of natural resources and waste production, while simultaneously improving livability in order to better fit within the capacities of local, regional and global ecosystems [10] in a framework of social equity and welfare [11].

The design of sustainable urban areas is not a simple task since there is no agreement on what a sustainable settlement should be [12] and which is the path for achieving it [13]. Since a universal model for a sustainable city cannot be found, nor implemented [14] and it is naïveté to assume that what may work in one context and culture will work in another, it is clear that each location has to define its own design process which
should take into account the local context—that is to say, site-specific characteristics (territory, financial context, technological aspects, society, policy and legal framework) and given conditions (such as existing buildings, infrastructure, vegetation and landscape [15]). Therefore, the complexity of designing sustainable neighbourhoods becomes evident, as well as the singularity of each process and project. In this context, the methodology of ecodesign of products, applied to the neighbourhood level, appears to be useful. The benefits of ecodesign are many: reducing environmental impact, reducing costs, innovating, satisfying legal environmental requirements, increasing the quality of the product and improving the image of the neighbourhood and the whole municipality [16].

The aim of this paper is to describe the methodology of urban ecodesign based on a real case study from the neighbourhood of Vallbona in the city of Barcelona.

CASE STUDY NEIGHBOURHOOD

The city of Barcelona is located on the north-eastern coast of Spain with a population of approximately 1.6 million inhabitants and an area of 100 km². It has a Mediterranean climate with average rainfall of 600 mm and an average annual temperature of 15.5°C. The city has rapidly evolved over the past decades during which it has gained worldwide recognition [17]. Currently, environmental criteria are becoming more and more important in the planning process of cities, including issues of water consumption, waste, greenhouse gas emissions, and efficient use of energy [18]. Actually, the city council of Barcelona unanimously approved, in October 2008, to establish sustainability as the driving force for the planning of the last section of its territory to be urbanised. This new neighbourhood will be situated in an area called Vallbona located in the northern part of the city (Figure 1), which occupies a developable area of 32.6 Ha. It was zoned as mobility systems (52.3% railway, 12.5% roads), facilities (local 12.5%, metropolitan 14.4%), free spaces (parks and gardens 4.9%) and other (general systems protection 3.4%). However, the current use of this area is mostly degraded or neglected areas, infrastructures and agricultural land.
surrounded by natural and artificial barriers: the Besós River and several roads, highways and several railways.

**ECODESIGN METHODOLOGY**

Ecodesign means that environmental aspects have been taken into account for decision-making along the neighbourhood design process, as an additional factor to the ones which have traditionally been considered (financial, social, political... aspects). The goal of ecodesign is to reduce the environmental impact of the neighbourhood along its whole life cycle. The life cycle of a city is here understood as all the stages for which it evolves, which includes (a) the planning stage, (b) the architectural design and construction stage, (c) the neighbourhood management stage and eventually (d) urban transformation (rebuilding the city) and revision of planning schemes (figure 2).

![Figure 2. Life cycle of an urban settlement](image)

The life cycle approach at the design and planning level implies the recognition that each decision made in the early stages of planning has consequences (social, economic and environmental) on the following urban stages. Often these are not obvious or immediate and they are only observed when examining the complete life cycle of the neighbourhood. Through a life cycle approach, decisions can be made in a more deliberate and systematic way. Furthermore, it can lead to a decrease in financial spending at the mid-term and, at the same time, less environmental pressure in terms of reduced depletion of resources.

Environmental aspects have been incorporated since the conceptualization of the neighbourhood and considering the intrinsic determining factors of the area. These aspects have been developed for the first three stages (a, b, c). However, it has to be stated that the set of strategic actions beyond the planning stage is just a list of recommendations, since we were working on a planning proposal and not on concrete construction projects. Despite this, the aim is to set a basis for the professionals who are going to undergo the architectonical design and construction and also the people responsible for the management of the neighbourhood. Once the planning stage is complete, the next stages - (b) and (c) - of the neighbourhood life cycle will take place, all of them circumscribed to the orientations and requirements stated earlier in the planning (a).

![Figure 3](image) shows a diagram of the methodology followed throughout the design and planning process of Vallbona. Vallbona was originally designed as a conventional
neighbourhood in early 2008. This was the case until a specific political request came from the town council to build a sustainable neighbourhood in October 2008. From that moment, a methodology similar to that which could be applied to the ecodesign of products, was applied on a broader neighbourhood scale.

**Figure 3.** Diagram of the planning and ecodesign methodology applied at the neighbourhood scale in Vallbona (Barcelona, Spain). The dotted boxes will not be carried out until the operation of the neighbourhood.

