Barcelona
Catalan Design
Conceptual Circuit
Critical Reinterpretation
Crowdsourcing

Ecoinnovation
Ecoproduct
LCA Life Cycle Assessment
Sustainability

Ethics of Function
Historiographic Challenges
Incorporated Energy
Industrialisation
Innovation
Internet

Local Action
Low Environmental Impact
Material Environment
Modular Construction
New Designers
New Materials
Optimisation
Recycle
Reduce
Rehabilitation
Research
Reuse

Technological Transfer
University
Utility
Utopia
WWW
Zero Emission

“The ecodesign strategies were evaluated from technological, economic and social standpoints”

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Urban Ecodesign in the City of Barcelona

Designing sustainable cities seems to be the best solution for facing the global environmental problems that our society has created. With this aim, new approaches and tools for improved urban design and planning are necessary. In this context, ecodesign presents itself as one of the key tools in the move towards more sustainable cities. This article presents three case studies of how it has been applied in Barcelona: a street light; a waste collection point and an entire neighbourhood.

Urban areas and environments are expanding worldwide. Statistics of urban population share reach figures of 70% in Europe, America and Oceania and 50% globally[1]. This ever-increasing urban population is likely to grow even more[2]. With this unprecedented growth in urbanisation, global sustainability is increasingly linked to urban sustainability. This is especially so considering the impact that people living in cities have on the rest of the globe and the sustainability of life in the cities themselves[3]. Despite representing only 2.7% of the world’s surface area[4], the world’s cities are responsible for 75% of the world’s energy consumption and 80% of greenhouse gas emissions[5]. Therefore, it is essential to improve the environmental performance of urban systems.

In this article, we adapt and apply product ecodesign methodology to urban elements at different levels:

—Urban element: urban furniture, street light
—Building: public facility, waste collection point
—Neighbourhood: newly designed neighbourhood

The ecodesign of urban environments at different spatial scales[6] is an emerging topic fostered by the research on ecodesign and urban sustainability.

1 United Nations. *World Urbanization Prospects: The 2007 Revision Population Database* [online]. New York: United Nations, 2008. [Consultation: July 29, 2011]. Available at: http://uscdn.creamermedia.co.za/assets/articles/attachments/11764_prospects.pdf

2 Pacione, M. *Urban geography: a global perspective*. 3rd ed. London: Routledge, 2009, p.703.

3 Bugliarello, G. “Urban sustainability: dilemmas, challenges and paradigms” in *Technology in society*. Vol. 28 (2006), p. 19-26.

4 United Nations. *Urban population, Development and the Environment* [online]. New York: United Nations, 2007. [Consultation: July 29, 2011]. Available at: http://www.un.org/esa/population/publications/2007_PopDevt/Urban_2007.pdf

5 Ash, C.; Jasny, B. R.; Roberts, L.; Stone, R.; Sugden, A. “Reimagining cities: introduction” in *Science*. Vol. 319, No. 5864 (8 Feb. 2008), p. 739.

6 Farreny, R. [et al.]. *The Ecodesign of Urban Environments at Different Spatial Scales*. Paper presented at the ISIE Conference, 2011, Berkeley.

SELF-SUFFICIENCY MATERIALS WATER ENERGY FOOD	**CIRCULAR FLOWS** CLOSING ENERGY, WATER AND MATERIAL FLOWS WITHIN NEIGHBOURHOODS. CREATING SYNERGIES. PREVENTING ENVIRONMENTAL IMPACTS. INTRODUCING ENVIRONMENTAL CRITERIA IN PUBLIC SERVICES.
FOR THE PEOPLE SPACE —MINIMIZING SPACE FOR PRIVATE VEHICLES. —ENVIRONMENTAL HEALTH. REDUCING ATMOSPHERIC AND ACOUSTIC POLLUTION. PARTICIPATION —ENVIRONMENTAL EDUCATION. —PARTICIPATIVE PROCESSES.	**MIX OF USES + BIODIVERSITY** INTEGRATE AGRICULTURE, INDUSTRY, SERVICES AND HOUSING IN ORDER TO REDUCE ENVIRONMENTAL LOADS. VERTICAL MIXTICITY OF USES. MULTIFUNCTIONAL SPACES. PROTECTING LOCAL BIODIVERSITY. CREATING NEW SPACES FOR BIODIVERSITY.

