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Training for Renovated Energy Efficient Social housing

Intelligent Energy -Europe programme, contract n° EIE/05/110/SI2.420021

Intelligent Energy Europe

Section 2 Tools
2.3 Life cycle assessment

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Main issues and definitions

- **Eco-design : Integrating environmental aspects during the design, e.g. of a new construction or a renovation project**
- **Environmental aspects :**
  - **Preservation of resources (energy, water, materials, land),**
  - **Protection of ecosystems at different scales : planetary (climate, ozone layer), regional (forests, rivers…), local (waste, air quality…)**
  - **Links between environment and health**
- **LCA (life cycle assessment) : accounting substances taken from and emitted to the environment, deriving environmental indicators, e.g. global warming potential, interpreting the results**

Possible applications of life cycle assessment

- manufacturers can study the eco-design of building materials and equipment,
- Architects and building consultants can compare various alternatives during the design phase in order to reduce the environmental impacts of a renovation project,
- facility managers can study the influence of the users behaviour and advise appropriate measures during the operation phase of a building,
- building owners and local communities can require and check the environmental performance level of projects.

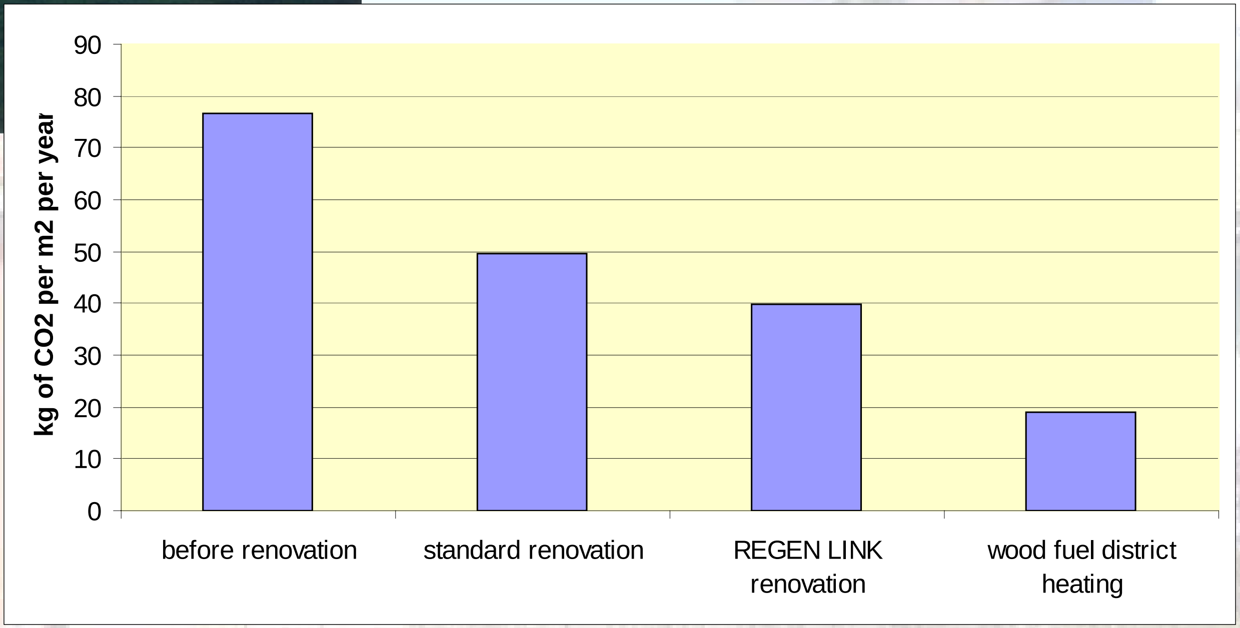
Example LCA application : renovation of a social housing block near Paris

Construction : 1969

not insulated, single glazing

heating load : 150 kWh/m2/an

Comparison of renovation alternatives using EQUER (www.izuba.fr)



CO_2 emissions per m² and per year

Contents

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Introduction

- **Important environmental problems : climate change, toxic emissions, resource depletion, waste…**
- **High contribution of the building sector, e.g. 40% of the energy consumption, 30% of raw material consumption, 30% of solid waste generation**
- **Need of integrating environmental issues in design, largely influencing the performance of buildings**
- **Life cycle assessment constitutes a relevant tool, in new constructions but also in renovation**

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Contribution of the building sector to environmental burden

- **40% of the total energy consumption (United Nations Environment Programme), 45% in Europe**
- **30% of raw materials use (UNEP data)**
- **20% of the total water consumption and effluents (UNEP)**
- **40% of CO_2 emissions (UNEP)**
- **30% of solid waste generation (UNEP)**
- **Essential effects on human health (we spend 90% of our time in buildings) : air quality, noise…**

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Eco-design of buildings

- **Integrating environmental aspects during the design of a new construction or a renovation project**
- **Preservation of resources (energy, water, materials, land),**
- **Protection of ecosystems at different scales : planetary (climate, ozone layer), regional (forests, rivers…), local (waste, air quality…)**
- **Links between environment and health**
- **LCA (life cycle assessment) is a method to assess these issues**

Possible applications of life cycle assessment

- manufacturers can study the eco-design of building materials and equipment,
- Architects and building consultants can compare various alternatives during the design phase in order to reduce the environmental impacts of a project,
- facility managers can study the influence of the users behaviour and advise appropriate measures during the operation phase of a building,
- building owners and local communities can require and check the environmental performance level of projects.

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ISO 14 000 standards

- **14001 : management system**
- **14010 : audit**
- **14020 : labels**
- **14030 : environmental performance assessment**
- **14040 : life cycle assessment**
- **14050 : glossary**

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14040 standards (LCA)

- **14040 : general principles (1997, updated 2006)**
- **14041 : goal and scope definition and inventory analysis (1998)**
- **14042 : life cycle impact assessment (2000)**
- **14043 : interpretation (2000)**
- **14044 : requirements and guidelines (2006)**
- **14047 : examples of application of ISO 14042 (2003)**
- **14048 : data documentation format (2002)**
- **14049 : examples of application of ISO 14041 (2000)**