**Creation of an interdisciplinary team**

An interdisciplinary design team is of great value [15] and it is essential in urban planning [19]. The design team should have sufficient understanding of sustainable design practices, constraints, existing conditions and specifications [15]. Practical experiences, together with the rapid evolution of the sustainability science, provide planners with a knowledge body at their disposal. From these experiences, data and criteria may be obtained for the design of future neighbourhoods. The close collaboration between scholars and practitioners coproduces the necessary knowledge to harness science and technology for sustainability [20]. In Vallbona, the team was lead by Barcelona Regional (the agency for the development of urbanism and infrastructures in the Metropolitan Area of Barcelona; an entity with wide experience and proud of having a highly interdisciplinary team). Furthermore, a team...
of researchers from the Institute of Environmental Science and Technology at the UAB also participated in the work group. Their main goal was to reinforce the environmental approach of the planning and design, both in terms of methodology and concepts. All in all, a total of 23 professionals were directly involved in the definition, discussion and redaction of the proposal; and many other professionals were consulted and/or interviewed. The team exploited the synergies that were created among its members and their previous experiences in other town-planning projects [21-26] and in the field of environmental analysis [11, 27-35].

**Concepts and framework**

Once such an interdisciplinary team had been formed, several sessions were planned to debate and decide how the neighbourhood should be and which the best strategies to achieve it were. A session was dedicated to general concepts about urban sustainability and sustainable neighbourhoods in order to set a framework for debate and decision-making for Vallbona. Here, the definition of ‘sustainable neighbourhood’ was defined and agreed upon, in order to move from a political wish to a specific result.

We defined a sustainable neighbourhood as an urban settlement that is adapted to the local environmental characteristics and makes an efficient use of resources (first and foremost local), minimises its emissions, and shows an increase in quality of life and respect towards the natural environment, so it can better fit within the capacities of the local, regional and global ecosystems.

Together with this definition, the team debated and agreed upon several key concepts whose fulfilment was, in our opinion, necessary for the achievement of the sustainable neighbourhood:

- Circular metabolic flows and trend towards self-sufficiency (trying to close the flows of materials, water, energy, food..., developing synergies within the neighbourhood and with the surrounding areas, environmental prevention...)
- Neighbourhood for people (streets for pedestrians, healthy environment, environmental education, participative processes...)
- Mixticity of land uses (agriculture as an urban land use, vertical integration of land uses, multifunctionality of spaces...)
- Biodiversity (protection of characteristic local elements, creation of new biotopes related to water management and/or to buildings...)

**Analysis of the territory and of reference elements. Definition of critical points and opportunities**

The task was to undergo an environmental, social and financial analysis and diagnosis of the territory where the neighbourhood was going to be located and also the analysis of some reference elements (other neighbourhoods in the metropolitan area and in other regions) in order to detect their critical points but also their strengths and opportunities.
Goals

Next, several thematic sessions were carried out in order to set goals for each of the following topics: energy, water, wastes, green and agricultural areas, mobility and transportation, public space and social environment. For each one, the set of goals was proposed having as an indication the analysis and diagnosis for the reference elements.

Strategic actions

Later, a total of 68 strategic actions were defined for each topic, taking into account the different stages that shape the neighbourhood through the life cycle of a city, which try to achieve the goals. However, it was strongly believed that it was necessary to focus most of our attention on certain specific actions which could have the highest positive impact on the neighbourhood. Therefore, from the set of actions, all of them important, there were 5 which were highlighted as particularly important in order to assure the development of the neighbourhood under sustainability criteria. These actions were:

- To minimize the energy demand of buildings. There is large room for this at the planning level through the layout of buildings and blocks in order to take advantage of solar passive architecture and natural ventilation systems. It is also possible to set a minimum requirement for energy efficiency in buildings.

- To use local renewable energy sources and a district heating network. The intense solar radiation enables us to efficiently introduce thermal and photovoltaic solar systems. Furthermore, a district heating network may take advantage of thermal solar energy and cover most heating, ventilation and air conditioning needs.

- To maintain as much as possible the agricultural mosaic of the area. The area under planning hosts one of the last pieces of agricultural land in the city, which has a great landscape value and represents a distinctive element of it.

- To diversify the water sources, adapting the quality of water to its uses. There are several potential water sources in the area (rainwater, groundwater, surface water, pipe water, grey and black waters ...) which have to be efficiently managed and assigned to the most adequate use.

