EUROPEAN COMMISSION, DIRECTORATE GENERAL TREN, Contract n° NNE5/2001/551

Summary

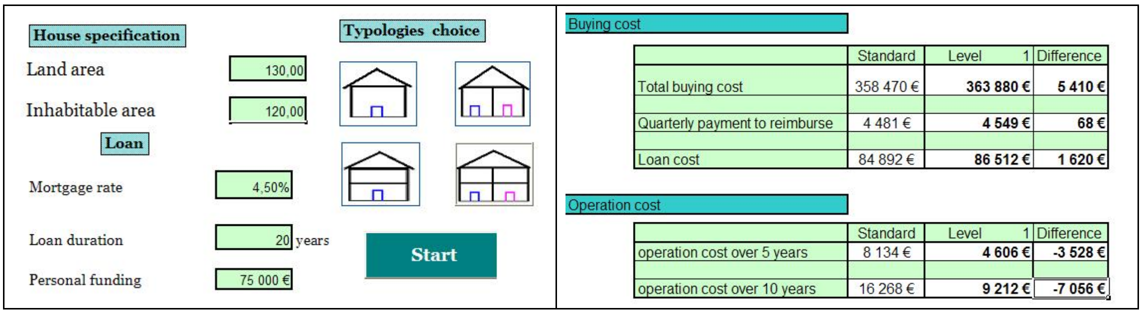
The e-co-housing project aims to develop and test tools supporting a participatory process from the design brief to the real operation of a housing project (e.g. neighbourhood construction, apartment building renovation). The partners are IFIB (Germany), SINTEF (Norway), DHV (The Netherlands), GTM (France) and ARMINES/ENSMP (France, coordinator).
Methods for innovative property development (e.g. co-housing, accounting tools) and decision making (sustainability indicators), design tools (energy and life cycle simulation), guidelines (design brief, architectural and technical design, commissioning and operation) have been developed, implemented through a life cycle based communication and management platform, and tested in two application projects : Svartlamon (Norway) and Montreuil (France). Cluster activities with another European project, Solanova, allow some tools to be tested in a third project situated in Dunaujvaros (Hungary).

1. CONTEXT

Achieving European energy efficiency and climate protection objectives implies to improve the performance standards in the building sector beyond the regulation levels with a limited over-cost and improving overall life cycle quality. Sectoral and exclusively technology based approaches cannot achieve these objectives. Present project and property development as well as design process do not allow to integrate long term, comprehensive performance and quality management objectives. The stakeholders, i.e. end users, are not involved at the early phases of a project when the essential technological, economic and operational objectives are fixed. This process is a barrier against emerging energy efficient techniques : the stakeholder has no interest in investing as he will not get his money back during the operation phase.
In order to overcome this barrier, the E-co-housing project combines a new participation form with a life cycle based communication and management platform and a set of confirmed design tools. The tools developed in this project are presented here, and illustrated by two application projects.

2. CO-HOUSING AND PROPERTY DEVELOPMENT

Co-housing [1] is a type of collaborative housing including private dwellings and extensive common facilities (parking area, pedestrian street, common house, garden,…). Such communities are designed and managed by the residents according to a participatory process : a set of quality criteria is elaborated, constituting performance objectives for the architect and contractors. Usually, energy efficiency as well as affordability and low maintenance are part of these criteria. The co-housing process is therefore a useful tool to promote and implement green housing concepts.
A review of co-housing experiences in Europe and USA has been elaborated in order to identify good practice. Also, the standard property development process has been analysed and the possibility to implement some participatory process has been studied.
A simplified cost assessment tool has been developed as a sensibilisation tool to compare the life cycle cost of a dwelling with several quality levels. The life cycle cost includes the investment cost, accounting for a possible loan, and the operation cost (energy, water, maintenance). The tool allows the interest of technical measures to be assessed (e.g. advanced glazing, ventilation air pre-heating, water saving etc.). It is complemented by a more global accounting tool regarding the share of common expenses (e.g. pathways, garden, common house) among the residents.



Investment and operation costs, comparison of 2 quality levels

3. DESIGN BRIEF

The elaboration of a design brief is an essential step in a building project because it expresses the client's requirements and the objectives of the designers and builders. Sustainability is a broad concept including environmental, economical and social issues. This may lead to difficult discussions within a participatory process, therefore a tool has been developed to help criteria and priorities to be discussed and chosen.