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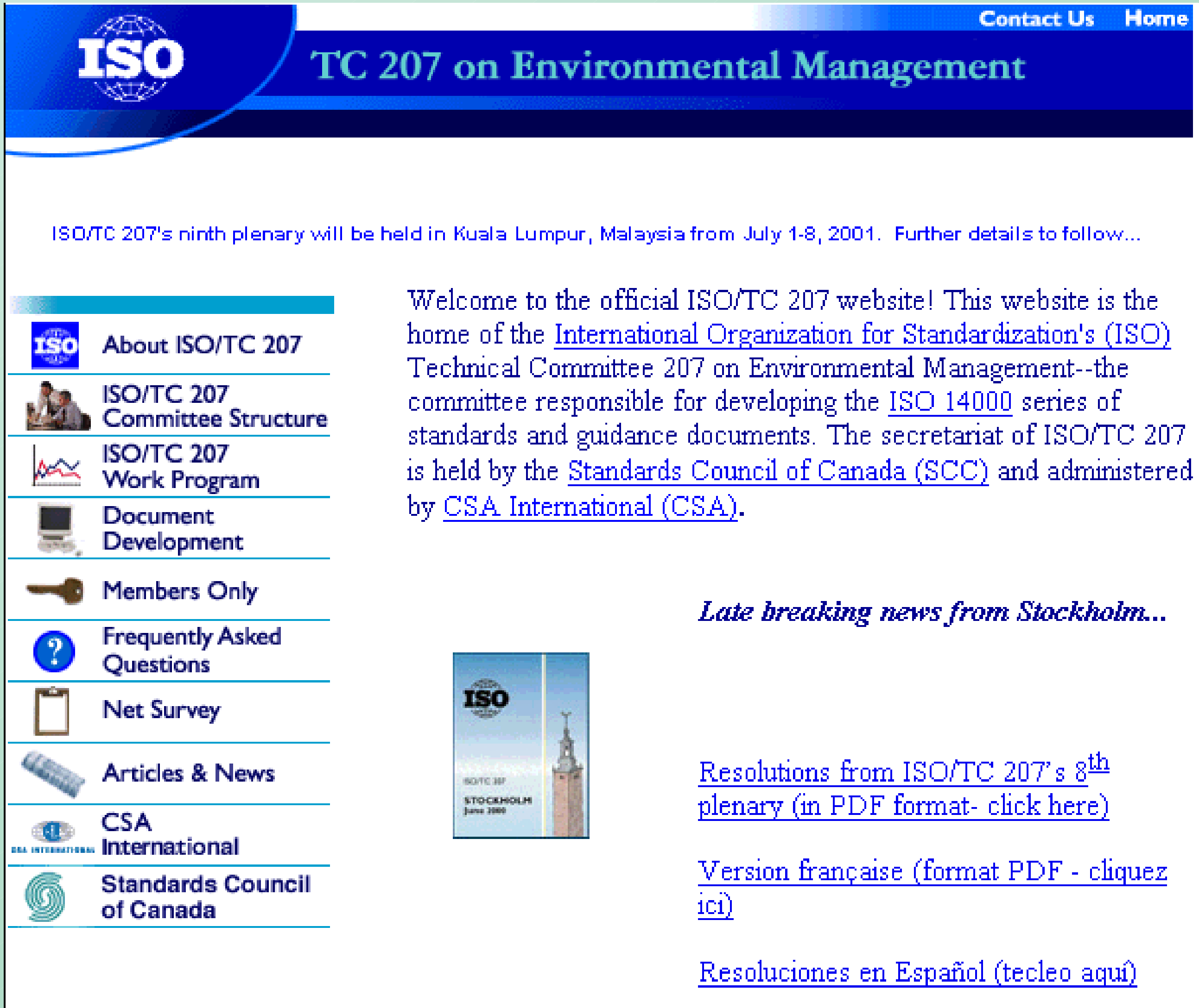
Www.tc207.org



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French standards regarding buildings (AFNOR)

- **P 01-010 : information about environmental characteristics of construction products**
- **P 01-020 : environmental and sanitary characteristics of buildings**
- **P 01-030 : environmental management of building projects**

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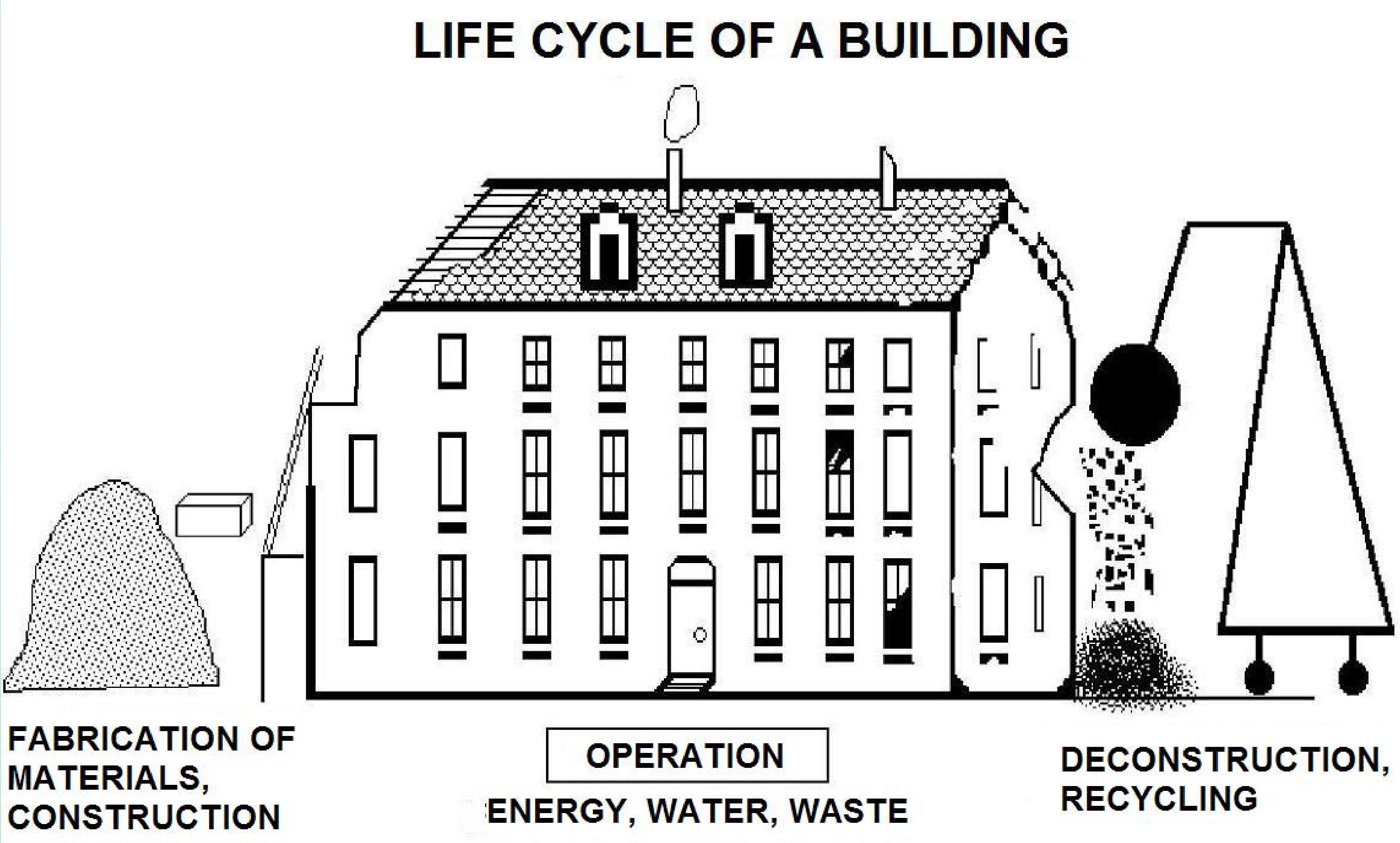
Life cycle of a building



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Phases of an LCA (ISO 14040)

- **Goal and scope definition**
  - Functional unit
  - Systems boundaries
- **Inventory analysis**
  - Hypotheses regarding energy, transport, recycling etc.
- **Impact assessment, eco-profile**
- **Interpretation**
- **+ applications, e.g. product development and improvement**

Goal and scope definition

- **Design a building with lower impacts**
- **Functional unit :**
  - Quantity, e.g. 4,820 m^2 or 1 m^2 dwelling area,
  - Function : apartment building,
  - Quality of the function : comfort (clear, 20°C in winter and under 30°C during a typical summer, quiet…), health (air and water quality…)
  - Duration : e.g. 30 years, or 1 year
- **System and boundaries (see next slide),**
- **Method and hypotheses (see next slides)**