- Local resources manager. This last action, which is thought to be put in practice along the management stage of the neighbourhood, is a relatively new concept. City management has become a complex undertaking because social-cultural, economic, environmental and institutional processes have become increasingly intertwined in cities [36]. Therefore, there is a need for a resources manager who could proficiently handle local resources and manage the neighbourhoods’ environmental facilities. This need has already been detected in the industrial sector as a key concept for its sustainable development [37], but it is rarely observed in neighbourhoods or cities. The resources manager could deal with local resources such as solar energy installations, public vegetable gardens, own water distribution systems (grey water, stormwater runoff ...), organic wastes and composting ... and could take care of environmental facilities such as common parking areas. This actor is
essential for sustainable development since the holistic system approach to resource management is a must for the efficient use of resources.

**Indicators**

Several indicators have been defined along the design process, in parallel to the definition of goals and strategic actions. A set of environmental indicators is necessary to visualise the path of the neighbourhood in order to determine its position compared to the strategy formulated and thereby enabling the diagnosis of the current status, but also the prognosis of the future situation [38]. The final selection of 15 indicators tries to meet the following criteria: quantifiability, representativeness, low cost, homogeneous measure over time and clarity in the interpretation. Each indicator is described considering its definition, how its variables are defined, which is the desirable trend, calculation equation, data source and other complementary comments. The indicators are defined for the management stage, since most environmental and financial costs are related to the operation of the neighbourhood (often over 90% of life cycle costs for typical infrastructures in cities are spent during operational maintenance and rehabilitation [39]).

**Table 1** summarizes the goals, strategic actions and indicators for the case study neighbourhood. The list of strategic actions has been simplified for reasons of space. After the table, two of the indicators will be described in more detail as an example.
**Table 1. Summary of goals, strategic actions and indicators for the Vallbona neighbourhood**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>GOALS</th>
<th>STRATEGIC ACTIONS</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENERGY</strong></td>
<td>• To minimize energy demand per inhabitant in buildings</td>
<td>• Passive saving measures: Orientation optimization (minimum 4 hours direct insolation/day in winter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To use local renewable energies</td>
<td>• Natural ventilation</td>
<td>• Primary energy consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• District heating</td>
<td>• Renewables production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Efficient architecture</td>
<td>• Equivalent CO₂ emissions</td>
</tr>
<tr>
<td><strong>WATER</strong></td>
<td>• To diversify water sources, adequate water quality to its uses and use local water sources</td>
<td>• Separative sewer</td>
<td>• Total pipe water consumption/inhabitant</td>
</tr>
<tr>
<td></td>
<td>• To reduce consumption</td>
<td>• Rainwater harvesting from roofs and non-trafficked areas</td>
<td>• Water self-sufficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Irrigation with local river sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Groundwater use</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Greywater reuse</td>
<td></td>
</tr>
<tr>
<td><strong>WASTES</strong></td>
<td>• To maximize selective waste collection</td>
<td>• To compost organic waste within the neighbourhood</td>
<td>• Urban solid wastes production</td>
</tr>
<tr>
<td></td>
<td>• To cover the manure demand of agricultural areas with local compost</td>
<td>• Waste collection at street level (not pneumatic)</td>
<td>• Selective collection of wastes</td>
</tr>
<tr>
<td><strong>GREEN &amp; AGRICULTURAL SPACES</strong></td>
<td>• To preserve and foster local biodiversity</td>
<td>• Preservation of an irrigated agricultural plot of 2,3 Ha</td>
<td>• Local food production</td>
</tr>
<tr>
<td></td>
<td>• To maintain the agricultural mosaic as a distinctive landscape element</td>
<td>• To make compatible professional agriculture and social vegetable gardens</td>
<td>• Bird biodiversity in green areas</td>
</tr>
<tr>
<td></td>
<td>• To foster the local river as a structural element</td>
<td>• Xerogardening</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To design new green areas with environmentally-friendly criteria</td>
<td>• Promoting green areas with sustainable criteria and aimed at preserving local biodiversity within the urban fabric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Participative management of non-professional vegetable gardens</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MOBILITY</strong></td>
<td>• To improve the connectivity with the surrounding areas</td>
<td>• New connections with the surrounding areas</td>
<td>• Transportation modal split</td>
</tr>
<tr>
<td></td>
<td>• To rationalize the mobility flows</td>
<td>• To keep 75% of the road network for pedestrians</td>
<td>• Car sharing clients</td>
</tr>
<tr>
<td></td>
<td>• To recover the public space for people</td>
<td>• To foster bicycle use</td>
<td>• Average time for several trips</td>
</tr>
<tr>
<td></td>
<td>• To reduce private mobility</td>
<td>• To minimize public space devoted to parking</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improvement of the bus network</td>
<td></td>
</tr>
<tr>
<td><strong>PUBLIC SPACE AND SOCIAL ENVIRONMENT</strong></td>
<td>• To minimize acoustic pollution</td>
<td>• Installation of noise-reduction elements</td>
<td>• Proximity to basic urban services</td>
</tr>
<tr>
<td></td>
<td>• To assure the permeability of public spaces</td>
<td>• To facilitate access to public transportation systems and to services through new accesses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To design public space in order to foster social relationships</td>
<td>• New equipments so as to serve people’s needs and to integrate the neighbourhood in the whole city</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Ecodesigned urban furniture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Social participation</td>
</tr>
</tbody>
</table>
Indicator: Water Self-Sufficiency