The residents should be involved in such a process but they are no professionals. They should be aware of the main options and directions which they can choose without being obliged to cope with the technical complexity of a complete assessment process. A hierarchical definition of main goals and sustainability objectives is proposed as a comprehensive and understandable point of departure in the cooperation between the design team and the residents. The sustainability objectives have been structured in 4 dimensions and 9 main goals, cf. next table.

Dimensions	Main goals	Objectives
1 Ecological	1 Preserve resources	1 Preserve material resources
		2 Save energy
		3 Save water
		4 Reduce land use
	2 Protect the ecosystems	1 Limit toxic emissions
		2 Protect the climate
		3 Protect the forests
		4 Protect rivers and lakes
		5 Improve outdoor air quality
		6 Protect fauna and flora
		7 Reduce waste
		8 Reduce radioactive waste
		9 Preserve the ozone layer
		10 Limit floods
2 Economic	1 Reduce life cycle cost	1 Reduce construction cost
		2 Reduce operation cost
		3 Reduce maintenance cost
		4 Reduce renovation cost
		5 Reduce demolition cost
	2 Add value	1 Ease space modification
		2 Ease use modification
3 Social	1 Preserve residents health	1 Improve indoor air quality
		2 Improve water quality
		3 Reduce electromagnetic fields ?
		4 Reduce risks (fire, explosion…)
	2 Improve comfort	1 Improve visual comfort
		2 Improve thermal comfort
		3 Reduce noise
		4 Reduce odours
		5 Improve well being
	3 Add social value	1 Improve quality of use
		2 Increase social and gender equity
		3 Integrate the disability issues
		4 Ease social relationships
		5 Improve participation
4 Cultural	1 Develop creativity	1 Improve architecture and image
		2 Improve site integration
	2 Integrate cultural value	1 Conserve historical sites
		2 Consider conserving or transforming existing buildings
		3 Support cultural activities

Structure of the sustainability objectives, dimensions and main goals

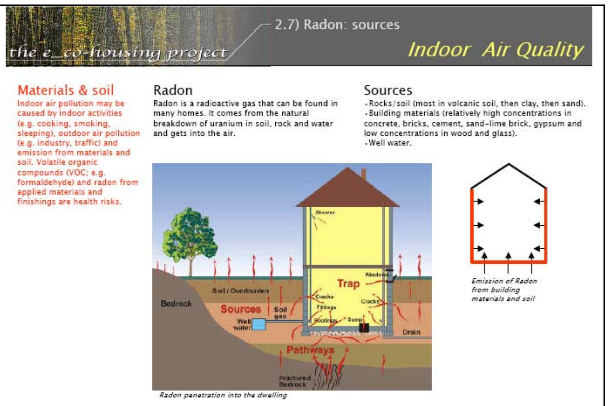
Supplementary issues can be added according to a local context. The first step in the tool is to select objectives. In the second step, the user can make adaptations to his selected user objectives. Priorities are asked in a third step.
A design brief guide complements the criteria and priority tool. Advice is given about the contents of a design brief and the organisation of a participatory process. For each objective, performance indicators are proposed concerning three levels : the whole neighbourhood, the buildings, and the open spaces. Some illustration is provided using case studies. This guide aims to help the users by explaining them how to inform the design and construction team about their requirements.

4. DESIGN

a. Guidelines

The design process may differ according to national contexts : in some countries, architects work primarily on spaces and geometry, then engineers study the technical aspects. In other parts of Europe technical issues are more integrated in architecture, which seems to be advisable. We have divided the design guides in two parts : architectural and technical guidelines, but of course an architect interested in a global approach can read both documents. The architectural guidelines are structured in various themes : energy, water, space, and social aspects. Like in the design brief guide, three levels are considered : neighbourhood, buildings, and green/grey areas.
Achieving sustainability objectives has generally technical implications. Each technique is like a piece of a puzzle : all pieces are important, but the essential role of a designer is to assemble them in order to create a consistent project, be it a building or a neighbourhood. To illustrate this integration process, the technical guide is organised in a variety of concept presentations. For instance the passive house concept combines a high insulation level, passive solar gains and preheating of ventilation air.