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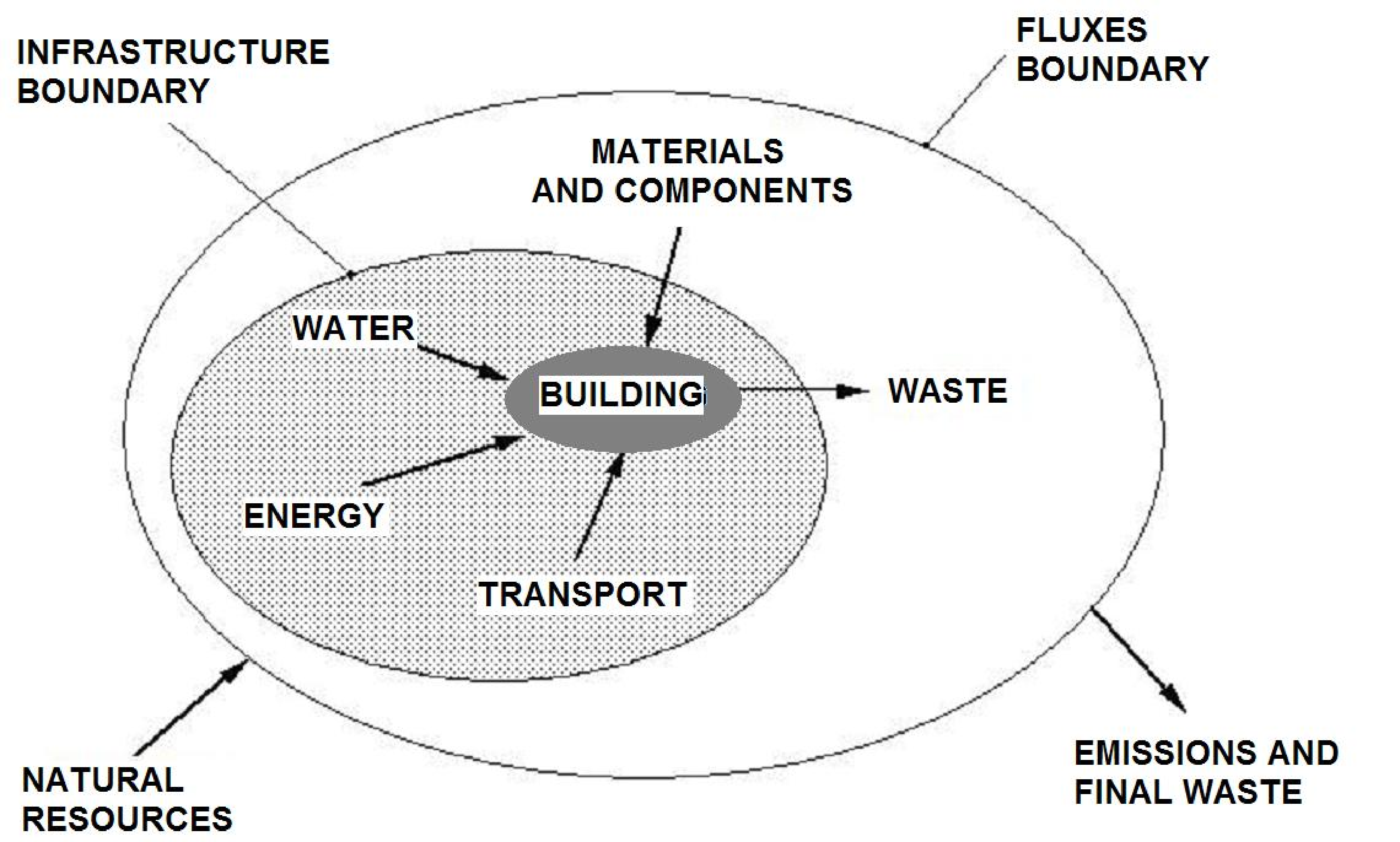
System boundaries corresponding to a building



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Hypotheses regarding energy, transport, recycling…

- **How is energy consumption calculated (correlation, simulation) ?**
- **Is renewable energy included ?**
- **How is the transport of materials modelled (load calculated according to the quantity and density of the material, assuming empty return of vehicles ?)**
- **How is recycling accounted for, e.g. bonus at both the fabrication and end of life phases, « value corrected substitution method », International iron and steel Institute method**

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Inventory phase

- **Substances taken from and emitted to the environment (input and output fluxes) :**
- **Raw materials, primary energy…**
- **Emissions into air**
- **Emissions into water**
- **Emissions into the ground, waste**
- **Including upstream processes (e.g. extraction and transport of energy, raw materials…)**
- **Including downstream processes (waste)**

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Exemple inventories : several hundreds of data

Oekoinventare, ETH Zürich

		Laine minérale	Manganèse	Minerai de Fer	Mousse dure PUR	NaCl	NaOH
Cd Cadmium m	kg	1.26E-10	5.65E-11	1.98E-11	4.14E-10	1.11E-10	8.94E-11
Cd Cadmium p	kg	1.96E-08	1.53E-08	1.15E-09	1.21E-08	3.61E-10	2.50E-09
Cd Cadmium s	kg	2.08E-08	1.05E-07	3.40E-09	8.81E-07	1.03E-08	2.32E-08
CF4 p	kg	1.70E-08	2.58E-07	1.21E-08	1.72E-07	5.31E-09	4.25E-08
CH3Br p	kg	0	0	0	0	0	0
CH4 Methan m	kg	9.74E-07	2.94E-06	6.66E-06	7.12E-06	3.51E-07	6.72E-07
CH4 Methan p	kg	0.00379	0.00929	0.000246	0.00871	0.000196	0.00153
CH4 Methan s	kg	1.41E-05	0.000116	3.25E-06	0.000176	4.88E-06	2.03E-05
CN Cyanide p	kg	3.60E-16	1.73E-15	1.41E-16	2.80E-08	2.88E-15	2.39E-15
CN Cyanide s	kg	1.56E-08	1.09E-08	9.56E-10	8.79E-09	2.24E-10	1.74E-09
Co Cobalt m	kg	6.74E-10	4.63E-09	7.27E-09	4.89E-09	1.01E-10	7.58E-10
Co Cobalt p	kg	1.56E-09	1.83E-09	3.06E-10	1.60E-09	6.12E-11	2.73E-10
Co Cobalt s	kg	4.03E-08	6.38E-07	6.63E-09	1.17E-06	1.24E-08	1.05E-07
CO Kohlenmonoxid m	kg	3.03E-05	7.73E-05	0.000139	0.000146	1.86E-05	2.50E-05
CO Kohlenmonoxid p	kg	0.0747	0.000314	7.71E-05	0.00774	7.58E-06	3.54E-05
CO Kohlenmonoxid s	kg	0.000453	0.00141	0.000126	0.00142	5.30E-05	0.000193
CO2 Kohlendioxid m	kg	0.0135	0.0412	0.0647	0.0699	0.0073	0.0114
CO2 Kohlendioxid p	kg	0.975	0.0342	0.00517	0.174	0.00161	0.00518
CO2 Kohlendioxid s	kg	0.39	5.03	0.0591	4.91	0.0854	0.809
Cr Chrom m	kg	5.32E-10	3.65E-09	5.74E-09	3.86E-09	7.99E-11	5.98E-10
Cr Chrom p	kg	3.88E-08	1.77E-08	3.18E-09	1.77E-08	7.04E-10	2.98E-09
Cr Chrom s	kg	2.76E-08	4.82E-07	4.51E-09	6.65E-07	1.14E-08	8.09E-08
Cu Kupfer m	kg	1.15E-07	3.44E-07	5.10E-07	8.11E-07	6.36E-09	5.56E-08
Cu Kupfer p	kg	1.11E-08	3.50E-08	1.64E-09	2.55E-08	8.37E-10	5.81E-09
Cu Kupfer s	kg	1.02E-07	1.03E-06	2.88E-08	1.82E-06	2.28E-08	1.71E-07
Cycloalkane p	kg	0	0	0	0	0	0
Dichlormethan p	kg	1.27E-09	4.11E-09	5.54E-11	1.16E-07	2.68E-11	3.80E-06
Dichlormonofluormethan p	kg	4.44E-08	3.17E-08	6.46E-09	3.07E-07	3.65E-08	5.43E-06

Other data bases

- **www.ecoinvent.ch (Switzerland, hundreds of materials and processes)**
- **www.ivam.uva.nl/uk/ (The Netherlands, data base compatible with the SIMA PRO LCA tool)**
- **www.inies.fr (France, no process and fewer materials : concrete blocks, timber, gypsum, PVC tiles, aluminium, polystyrene, reflecting insulation…)**