It is desirable for any urban system not to depend too much on external water resources. This indicator measures the capacity of the neighbourhood to self-provide the water consumption it demands. It is calculated as the ratio between the local endogenous water resources consumption (groundwater and rainwater) to the total water consumption (including pipe water). The desired trend is to move towards 1, which would mean not depending on reticulated mains water.

Indicator: Local Food production

Urban agriculture is emerging as a strategy for urban sustainability [40] since presents many benefits: it creates occupation, reduces transportation demands and costs, enhances the links of people with nature, improves the quality of urban environments... This indicator evaluates the local food production of in the agricultural areas, expressed in tones/year. As sub-indicators, it is also expressed in production per unit of area of agricultural land and per inhabitant.

Neighbourhood analysis and assessment of improvements

The next step of the ecodesign methodology would consist of an analysis of the final product, that is to say, the neighbourhood. The aim of this procedure is to obtain an environmental diagnosis of the neighbourhood. There are several methodologies and tools in order to achieve it, being one of them the monitoring and control of the set of indicators. Then, the assessment of improvements would consist of a comparative analysis of the neighbourhood with the reference elements previously studied. However, this analysis will have to wait until the neighbourhood becomes a reality and is in operation. For this reason, the last step of the ecodesign methodology was devoted to reviewing the process and revising the initial definition.

After the ecodesign

From the ecodesign process, a sustainable neighbourhood planning proposal was defined. Then, it was evaluated by the city council. This procedure resulted in feedback and, where necessary, the proposal was adapted. After this, a public hearing and debate process took place. Eventually, the city council passed an initial approval of the planning proposal in March 2009. After this initial approval, and once the indications from the implicated agents, objections and preceptive reports are considered, the definitive approval will take place (supposedly, at earliest, in early 2011).

DISCUSSION AND CONCLUSIONS

The ecodesign methodology has been applied to the design of a neighbourhood. This process differs from a conventional one mostly due to the incorporation of environmental criteria along the whole life cycle of the neighbourhood and the presence of such a highly interdisciplinary team. Among these aspects, the former is of particular relevance since the incorporation of the life cycle approach in the early design of a neighbourhood (from planning to architectural design and construction, to later management and followed by urban transformation) encourages urban environmental prevention and guarantees the achievement of urban sustainability goals.
It must be kept in mind that the planning of a sustainable neighbourhood does not necessarily mean that the eventual neighbourhood will actually be sustainable. For this, it is necessary to establish monitoring and control mechanisms to make sure that the plan is correctly implemented and results in a sustainable neighbourhood. However, a good planning proposal is the basis for the achievement of the sustainability goals and, consequently, the environmental performance of the neighbourhood is expected to achieve high standards.

Furthermore, the planning process generally takes place in a complex institutional frame with a large number of public and private actors (technicians, politicians, builders, real estate agents, citizens, property owners, NGOs), each of them with their own interests and responsibilities. Therefore, the ecodesigned proposal may find obstacles to its approval. Besides this, the local context and given conditions are determinant for the successful achievement of the proposed goals. For example, the development of Vallbona was highly conditioned by its previous classification as a Strategic Residential Area (SRA) under the auspices of the Catalan government in order to solve regional housing shortages [41]. This constitutes an important determining factor since it made certain compulsory specifications, such as the extent to which land use is mixed, heavily influenced by the need to provide housing. Therefore, Vallbona was not originally intended to be a sustainable neighbourhood but just a residential one, although since the declaration by the city council it has tried to follow urban sustainability principles.

From this, it becomes clear that the design of neighbourhoods in different locations will lead to different results, without the existence of a unique path to achieving urban sustainability or a uniform solution. In spite of this, the presented ecodesign methodology tries to bring light into this issue by providing planners with a structured way of designing urban settlement so as to move towards sustainable urban environments.