▲ Table 1. Strategies for urban sustainability

Strategies for urban sustainability

The most important strategies for fostering urban sustainability are listed in Table 1.

Tools for urban transition towards sustainability

During recent years, cities in general (and Barcelona in particular) have applied environmental assessment tools such as environmental audits or planning tools such as Agenda 21. Currently, Barcelona has signed the Covenant of Mayors, committing itself to reduce 20% of greenhouse gas emissions by 2020. However, experience with more innovative tools such as Life Cycle Assessment (LCA) or ecodesign is more limited. In spite of this, these tools are eliciting a great deal of interest from cities[7].

Methodology overview

Ecodesign

Ecodesign consists of the consideration of environmental criteria in the development of a product, without ignoring other key aspects of design (cost, functionality, aesthetics, etc.). The aim of ecodesign is to use the minimum amount of resources and generate the least possible emissions along the life cycle of the product. It can be defined as "the systematic incorporation of life cycle considerations into the design of products, processes or services"[8]. Actually, it is one of the most valid tools to reduce the inherent environmental drawbacks associated with products.

7 Oliver-Solà, J.; Rieradevall, J.; Gabarrell, X. "Environmental impacts of the infrastructure for district heating in urban neighbourhoods" in *Energy Policy*. Vol. 37 (2009a), No. 11, p. 4711-4719.
Oliver-Solà, J.; Gabarrell, X.; Rieradevall, J. "Environmental impacts of natural gas distribution networks within urban neighborhoods" in *Applied Energy*. Vol. 86 (2009b), No. 10, p. 1915-1924.
Oliver-Solà, J.; Gabarrell, X.; Rieradevall, J. "Environmental optimization of concrete sidewalks in urban areas" in *The International Journal of Life Cycle Assessment*. Vol. 14 (2009c), No. 4, p. 302-312.
Oliver-Solà, J. [et al.] "The GWP-Chart: An environmental tool for guiding urban planning processes: Application to concrete sidewalks" in *Cities*. Vol. 28 (2011), No. 3, p. 245-250.

8 Tukker, A.; Haag, E.; Eder, P. "Eco-design: The state of implementation in Europe: Conclusions of a state of the art study for IPTS" in *The Journal of Sustainable Product Design*. Vol. 1 (2000), No. 3, p. 147-161.

1. CREATION OF MULTIDISCIPLINARY ECO-DESIGN TEAM
2. DEFINITION OF THE VARIABLE WHICH DEFINE THE MOST REPRESENTATIVE PRODUCTS
3. SIMPLIFIED LCA OF THE SELECTED PRODUCTS
4. ECO-BRIEFING AND ECO-DESIGN STRATEGIES
5. CONCEPTUAL DEVELOPMENT OF ECO-DESIGN
6. ENVIRONMENTAL ASSESSMENT OF THE ECO-DESIGN OF THE PRODUCT
7. MANUFACTURE OF A PROTOTYPE ECO-DESIGNED PRODUCT

▲ Table 2. General stages of a process of ecodesign, applicable to the case studies presented

The ecodesign methodology is shown in Table 2.

The interdisciplinary team which works on the environmental aspects in this type of design is key for enhancing product stages: production materials, process, transport, packing, installation, use, maintenance, dismantling and end of life. The team is aware that these initial decisions have a consequence on the whole life cycle[9].

Ecodesign of a street light

Artificial lighting accounts for 19% of the world's electricity consumption[10], so the first case study focused on designing an environmentally friendly street lamp Table 4 presents the main characteristics of the case study.