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Aggregation in environmental indicators, examples

environmental theme	unit
energy consumption	MJ
water consumption	m^3
depletion of abiotic resources	10^{-9} (1/1 billion), dimensionless, calculated by dividing used resources by known resources
waste creation	tons
radioactive waste creation	dm^3
global warming	ton CO_2 equivalent
depletion of the ozone layer	kg CFC-11 equivalent
acidification	kg SO_2 equivalent
eutrophication	kg PO_4^{3-} equivalent
aquatic ecotoxicity	m^3 of polluted water
human toxicity	kg, human weight
photochemical oxidant formation	kg C_2H_4 equivalent
malodorous air	m^3 of contaminated air (ammonia is used as a reference)

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Indicators, example : contribution to climate change

Source : school in Les Houches

- *Global Warming Potential*
- *depends on optical properties of gases*
- *equivalent CO_2, over a 100 years duration*
- *GWP_{100} = kg CO_2 + 25 x kg CH_4 + 320 x kg N_2O + Σ GWP_i x kg CFC ou $HCFC_i$*
- *effect (potential) and no impact (real)*

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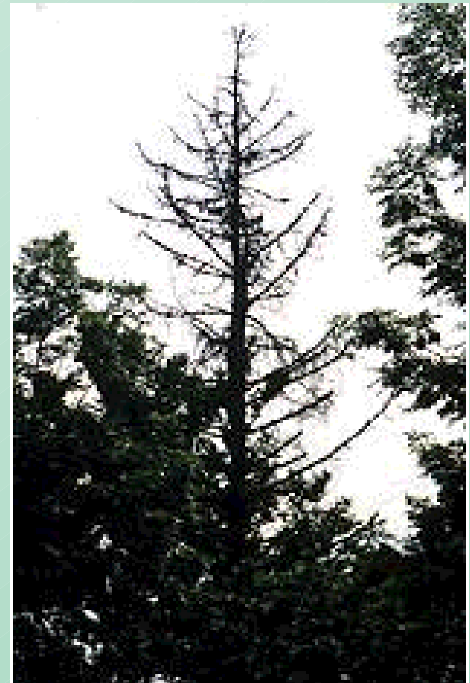
Contribution to acidification



- **Acidification Potential (eq. SO_2 or H+)**
- **Potential effect (real impact depends on background concentration)**

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Contribution to eutrophication

Photo : Halte aux marées vertes

- **Eutrophication Potential (eq. PO_4^{3-})**
- **Increase of a natural phenomenon**
- **Potential impact (real impact depends on dilution, e.g. greater in a small lake than in a large river)**

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Air quality and ozone

Source : Frederic Cherqui, Doctorate thesis

- **ozone and altitude, 2 different problems :**
- **Stratospheric level (30 km), Ozone depletion potential (eq. CFC-11)**
- **Tropospheric level (ground level), Summer smog (photochemical ozone formation), eq. C_2H_4**

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Critical volumes method

- **maximum tolerable concentration Cm at which 95% of individuals are preserved in water (kg/m^3)**
- **critical volume (m^3) = Emissions / Cm**
- **aquatic ecotoxicity indicator :**

Σ critical volumes (m^3 of polluted water)

- **same method for terrestrial ecotoxicity**
- **Human toxicity : dose instead of concentration, e.g. threshold = dose at which the risk of cancer is 1/10, 000 , average human weight, planetary average and not local indicator**

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Other critical volume indicator : odours

- **Odours, detection threshold = concentration Cs at which 50% of a representative sample detects the product**
- **critical volume = Emission / Cs**
- **Odours indicator (m^3 of polluted air) =**

Σ critical volumes

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Primary energy

- **1 kWh electricity needs more energy to be produced than 1 kWh heat (related to the efficiency of electricity plants and grid)**
- **The primary energy indicator allows different types of energy to be integrated on a homogeneous basis**
- **Upstream processes should be included (e.g. extraction and transportation of gas) otherwise displacement of pollution would not be accounted (e.g. replacing a boiler by electric heating reduces emissions inside a building but increases them upstream in electricity plants)**
- **Higher heating value is preferable**
- **Renewable energies are preferably included**

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Other indicators

- **Exhaust of resources, for instance :**

  Σ Mi / available reserves i

- **Water consumption, e.g. expressed in m^3**
- **Produced waste, e.g; expressed in tonnes**
- **Radioactive waste, dm^3**

Photo : PNUE

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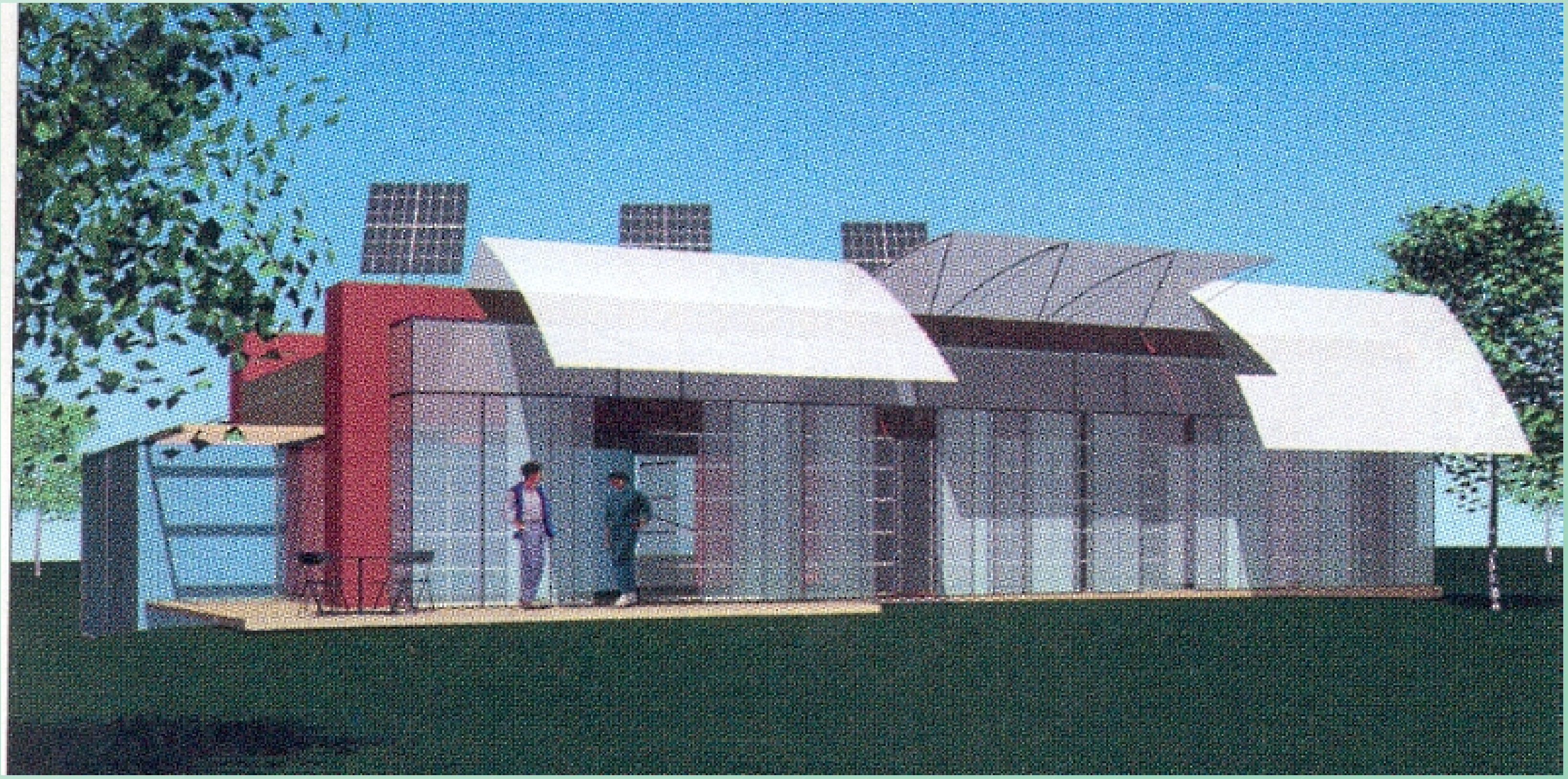
Example result, EcoLogis exhibition in Paris