ACKNOWLEDGMENTS

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Strategy for zero CO$_2$ balance in an existing Mediterranean tourist development

Ramon Rodriguez

ABSTRACT

Climate change is a fact which is now said to be “unequivocal” by the IPCC and clearly evidenced in the records of recent decades which show the rising average temperatures of the air and the seas, the general melting of polar snow and ice, and the rise of average worldwide sea levels.

This warming is already causing impacts on numerous natural systems which are being affected by regional climate changes. Projections predict an average global warming of the earth’s surface of over 0.2 °C per decade, which will have an irreversible effect on ecosystems and, consequently, on the human societies supported by them.

Climate change is very closely linked to a development and growth model based on the use of fossil fuels and inefficient energy production and consumption patterns. We have a clear obligation to reduce emissions towards a scenario which will mitigate the rise of the average temperature of our planet’s surface and the impact of that rise. To do this, the most developed societies and countries must bear the largest burden in terms of reducing emissions, and promote by example sustainable development models not based on fossil fuels.

The purpose of this presentation is to show one such development in which the Consortium set up for this purpose is carrying out an integrated regeneration project in Palma de Mallorca. Palma Beach is one of the most important tourist destinations on the Mediterranean but it is showing clear signs of decline. There is a need to create a new model of sustainable tourism which will show the way to other resorts and be a worldwide benchmark for urban regeneration and the integration of environmental, social and economic criteria.

This presentation will describe the strategy which has been established and the measures planned in order to reach the target of zero CO$_2$ emissions for 2050, and will provide a description of an energy model based 100% on renewable energies. The strategies include not only technological measures aimed at energy efficiency and the integration of renewable energies in buildings and the urban environment, but also other measures designed to change energy consumption patterns. In this latter respect, in addition to citizen awareness programmes, energy demand management models based on intelligent electrical networks will be implemented. The viable implementation of the strategies requires the establishment of energy business models and models for the corporate structures set up around the Palma Beach energy agency.

Spain continues to be a world tourism power and tourism is one of the most important economic sectors of the country, with one of the highest national GDP shares. However, the signs of decline and loss of competitiveness are increasingly more apparent; for example, 2009 saw tourism hit an all time low in GDP share terms at 10.3%. In this context, Mallorca plays a decisive role, and Palma Beach in particular as one of its largest developments is one of the most important tourist destinations on the Mediterranean. For many people Palma Beach is at the same time a model in decline and an opportunity for a global change in the tourism model.

The “Town Planning Consortium for the Improvement and Landscaping of Palma Beach” is responsible for bringing about this change. The Consortium has geared its work towards defining a new tourism model for the Palma Beach which will make it a world benchmark. It includes among its change drivers “sustainability, climate change, global change, social and residential cohesion, in short a new model for a new destination in line with the 21st century and with the people who will be visiting us over the next decades.”

The change planned for Palma Beach will be an integrated revitalization of the area at all levels, which will ensure the sustainability of the model and aspires to be an example for all Mediterranean tourist destinations. Part of the work performed by Arup for the revitalization of Palma Beach, concerning the management of natural resources

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and the reduction of the environmental impact, is to define the strategies for sustainable energy and climate change mitigation, mobility, water and waste cycles, which form part of the global sustainability strategy. This strategy also includes other aspects such as the change in the tourism model and its impact on social and economic spheres. This presentation only deals with the work performed by Arup as part of the reports of the Concept Master Plan for the sustainable energy and climate change mitigation strategy, work which will continue to be performed in later stages of the project.

**OBJECTIVE**

The objective of the energy and climate change mitigation strategy set out in the Concept Master Plan for Palma Beach is to reach zero CO₂ emissions by 2050, with a final energy balance target based 100% on renewable energies. The emissions which form part of this target are those associated with all the energy consumptions of buildings, infrastructure (public lighting and supply/treatment of water), and transport (of people, goods and waste) in Mallorca associated with Palma Beach.

**CONTEXT**

If the world continues to emit greenhouse gases like carbon dioxide (CO₂) at the present rate, average global temperatures could increase by 6 °C by the end of this century³.

To prevent the most dangerous impacts of climate change, the average global temperature increase must not exceed 2 °C⁴ which means that we must start to reduce emissions before 2020 and that the reduction must be at least to 50% below 1990 levels before the year 2050.

![Figure 1.- Temperature increase scenarios under different CO₂ concentration increase scenarios Source: IPCC climate change scenarios](image1)

![Figure 2. CO₂ emissions concentration scenarios and level that the IPCC has estimated as safe for limiting temperature increases.](image2)

The context of the Balearics is marked by a past which was totally dependent on the fossil fuels with the most significant impact on global warming, but a present of energy interconnection with the mainland and plans by the Balearic authorities to promote the growing penetration of renewable energies.