The results of the market study show that the most widely-used materials for manufacturing the streetlight body are galvanized steel and cast aluminium, although some models are still manufactured using reinforced concrete. The streetlight bases involve the construction, *in situ*, of concrete supports. The most widely used lamps are Compact Fluorescents, High or Low Pressure Sodium Vapour lamps, which are more energy efficient than Mercury Vapour Lamps, with an installed power of between 50 and 70W, and luminance of between 20 and 30lx. All the streetlights analysed in the market study are designed for a useful life of 20 years.

The simplified LCA of the selected streetlights in the market study shows that the main impact is concentrated in the Use stage, which represents over 84% of the total environmental impact. The environmental impact of the Material Extraction and Processing stage of the light element and base represents over 15% of the total.

In order to make it easier to subsequently compare the environmental impact of the traditional streetlight with the ecodesigned unit, a scenario was proposed in which lighting was adjusted to the 15lx indicated in the functional unit. In this scenario, the impact of the Use stage was reduced to 77% of the total, and to 37% with respect to the current use stage.

The results of the simplified LCA indicate that the *eco-briefing* should focus on the stages of Use and Material Extraction and Processing as indicated in Table 3.

The ecodesign strategies were evaluated from technological, economic and social standpoints. The strategies that proved most viable were the use of high efficiency lamps, the application of a photovoltaic system, and the design of the streetlight in modules and bases which were easily installed and dismantled.

The proposed ecodesigned streetlight comprises three basic elements: support, light, and a panel sup-

9 Borsboom, T. "The environment's influence on design". *Design management journal*. Vol. 2, No. 4 (Fall 1991), p. 42-47.
Brezet, H.; Van Hemel, C. *Eco-design: a promising approach to sustainable production and consumption*. The Hague: Rathenau Institute; Delft: TU Delft; Paris: United Nations Environment Programme, 1997.

10 *Light labour's lost: policies for energy-efficient lighting* [online]. Paris: International Energy Agency, 2010. Available at: http://www.iea.org/textbase/npsum/lll.pdf

ENVIRONMENTAL ASPECT	
INTEGRATION IN URBAN SURROUNDINGS	AVOIDING LIGHT DISPERSION
DEMATERIALIZATION OF THE LIGHT AND THE BASE	INSTALLATION SIMPLIFICATION
USE OF MATERIALS WITH A LOW ENVIRONMENTAL IMPACT	MAINTENANCE SIMPLIFICATION
INCREASE IN ENERGY EFFICIENCY	REUSE OF COMPONENTS
OPTIMISATION OF LIGHT EMITTED	

▲ Table 3. Eco-briefing streetlight

porting the photovoltaic module. These elements are bolted down to a pre-moulded post allowing for fast and easy installation and dismantling. The streetlight's electric components are high-efficiency lamps, a photovoltaic module, battery, wiring, presence sensor and a photoelectric regulator.

The eco-streetlight, which is about 3.5m tall, features a conical body and a mesh-style support which opens up at the top in the form of a panel to hold a photovoltaic module. The lights are attached at the top of the support in clusters of long-life high-efficiency lamps. There is a storage space under the streetlight for hiding the battery. The light given off by the streetlight varies according to several factors: the presence of users and sunlight.

In the Material Extraction and Processing stages, the impact of the eco-streetlight is reduced by 57% in terms of streetlight materials and by 66% in terms of base material.

The manufacture of the prototype ecodesigned streetlights did not pose any significant technological difficulties. Manufacture of the prototype proved the viability of the core element of the product concept, namely the ecodesign strategies (see Table 4). The streetlight has been in place for six months in a public square next to the Barcelona Technology and Science Museum.

Ecodesign of a building: a waste collection point

A waste collection point (WCP) is a facility where people can dispose of the waste fractions that are not collected on a regular basis from street containers (i.e., glass, packaging, carton and cardboard, organic waste and residual waste). Fractions that are collected in WCPs include used cooking oils, textiles, electric and electronic waste, fluorescents, chemicals, batteries, etc.