Impacts of this innovative project have been compared To a standard house in the same site

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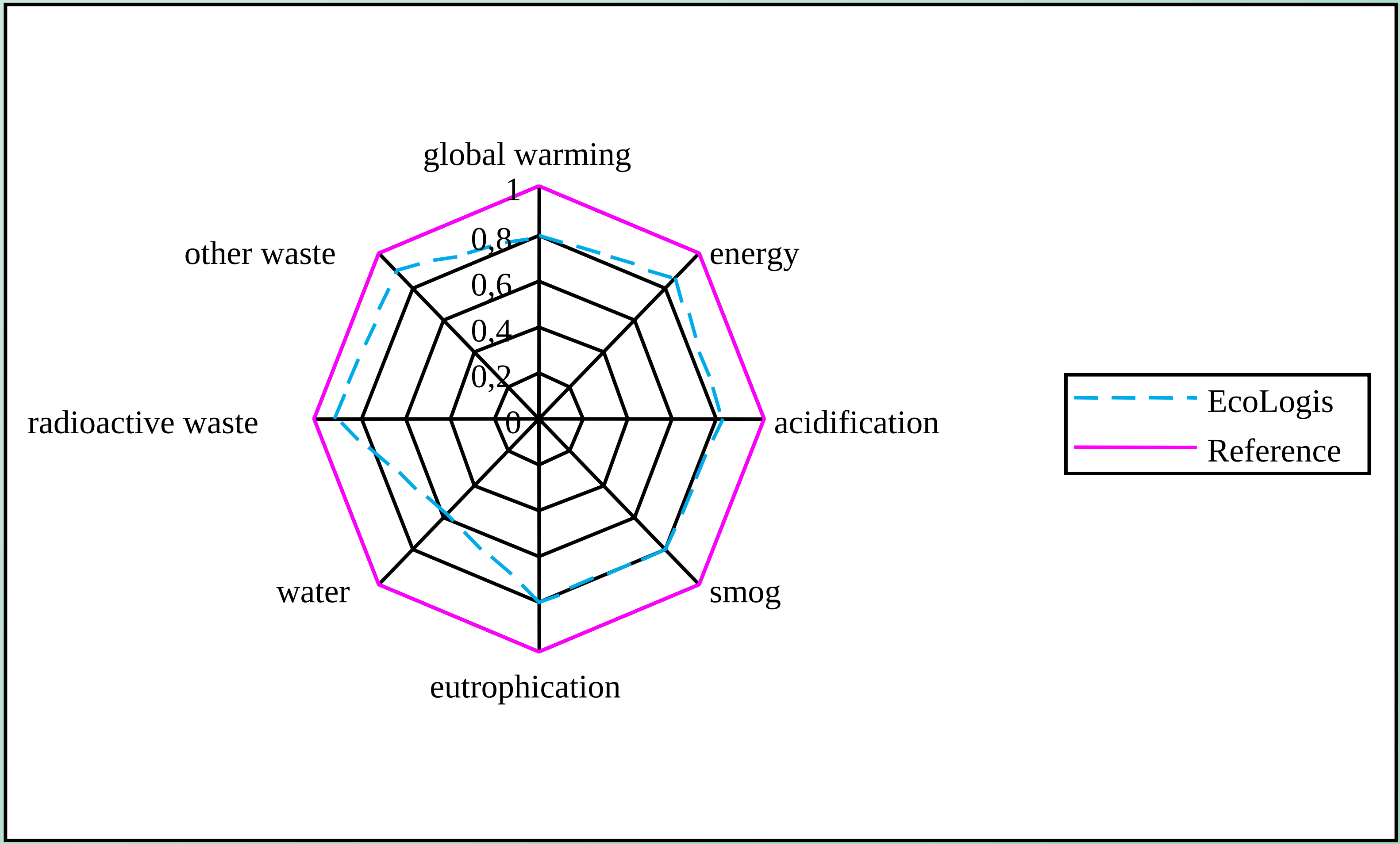
EcoLogis exhibition, comparison with a reference



Each axis corresponds to an indicator. The reference value is 1 and relative values are given for the project, e.g. the contribution to global warming is reduced by 20%

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Normalisation

- **Collect average impact per person and year, e.g. 13 tons CO_2 per person and per year in Europe**
- **Divide the indicator value by this average in order to derive normalised values in equivalent persons**
- **Example : if the CO2 emissions are 1,300 tons for a building, the normalised value is 100 eq. Persons**
- **Normalising all indicators for which average data is available helps to define priorities (in general, higher priorities for higher normalised values)**

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Limits of the approach

- uncertainties concerning data (inventories) and indicators : for instance, the global warming potential (GWP) of other gases than CO2 is known with 35% uncertainty
- processe like electricity production may vary -> one year functional unit corresponding to near future
- processes occurring at the end of the building life cycle difficult to foresee -> scenarios and possibly probabilities
- **multi-criteria decision making -> define priorities in agreement with concerned actors (owner…)**

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Work performed in the frame of the PRESCO European thematic network

Objectives of this work :

- **Assist a more environmentally friendly approach in building design**
- **Exchange between tool developers**
- **Benchmarking and intercomparison**
- **Definition of a common baseline for assessment methodologies**

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Participants and tools

- **W/E, NL, ECO-QUANTUM**
- **EMPA, CH, LTE OGIP**
- **ARMINES, F, EQUER**
- **BRE, UK, ENVEST 2**
- **VTT, Fi, BECOST**
- **CSTB, F, ESCALE**
- **IBO, A, ECOSoft**
- **ASCONA and IFIB, D, LEGEP**