Example architectural guideline : "prepare for active solar installations"

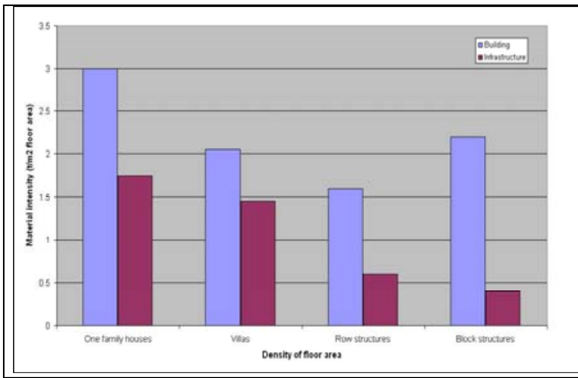


Example technical guideline : how to reduce radon concentration in the indoor air

Example architectural and technical guidelines

b. Software tools

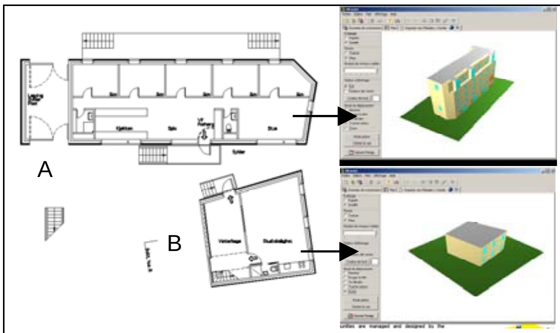
Software tools complement the guidelines, allowing the design to be refined : comparative studies can be performed in order to identify technical choices that reduce environmental impacts. One main task in this project is to extend the tools developed at the building level so that they can be used to design neighbourhoods. Two different tools are developed. Eco-opt is a global neighbourhood model developed by IFIB [2], based upon life cycle assessment [3].
As a result first mass flow segmentations for neighbourhoods, concerning infrastructure for water, gas, electricity and sewage are available. These data were integrated to databases, which contain average used infrastructure elements adapted to the settlement typology. Furthermore they were integrated to the existing LCA tools and allow first views on the interaction of life cycle assessment of buildings and the related infrastructure.



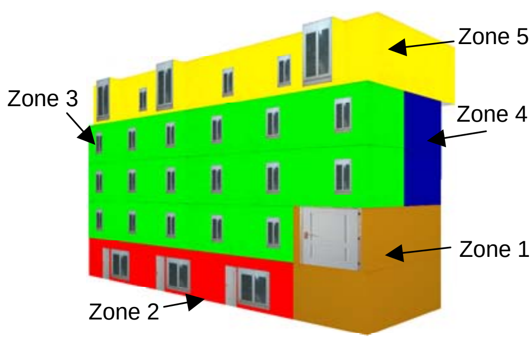
A first application study, concerning the average composition of a representative middle town was made. This allows a first insight in the average infrastructure mass flows. First front-end drafts to display the interaction of building LCA and infrastructure input have been completed.

Example Eco-opt result, material intensity of buildings and infra-structure in terms of density (left figure)

The life cycle assessment tool for settlements developed by ARMINES focuses more on design aid. The first step is to describe each building type, particularly the geometry using the 2-3D descriptor ALCYONE developed by IZUBA Energies (see www.izuba.fr). Buildings are divided in "thermal zones", i.e. spaces with a homogeneous temperature (e.g. living rooms, entrance hall…).

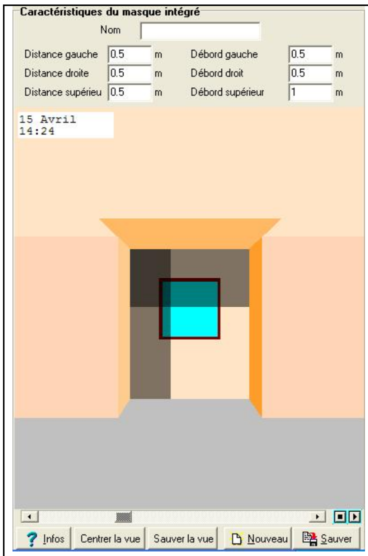


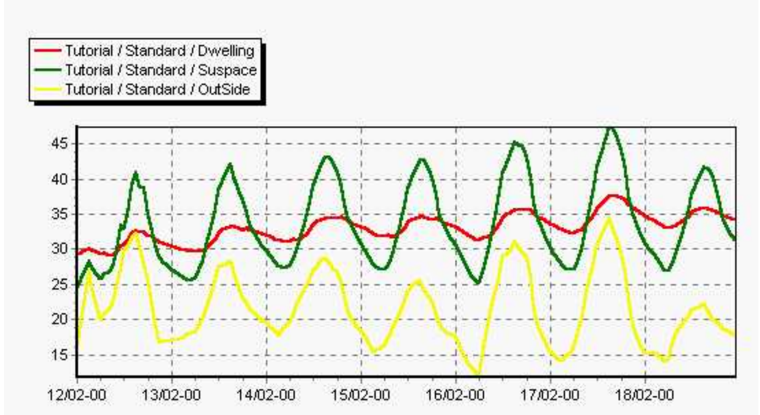
Description of building geometry and thermal zones using ALCYONE, example of the Norwegian application project