Currently, Barcelona has a network of 37 WCPs (eight of which are mobile units), that collect 20 tons of waste; the units have over half million users per year.

The goal of the project was to design a new WCP model designed to satisfy the needs of a neighbourhood. The process started with an interdisciplinary team that covered the required knowledge areas: architects, communicators, environmentalists, etc. The first action was to analyse different WCPs. This enabled the team to determine the problematic issues (social, environmental, financial) of WCPs and the strategies needed to define the WCP described below.

Besides being easy to use and functional, the ecodesigned WCP has an attractive appearance and features didactic elements. It is also able to communicate to society the needs and strengths related to waste management.

The main components of the ecodesigned WCP are:

— The desks. A modular element identifies the different types of waste while avoiding direct view of the containers. At the same time, the desks create two separate spaces: one in the central area for depositing waste and the other in the perimeter area for collection.
— Two prefabricated and transportable modules. The first is used as a fully equipped reception office and the second as a classroom or multipurpose space.
— A lightweight cover that protects the site from the elements, consisting of six "trees" (each made of a column holding the crossbars that support the roof) supporting in turn each of the planes that make up the "tree-covered" WCP, a nature metaphor.
— Finally, a perimeter fence naturalized with climbing plants helps blend the WCP into its environment.

The key points of the WCP are functionality, sustainability, management and communication.

In terms of functionality, the WCP enhances a clear and intuitive operation – both for operators and users –, a clear separation of WCP inputs (the waste brought by users) and outputs (perimeter area for waste collection, not accessible to users), and the multifunctionality of the space to accommodate different uses beyond collection such as classroom, exhibitions, events, neighbourhood activities, etc. In addition, the WCP is based on a few basic and flexible elements that make it possible for it to adapt to different needs and uses.

Its strength in terms of sustainable self-sufficiency is its exploitation of endogenous local resources (water and sunlight). It collects and stores rainwater for use in cleaning the facility, toilets and watering of the green areas. Sunlight is harnessed to illuminate the WCP, and solar thermal technology heats the water. The WCP is also designed for its dematerialisation, optimizing the use of materials and prioritizing those of lower environmental impact. Vegetation has been integrated into the perimeter fence to better control weather conditions in the area and absorb CO_2.

▼ Table 4. Main features of the streetlight project

TEAM	SOSTENIPRA (ICTA-UAB) AND JULI CAPELLA & STEPHANIE HERR
FINANCING	CEMA. GOVERNMENT OF CATALONIA
CONTEXT	PILOT PROJECT FOR THE ECODESIGN OF URBAN FURNITURE
IMPROVEMENTS ACHIEVED	—USE OF A HIGHLY EFFICIENT LIGHT BULB & PHOTOVOLTAIC ENERGY SYSTEM (71% REDUCTION OF ENVIRONMENTAL IMPACTS) —DEMATERIALIZATION OF AERIAL STRUCTURE —USE OF RECYCLED CONCRETE FOR THE BASE —DEMATERIALIZATION OF URBAN SETTING —ADDRESSING ENVIRONMENTAL ASPECTS TO STREET LIGHTING —REDUCTION OF LIGHT POLLUTION

The waste management system is designed to facilitate and encourage public involvement. Communication to users is essential to guide them to deposit the waste easily and without confusion.

In terms of communication, the WCP is itself an educational, environmental communication and interactive project, promoting the values of waste prevention and recycling and reuse among the general public.

Table 5 highlights the main characteristics of this case study, which followed the same ecodesign process than the first case.

The first WCP of this kind will be installed the first half of 2012 in the Barceloneta, Ciutat Vella district of Barcelona.

11 Farreny, R. [et al.]. "Transition Towards Sustainable Cities: Opportunities, Constraints and Strategies in Planning. A Neighbourhood Eco-Design Case Study in Barcelona (Spain)" in *Environment and planning A*. Vol. 43 (2011b), núm. 5, p. 1118-1134.