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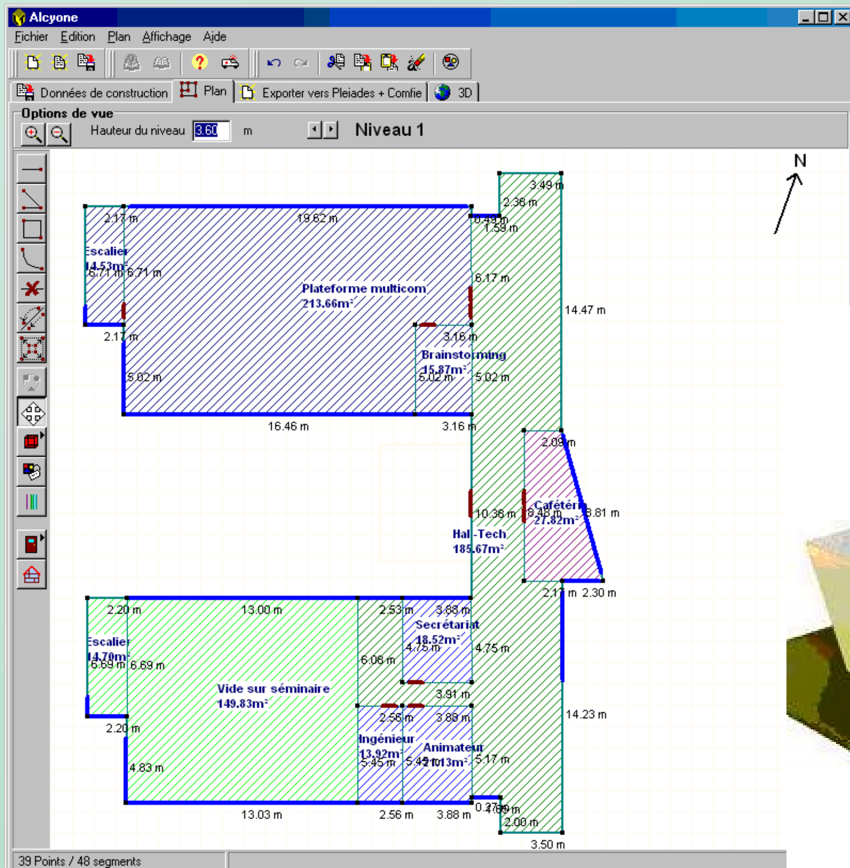
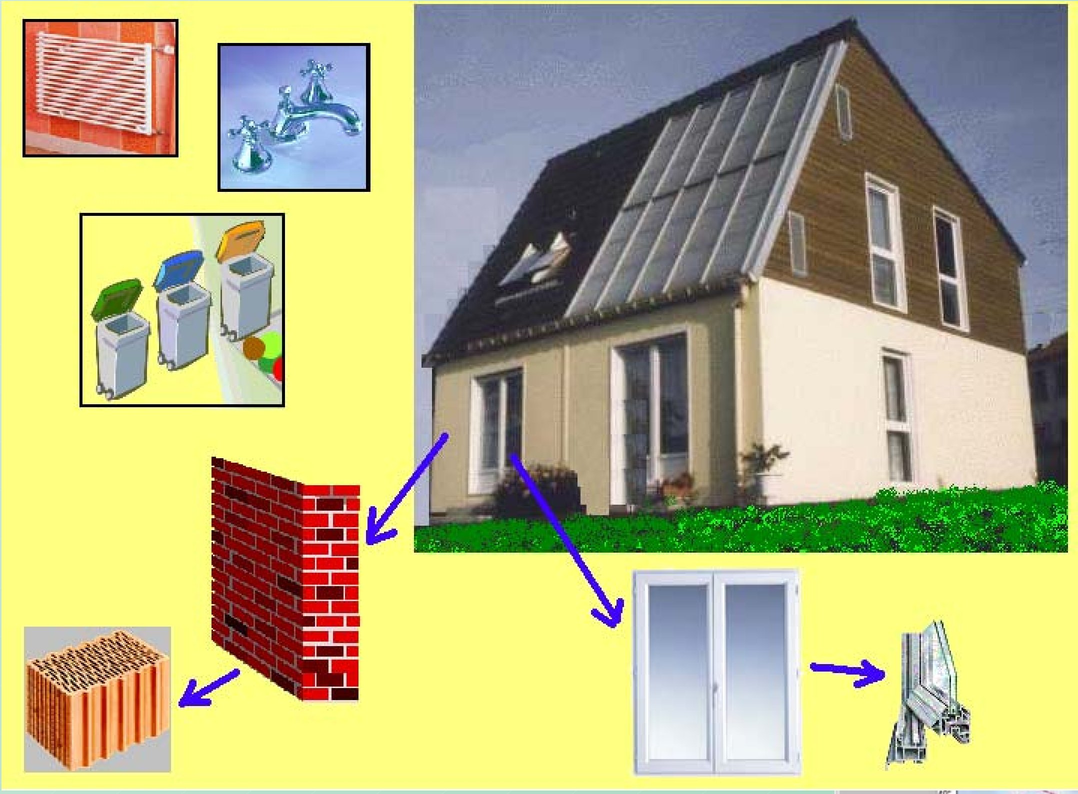
PRESENTATION OF EQUER, www.izuba.fr

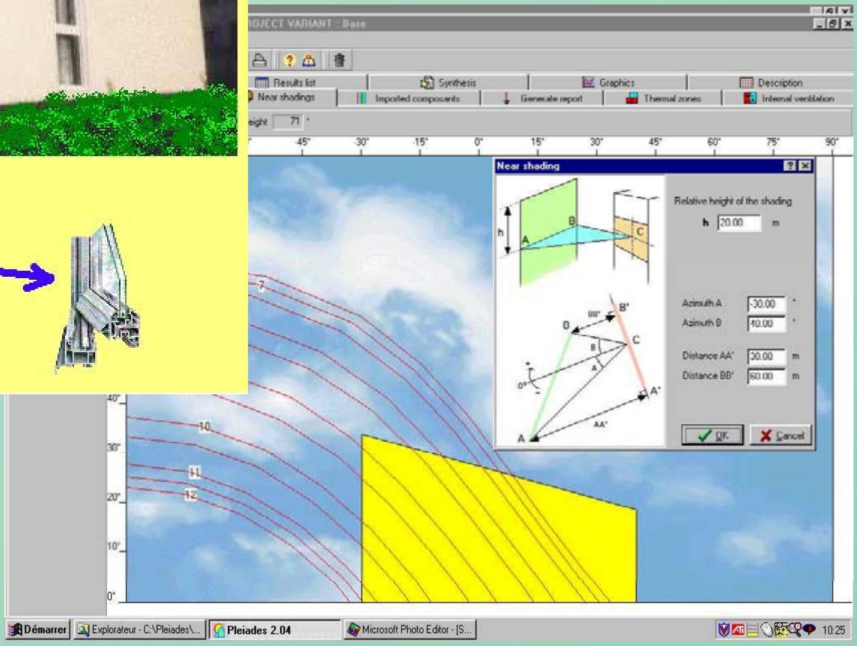
First step : 2D – 3D Description using ALCYONE



Building model



Description of the site and climate



Choice of materials and components

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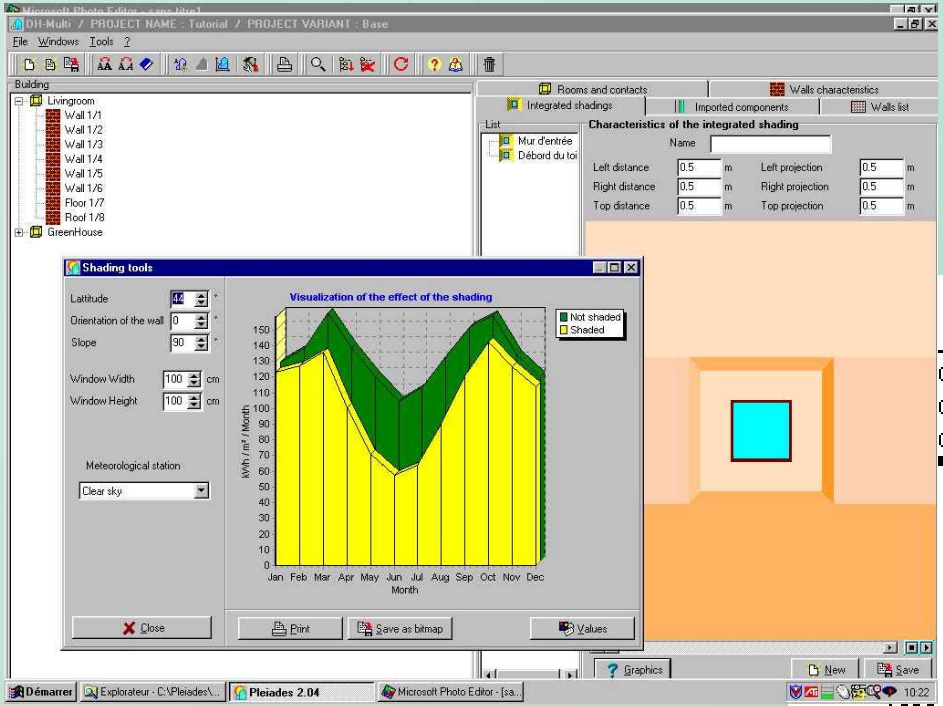
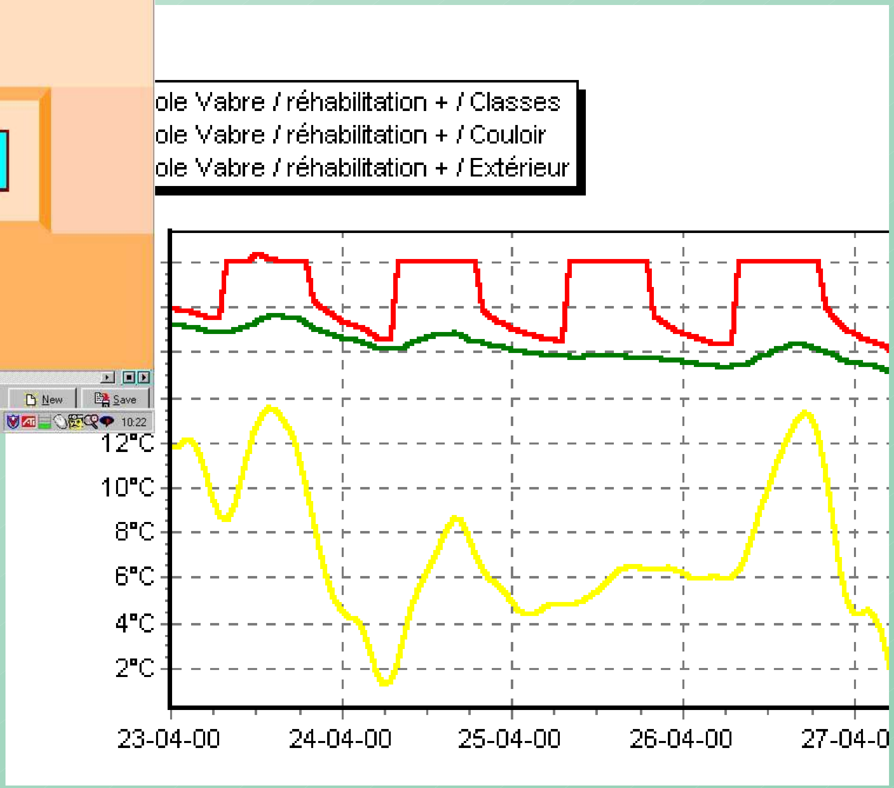
Link with thermal simulation, COMFIE