A 3-D view is derived from the plans

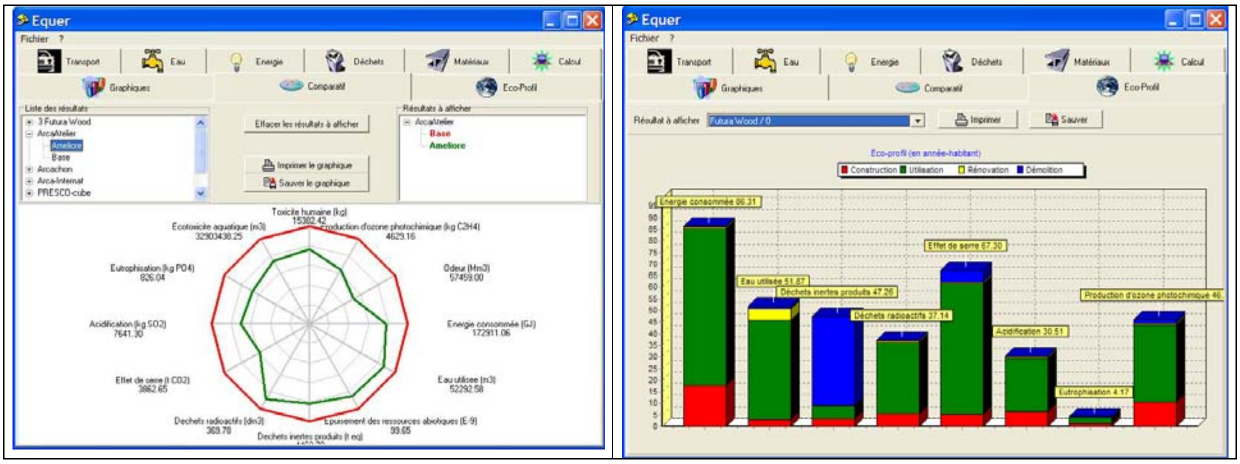
Thermal simulation [4] is used in a second step to evaluate the heating and possibly cooling load of the buildings, and also the thermal comfort in the different zones. The tool provides energy balances and graphs, e.g. showing the effect of a shading over a window, and temperature profiles.





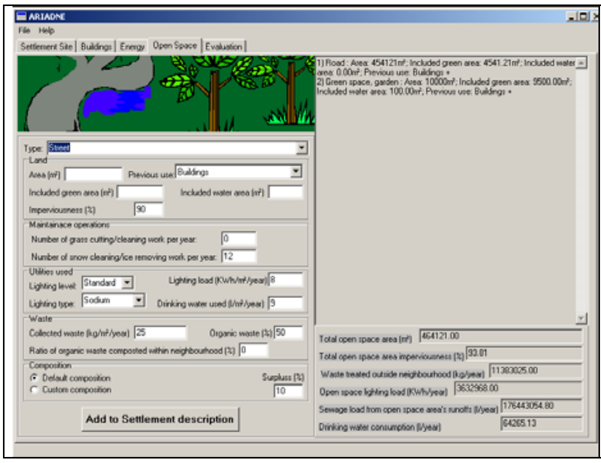
Thermal analysis using COMFIE (calculation) / PLEIADES (interface) software, shading effect (left) and temperature profile (right)

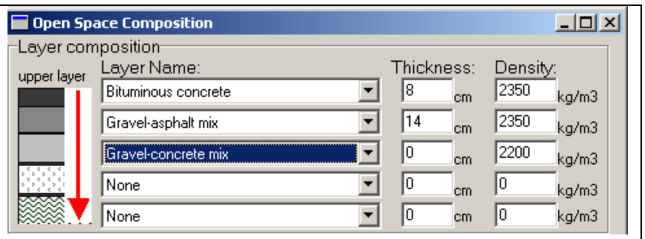
The building LCA tool EQUER allows environmental indicators to be evaluated according to the LCA methodology [3] (e.g. contribution in global warming, energy and water consumption, waste generation etc.). The Oekoinventare 96 life cycle inventory database [6] is used. Design alternatives can be compared, and different indicators [7,8,9] can be expressed using the same scale (equivalent inhabitant-year), cf. next figure.