**SCOPES CONSIDERED**

In order to establish a methodology which, in later stages, will enable a detailed inventory of Palma Beach’s CO₂ emissions to be made, the study has been divided into three scopes, taking as a reference the methodology set out in the “Greenhouse Gas Protocol” (GHGP).

![Fig. 3 Scopes of [word missing] established for the offsetting of CO₂ emissions at Palma Beach.](image3)

The specified scopes cover the CO₂ emissions associated with the following fields:

Scope 1:

- Energy in buildings, both “regulated” (air-conditioning, sanitary hot water, heating, lighting,...) and “unregulated” (domestic electrical appliances, office equipment, kitchen equipment, swimming pool filtering,...).

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³ EUROPEAN COMMISSION “EU action against climate change - Leading global action to 2020 and beyond. 2008 edition” Page 5

⁴ Ibid
− Energy consumed by urban infrastructures: public lighting, water potabilization and treatment, and waste management.

Scope 2:
− Internal mobility (on the island itself, generated by Palma Beach) of passengers, and internal transport of goods and waste.

Scope 3:
− Travel off the island by sea and air.
− Energy associated with the extraction, production and transport of the materials used in the possible refurbishment work and new works.

The Concept Master Plan contains estimates of emissions for scopes 1, 2 and 3 based on simulations, energy audits, and statistics which enabled a baseline to be established and the targets and strategies to be defined.

The measures involving direct intervention that have been proposed refer solely to scopes 1 and 2, which are the ones which can be controlled most directly within the scope and competencies of the Consortium and are the ones to which the zero CO₂ emissions target refers. The emissions of scope 3 (mainly the emissions produced by the air transport of tourists) have been quantified and complementary offsetting measures have been proposed which will be explained later in this document. The report shows how the change in the tourism model proposed for Palma Beach (possible reduction in the number of hotel beds, change in the number of overnight stays, less seasonality, etc.) will generate considerable reductions of CO₂ emissions in scope 3 as well.

Fig. 4 Matrix showing scopes versus measures for offsetting CO₂ emissions in Palma Beach

The roadmap to get from the current scenario to the carbon neutral scenario in 2050 has been divided into 3 targets, scheduled to achieve zero CO₂ balance in scopes 1 and 2. Each of these targets is made up of a series of measures summed up in the chart below. Energy saving and efficiency is the primary measure in all the scopes which must be established as the baseline with most impact in the offsetting of emissions.

Target 1
50% reduction of CO₂ emissions
− Energy efficiency in buildings by means of passive measures (envelope) and installations.
− Integration of renewable energies in buildings.
− Energy efficiency in infrastructures: Improved efficiency of lighting elements, general reduction in water consumption and water supply at a lower energy cost.
− Efficiency in transport: Measures which encourage and facilitate cycle and pedestrian traffic, implementation of large capacity public transport and creation of mobility hubs for people and goods. Replacement of private vehicles by electric public transport. Replacement of the fleet of delivery and waste collection vehicles powered by internal combustion by electric powered vehicles (coordinated with renewable energy integration strategies in the grid).

Target 2
25% reduction of CO₂ emissions
− Integration of renewable energies in the area of the Playa of Palma (outside buildings).
− Change in tourism model (reduction of the number of overnight stays of tourists).
− Change of consumption patterns through the sensitization of the population and change of the economic model for marketing electricity (introduction of supplementary services - remuneration of the consumer for managing demand).

Target 3
25% reduction of CO₂ emissions
Renewable installations directly associated with Palma Beach outside the Palma Beach area (preferably within the Balearics electricity system).
The chart below shows a summary of estimated CO₂ emissions and how by applying these targets we can move towards a zero CO₂ balance.

Fig. 4 Emissions reduction for Palma Beach scopes 1 and 2.
The proposed “Palma Beach” system consists of a set of buildings, infrastructures and transport whose main characteristic is a high level of efficiency and the responsible use of natural resources. The energy proposal has been based on a model of energy efficiency in which the production of heat and cool is mostly by means of electrical technologies, the energy consumption of which is offset in terms of primary energy through the use of 100% renewable electrical generation.

Efficiency measures are not limited to the application of technology, but also enter the field of human behaviour and management. In addition to intelligent electrical networks, new business models will be introduced in which the parties involved work towards the achievement of the same goals, as well as awareness-raising and outreach campaigns and policies.

At the centre of the project is the Palma Beach Energy agency, which will be a focal point around which synergies will be created among the various participants in the project. It will control and supervise the meeting of short-, medium-, and long-term targets and coordinate the various efforts made by the different parties involved. ESCOs (energy services companies), which will be responsible for operating the energy systems and selling their services to consumers while participating in the necessary investment, will play an important role in this model.