Heating and Cooling loads



Temperature profiles

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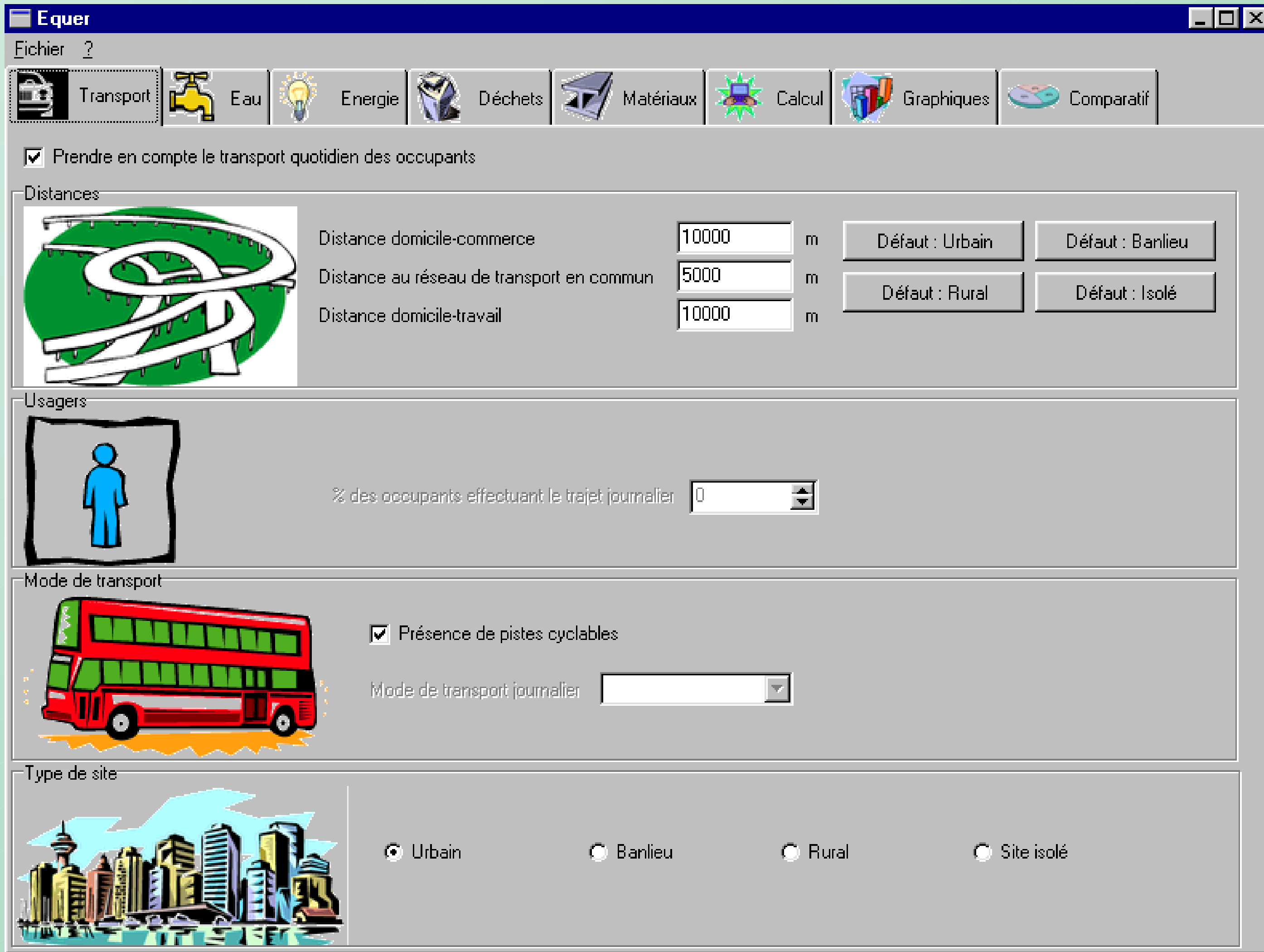
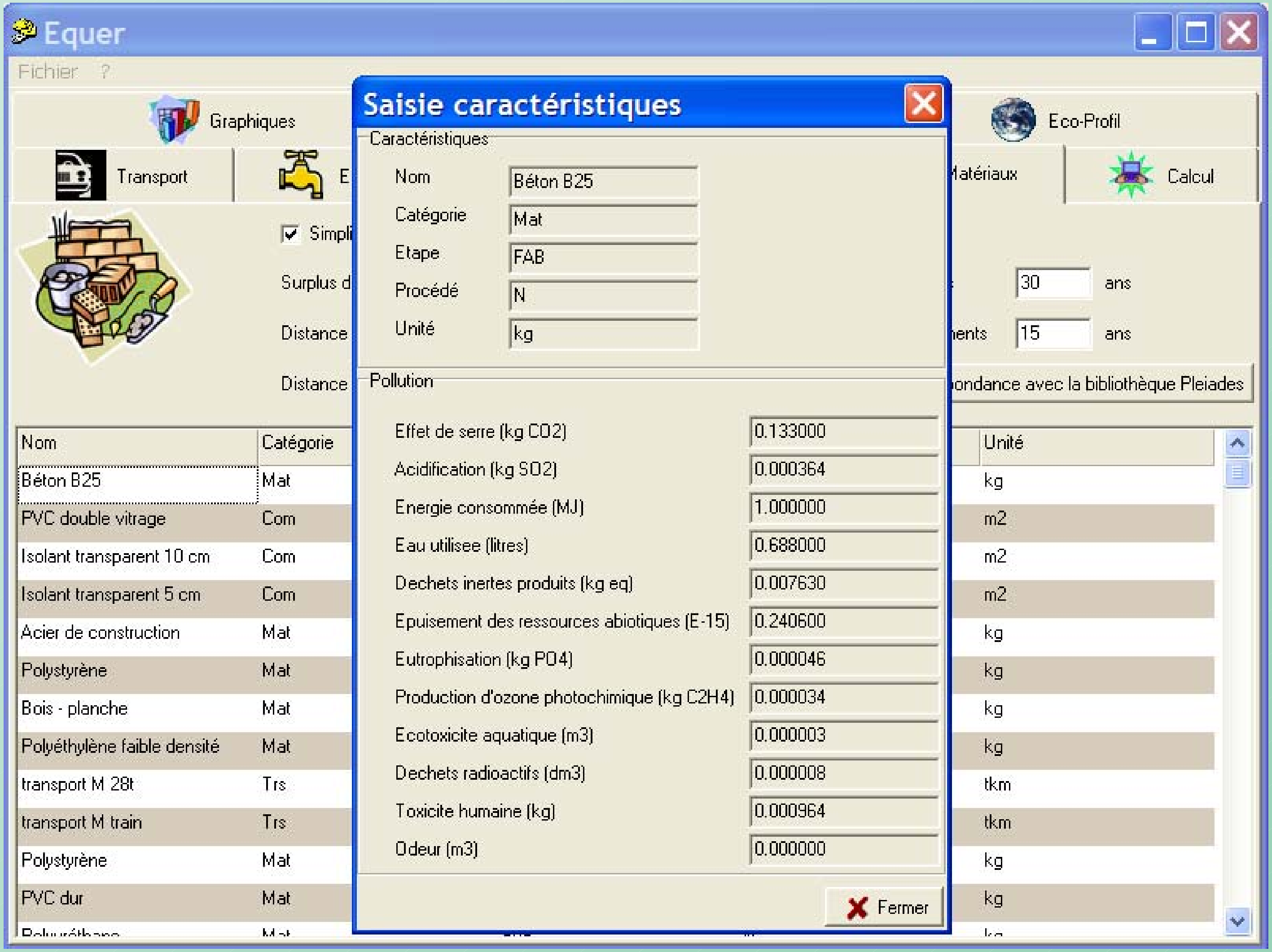
Equer, example input window