Example life cycle assessment output, comparison of alternatives (left), environmental profile of a project (right)

The Building-LCA model has been complemented, particularly by collecting data on networks (water, district heating), and developing an open space model (including e.g. street lighting, public waste treatment). A first prototype has been developed and tested in the application projects.





Neighbourhood LCA tool, input window for open spaces (left), detail for the description of a street composition with several material layers (right)

A web platform has been developed for the project, constituting an essential communication and dissemination tool. It includes a public part :
http://www.eco-housing.org
Some of the future inhabitants take part in the design and research process by registering to the public area of the platform. Some end-user issues have been integrated, as well as database connections to the developed tool. This will make it possible to run the participatory design process via the web. Building projects need multidisciplinary cooperation between designers, and the platform constitutes an appropriate tool to support this cooperation.

5. COMMISSIONING AND OPERATION

Guidelines have also been developed to help the residents during the commissioning phase (checking that the objectives included in the design brief have been fulfilled), and the operation phase (check-list of maintenance activities). Like the tools described above, these guidelines have been tested in the application projects and adapted according to the feed-back.

A presentation of the guidelines is available on the project web site. The full content may be adapted in the future to national contexts in order to be disseminated in the form of a handbook for professionals, and educational material for teachers.

6. APPLICATION CASES

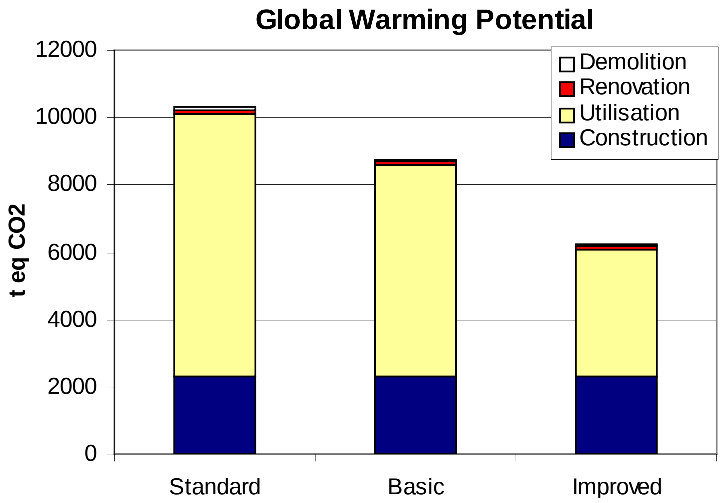
The two application cases included in the eco-housing project are situated in Norway (Trondheim) and France (Montreuil). They are no demonstration projects : the aim is to test the tools developed in the project (software and guidelines), and to propose some improvement. A cluster has been organised by the E.C. (D.G. TREN), which supports this research, with the Solanova project. This project concerns the energy efficient renovation of an apartment building situated in Hungary (Dunaujvaros). Some Eco-housing tools have therefore also been applied in the Solanova building.

The site and the houses in Svartlamon are owned by the municipality of Trondheim, but the neighbourhood is managed by a Housing Foundation. This foundation is led by a residential group of around 130 people and most decisions are made in monthly meetings. The project includes upgrading of approximately 110 existing housing units, and building 100-120 new units. The first building project, accommodating ca. 30 people, has been finished and moved into April 1. 2005.
The E_Co-housing tools and guidelines have been developed parallel to the ongoing activities in Svartlamon. Experiences from the first building construction gave input to the Financing tool. The energy simulation tool was used to develop an Energy plan for the neighbourhood (incl. the first buildings) and compared to other tools. Life cycle simulations were also tested for the first buildings.
The “sustainability tree” structuring the tool to elaborate sustainability objectives and make priorities (C&P-Tool), and the Design Brief guidelines gave input to the development of an environmental program for neighbourhood. Drafts guidelines have been reviewed by residents and architects. They have especially given input to the work on the environmental program.

	The young architects BRENDELAND & KRISTOFFERSEN won the competition and started the planning and design of the two buildings in 2003. The calculated total energy consumption (87 kWh/ m^2 for heat and 46 for electricity) is lower than the average energy consumption for new domestic buildings in Norway. The LCA tool EQUER was used to calculate the environmental impact, e.g. the Global Warming Potential (CO_2). Such a tool can simulate the effect of “green thinking”, e.g. by comparing a standard inhabitant’s behaviour with “ best practice”, in this example 40% waste reduction, 33% energy and water saving. Such an analysis shows the positive effect achieved by “green thinking”, particularly saving resources in the operation phase. In this Norwegian context (98% hydro-electricity), waste incineration constitutes the major part of the CO_2 –emission.