The emissions associated with external transport and the energy associated with materials have been accounted for separately and additional offsetting programmes have been proposed. The emissions associated with air transport account for the lion’s share of total emissions. The charts below show their proportion under the current scenario and under the proposed scenario for 2050, which represents a strongly retractive tourism model with an overall reduction in the annual number of tourists and a reduction in the seasonality of the tourism.

The chart below shows how not only are the emissions associated with the zero CO2 target reduced (scopes 1 and 2), but also those associated with external transport – mainly air transport – and with materials (scopes 1, 2 and 3), achieving a total reduction of emissions of 62%.

Figure 7. Emissions reduction for scopes 1, 2 and 3 for the offsetting of CO2 emissions in Palma Beach

THE SCENARIOS STUDIED

The different scenarios resulting from the change in the tourism model and their impact on aspects such as number of hotel beds or improved quality were produced and coordinated by AUIA (Urban Planners and Associated Engineers).

Arup has considered the energy implications of these different scenarios of change in the tourism model and of measures such as a possible reduction in the number of hotel beds, the improved quality and standard, and seasonality. Firstly the current situation was analysed (Scenarios A and B), which is characterised by the inefficient use of resources, mass low-cost tourism, and seasonality. If the expansive supply-side growth trend is maintained under the same conditions, this will lead to a scenario which is referred to as “Scenario C” in the project studies.

A change in the model of Palma Beach may change the direction of this trend (Scenarios D and E), the basic target of this study being the possible reduction of hotel beds and the prolongation of occupancy beyond the summer months.

Based on the vision that the Consortium has of the future model, we have established the energy policies that will drive the process. A 62% reduction of total emissions (scopes 1, 2 and 3), including air transport, by developing strategies which will be implemented by means of a series of actions in the next 20 years.

The diagrams below show the breakdown of emissions per sector for scopes 1 and 2. The consumption of energy and emissions associated with scope 3 will be considered separately later in this document.

Figure 7. Distribution of emissions of the scopes 1 and 2

JUSTIFICATION OF THE ELECTRICAL PROPOSAL USING 100% RENEWABLE GENERATION

The proposed strategy is based on two main cornerstones:
- Efficiency and passive measures
- Renewable energy, mostly solar

With regard to the choice of the heat production systems in the buildings, in the long term we have opted for high efficiency electrical systems (for example, heat pumps) as opposed to gas-based cogeneration systems. In the final scenario final all electricity consumption associated with this equipment will be generated or offset by the renewable energy facilities associated with the project.

The proposed model (electricity with 100% renewable generation) is consistent with the overall long-term emissions reduction targets and offers some important advantages. The measures proposed are replicable in other parts of Spain (for example, they do not rely on a huge supply of biomass to generate energy, which is likely to be needed in the long term for uses which currently have no alternative energy source – such as the aviation sector). Also, the proposed electrical system can maximize the use of intelligent networks, which will be necessary for managing a system with a high penetration of renewable energies.

Today, the use of gas-based cogeneration for generating heat and electricity saves on CO₂ emissions uses in the Balearic electricity system. However, as the electricity mix “decarbonizes”, different energy options change their positioning in terms CO₂ emissions.

The report produced by Arup reflects the different versions and sources which currently exist in Spain for this electrical energy/CO₂ equivalence ratio and reveals the need for greater rigour in the establishment of an official ratio and a procedure for keeping it up to date. At present, the production of one unit of heat by cogeneration in the East Balearic system has fewer associated emissions than heat pumps, while heat pumps, in turn, emit less than systems using electrical resistance. However, when the factor of emissions goes down by some 400 grCO₂/kWh, heat pumps emit less CO₂ than cogeneration. If the factor goes down by a further 240 grCO₂/kWh, the production of heat using electrical resistance (currently the ‘dirtiest’) option, will emit less CO₂ than gas-based cogeneration. Therefore, an energy strategy based on natural gas cogeneration would make it difficult to reach the zero CO₂ emissions target and, in the long term, when the electricity grid has been “decarbonized”, would be a burden rather than a help. This is demonstrated in the graphs below.

Figure 8. Possible projection of the factor of emissions associated with mainland electricity production

Figure 9. Emissions associated with cogeneration vs. heat pumps under different electricity mix emissions scenarios.

IMPLEMENTATION OF RENEWABLE ENERGIES

Although the detailed implementation of renewable energies and associated projects required in order to meet the carbon neutrality target will form part of later studies and will require the conduct of detailed and specific viability studies, up until now Arup has evaluated energy contribution and other aspects such as the local environmental impact of a possible combination of renewable technologies which will enable the targets to be met.