Eco-design of a neighbourhood

The city council of Barcelona unanimously approved, in October 2008, to establish sustainability as the driving force for the urban planning of the last section of its territory to be urbanised. This new neighbourhood will be located in an area called Vallbona located in the northern part of Barcelona. It stretches over 32.6 Ha and is currently mainly devoted to agricultural land uses.

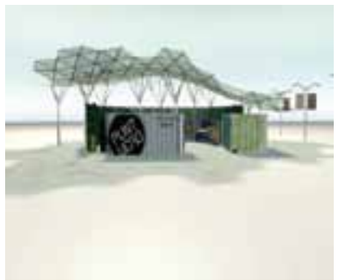
This neighbourhood will house 2,000 dwellings. The area lacks urban continuity and features many structural deficiencies as well as isolation from the rest of the city. Currently it is almost completely surrounded by natural and artificial barriers: the Besòs River and several roads, highways and railways.

Environmental aspects have been incorporated since the conceptualization of the neighbourhood and considering the intrinsic determining factors of the landscape. The methodology followed throughout the Vallbona design and planning process is an adaptation of the methodology followed in the previous sections, fully developed in T*ransition towards sustainable cities: opportunities, constraints and strategies in planning. A neighbourhood eco-design case study in Barcelona (Spain).*[11]

The table 6 presents the basic features of this case study.

▼ Table 5. Main characteristics of the WCP project

TEAM	SOSTENIPRA (ICTA-UAB & INÈDIT), PICH AGUILERA ARCHITECTS, SOLANAS, GERONA GROUP
FINANCING	BARCELONA CITY COUNCIL
CONTEXT	ECODESIGN OF A NEW MODEL OF WASTE COLLECTION POINT
IMPROVEMENTS ACHIEVED	—USE OF LOCAL ENDOGENOUS RESOURCES (RAINWATER, SOLAR ENERGY), AIMING AT SELF-SUFFICIENCY —USE OF RECYCLABLE MATERIALS —PASSIVE ENERGY SYSTEMS —INTEGRATED WITH THE URBAN ENVIRONMENT —DIDACTIC FUNCTION —MORE USER-FRIENDLY, ACCESSIBLE AND SIMPLE —INTERACTIVE WITH USERS



▼ Table 6. Main characteristics of the Vallbona project

TEAM	BARCELONA REGIONAL AND SOSTENIPRA (ICTA-UAB)
ENTITY	BARCELONA CITY COUNCIL
CONTEXT	ECODESIGN OF THE LAST NEIGHBOURHOOD TO BE URBANISED IN BARCELONA
IMPROVEMENTS ACHIEVED	MAIN STRATEGIC ACTIONS: —MINIMIZATION OF BUILDINGS' ENERGY DEMAND —USE OF LOCAL RENEWABLE ENERGY SOURCES AND A DISTRICT-WIDE HEATING NETWORK —PROTECTION OF THE AREA'S AGRICULTURAL MOSAIC —DIVERSIFICATION OF WATER SOURCES, ADAPTING THE QUALITY OF WATER TO ITS USES —LOCAL RESOURCES MANAGER THAT WOULD PROFICIENTLY MANAGE ENDOGENOUS RENEWABLE RESOURCES

Conclusions

The ecodesign methodology has been applied to the design of urban environments at different spatial scales in the city of Barcelona. This process differs from a conventional one mostly in that it takes into account environmental criteria throughout the entire lifecycle of the designed products and involves highly interdisciplinary teams. Considering environmental issues is of particular relevance since the incorporation of the lifecycle approach in the early design of a product/facility encourages prevention of urban environmental impacts and guarantees that sustainability goals will be reached.

Three urban ecodesign case studies have been considered (a streetlight, a waste collection point, and a neighbourhood) as examples of the potential of applying ecodesing in urban systems. This approach can help reduce environmental impacts and bring social (educational, functional, etc.) and financial (efficient use of resources) improvements.

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