Experiences from the process at Svartlamon showed that tools and guidelines may create a better understanding among residents and other actors of the need of making and clarifying priorities on sustainability issues. Simulation tools used early in the design process may give a better basis for all actors – also non professionals – to make informed decisions. They may also increase the understanding of the need to define binding performance levels on sustainability topics. Most important is still that residents and other actors share a common understanding of the objectives of the development. This understanding may be created through active dialogue and participation and the tools and guidelines can only support and not draw final conclusions in such a process.

The second application project is situated in Montreuil, a city of 96,000 inhabitants neighbouring the east of Paris. The project concerns an apartment building with 42 units. The owner is a social housing organisation, OPHLM de Montreuil. The program (client's brief) includes environmental quality objectives, and a label "Qualitel Environment" is targeted. This label aims to promote higher environmental quality in the social housing sector, and is related to some tax reduction. The architect is Jérôme BRULLE (M'Arche).
Among the techniques that have been integrated are : high insulation glazing, moisture controlled ventilation, solar domestic hot water (around 100 m^2 of thermal solar collectors), rain water storage, and low flow rate sanitary equipment. The calculated annual heating load is 50 kWh/m^2.



Comparison of CO_2 emissions evaluated for the project ("basic"), a reference ("standard") and best practice ("improved")


Construction of the building

The residents have been informed about best practice in the management of the building, and the objective is to involve them in improving the environmental performance, e.g. by implementing low consumption lighting.

The Hungarian project concerns the renovation of a social housing building including 42 units and situated in Dunaujvaros. More information can be obtained on the www.solanova.org web site.

The building has been modelled defining several thermal zones (basement, ground floor, south and north facing apartments). The energy consumption estimated using thermal simulation has been compared to the actual energy bill, and the model has been adapted (adding a zone for the staircases, accounting for thermal bridges around windows…). Then several renovation alternatives have been compared and the corresponding reduction of environmental impacts has been evaluated accounting for the national context (e.g. electricity mix : 40% nuclear, 26% coal, 19% gas, 14% oil and 1% hydro).

According to these calculations, the heating load (170 kWh/m^2 per year before renovation) and the related CO_2 emissions could be reduced by a factor 5 after renovation.

In conclusion, new tools have been developed to aid the design of sustainable neighbourhoods. Benchmarking would be useful to reduce the uncertainties and progress towards harmonization. The tests in three application projects has shown that this approach can be applied in very different contexts, provided that local data is collected (e.g. electricity production mix, climate, standard and best practice references). We hope that these research activities will contribute to a successful implementation of European policies towards sustainable cities.

BIBLIOGRAPHY

[1] C. Hanson, "The Cohousing handbook – Building a Place for a Community", Hartley & Marks Publishers, U.S.A., 1996

[2] Kohler, N. Life cycle models of buildings. EuropIA'95. European Lyon

[3] ISO (International Organisation for Standardisation), "14040 – Environmental Management – Life Cycle Assessment – Principles and Framework, EN ISO 14040, 1997.

[4] B. Peuportier and I. Blanc Sommereux : 'Simulation tool with its expert interface for the thermal design of multizone buildings', International Journal of solar Energy, vol. 8, 1990.

[5] B. Polster, B. Peuportier, I. Blanc Sommereux, P. Diaz Pedegral, C. Gobin, E. Durand : 'Evaluation of the environmental quality of buildings – a step towards a more environmentally conscious design', Solar Energy, vol. 57 n°3, 1996.

[6] R. Frischknecht et al., 'Ökoinventare für Energie Systeme', Eidgenössische Technische Hochschule, Zürich, 1995, and third version, ENET Publications, Bern 1996.

[7] R. Heijungs, Environmental life cycle assessment of products, Centre of environmental science (CML), Leiden, 1992.

[8] Guinée J.B. et al, Life cycle assessment, An operational guide to the ISO standards, Final report., CML, May 2001

[9] Goedkoop M.J., Spriesma R.: The Eco-indicator 99 A damage oriented method for Life Cycle Impact Assessment. Methodology Report and Operational annex, April 2000

RELATED PROJECTS

PRESCO European thematic network (Practical Recommendations on sustainable construction) : http://www.etn-presco.net/

ECOINVENT database (life cycle assessment database including material fabrication and other processes) : http://www.ecoinvent.ch/

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