Integration of PV solar energy in the development

The production of renewable energy in the development is mainly based on solar energy. The following options have been identified, quantified in terms of their contribution, and assessed in terms of their local environmental impact:

- Solar and PV thermal energy on the roofs of buildings.
- Integration of rooftop PV installations in car parks at the new mobility hubs. (see figure).
- Integration in urban furniture and other architectural features.

The figure below shows some of locations earmarked for the siting of PV panels in the development

Figure 10. Example of the integration of PV panels in car parks in Palma Beach

Major renewable solar energy facility
50 hectares of land to the south of the area, adjacent to the Autovía de Levante motorway has been earmarked as the possible site of a major renewable solar energy facility. With this measure a reduction of CO₂ emissions for the scopes analysed in the region of 13% by using parabolic trough concentration technology.

The land has been set aside for this purpose but the viability of a thermosolar plant on the available land is yet to be confirmed since this type of facility in Spain is currently more commercially viable when the site is over 100Ha. Therefore the land currently earmarked may not be large enough to ensure the commercial viability of this technology, in which case it will be necessary to enlarge the site, going outside the limits of the geographic scope of the project, or site the facility in an entirely new location within the Balearic electrical system.

In any event it will be necessary to make a detailed viability study in the next phase of the plan to analyse the many variables affecting its siting, including the commercial agreements to be established with the Consortium and the aid schemes available for the integration of renewable energies in the Palma Beach development.

**Biomass-based heat and electricity generation**

This measure consists of generating energy from waste biomass. Approximately half of that biomass could come from the dewatered sludge produced during the water treatment process at the Waste Water Treatment Plant (WWTP) attached to the development. The other half could come from various biomass sources but always based on waste biomass from the region (e.g. farm waste and/or forestry waste from Mallorca). The emissions reduction that could be achieved with this measure has evaluated by Arup to be in the region of 2% of all quantified emissions. In any event, in order to ensure that models are replicable to 2050, dependence on biomass will be limited to a small share of the Palma Beach energy mix (in the region of a little under 10%). EMAYA, the Municipal Water and Sewerage Company of Palma de Mallorca, has already installed a cogeneration plant at its Palma 1 WWTP take advantage of the biogas generated in the digestion of the sludge from the decanters, which enables the waste product from the treatment process to be reused as fuel. This process currently generates some 30,000 metric tons a year of sludge, with 20% of dried matter which is sent to the Son Reus incinerator. This represents an annual cost of some 4 million euros.

The proposal that the Consortium has received from EMAYA is to take the reuse of this waste a step further by dewatering it and using it to generate hot water to be used in the Palma Beach area. This additional process could generate around 27,000 kWh of hot water a day (close to 10 GWh a year), which represents around 8% of the calorific energy consumed at Palma Beach.

**PALMA BEACH ENERGY AGENCY AND ENERGY SERVICES COMPANIES (ESCOs)**

The viability of the energy efficiency technologies and renewable energies analysed and their implementation with the support of regulatory and urban planning measures will be necessary measures but not in themselves enough to ensure the successful implementation of the strategy. It will be necessary to define the organizational structures and energy business models which will enable them to be implemented and controlled.

In the studies carried out by Arup we recommend the creation of a Palma Beach Energy Agency, which would act as a focal point of the development and create synergies among the various participants in the project, while controlling and supervising the meeting of short-, medium-, and long-term targets and coordinating the various efforts made by the different parties involved.

Within these organizational and business model structures, it is clear that energy services companies (ESCOs) have an important role to play in the implementation of energy strategies. These companies may be part of the Energy Agency, but their role is clearly differentiated from that of the Agency in the sense that, while the Agency is a company with a responsibility to ensure the success of the project in terms of meeting the CO₂ reduction targets and protect other aspects such as the quality of service which consumers receive or the impact on the local urban environment, the ESCO is a commercial vehicle for implementing the strategies. In a project such as Palma Beach, in which there are some ambitious CO₂ reduction targets, the role of ESCOs is to monitor and report on progress towards the targets to which they have committed. Also, the service provided to the consumers in terms of quality and cost to those consumers should be competitive and their duties in this respect will be well defined at the start of the project.
The specific duties of the ESCOs and the rest of the participants depend on the project and there is no overall structure. The diagram below shows an example of a framework to regulate the duties and risks taken on by the ESCOs and the different parties involved.

*Figure 11. Possible map of responsibilities and risks of the ESCOs and the rest of the participants.*