Equer, example data window



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Oekoinventare 1996 data base (ETHZ)

New version using www.ecoinvent.ch

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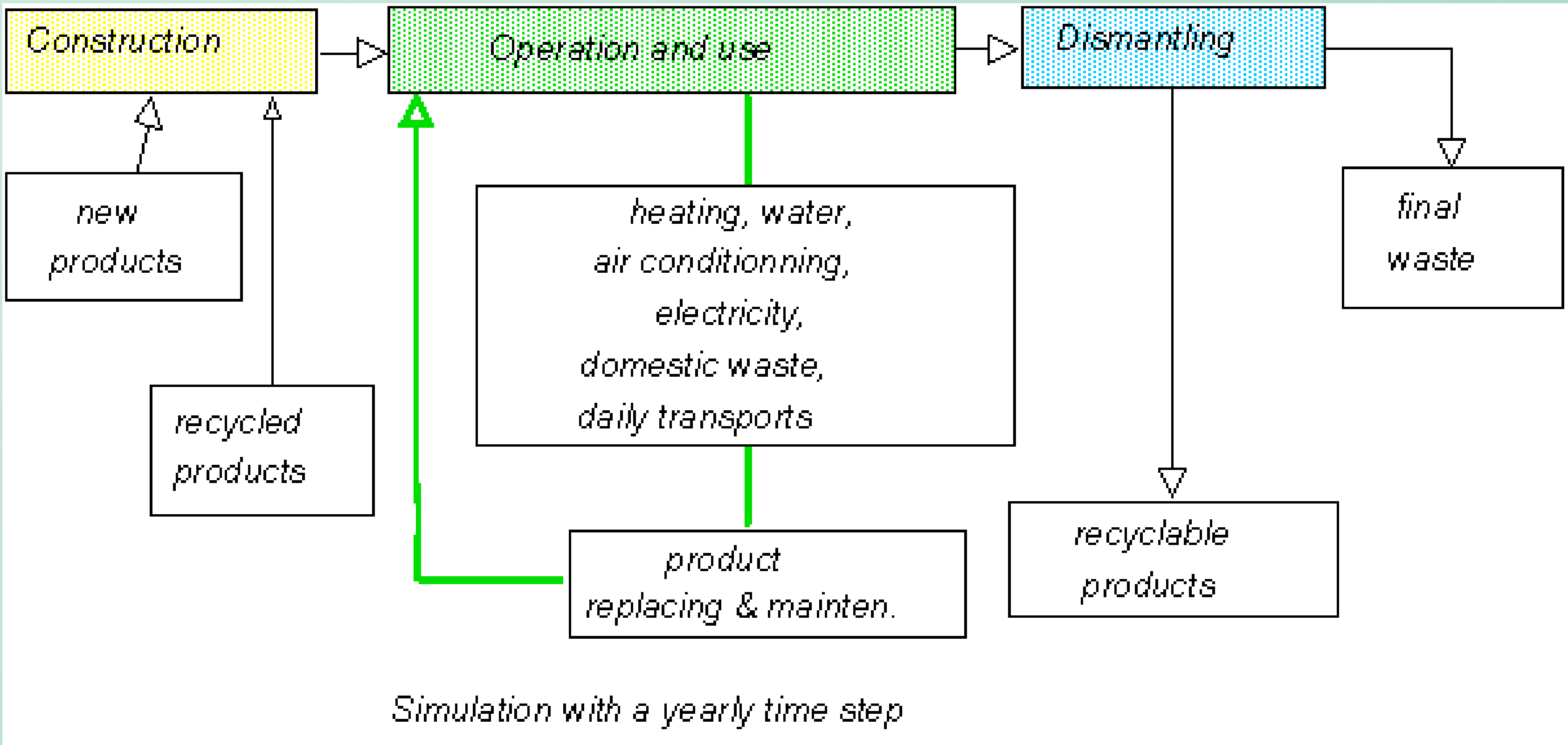
Life cycle assessment tool, EQUER



Simulation of the life cycle, accounting impacts year by year

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EQUER, example quantitative results

Equer

Fichier ?

Transport | Eau | Energie | Déchets | Matériaux | Calcul | Comparatif

Durée de l'analyse 80 ans

Lancer le calcul

Equality console

Equer console

Résultat à afficher

Impact	Construction	Utilisation	Rénovation	Démolition	Total
Energie consommee (MJ)	1010491.46549	36280678.88702	319335.12472	111654.34319	37722159.82042
Eau utilisee (m3)	940.97307	55194.76972	3511.86744	2159.00561	61806.61584
Utilisation des ressources abiotiques	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.00000
Dechets sterils produits (t eq)	60858.24260	42.73526	16601.10105	591113.34123	668615.42014
Dechets radioactifs (dm3)	0.21719	0.08402	0.00086	0.00042	0.30249
Effet de serre (kg CO2)	113903.78428	279082.45213	14912.05492	11638.59898	419536.89031
Acidification (kg SO2)	528.28276	753.09125	48.73926	45.75189	1375.86516
Eutrophisation (kg PO4)	70.65370	64.86307	6.34764	8.34285	150.20726
Ecotoxicite aquatique (m3)	1836042.29954	5428963.49935	521158.06157	359811.60214	8145975.46260
Toxicite humaine (kg)	205773184.20386	963.61531	411545124.88232	64.00529	617319336.70678
Production d'ozone photochimique (kg C2H4)	457.92271	392.19398	27.92867	48.25344	926.29880
Odeur (m3)	418249687.33301	3924453154.07812	12723086.42888	4484683.18819	4359910611.02820

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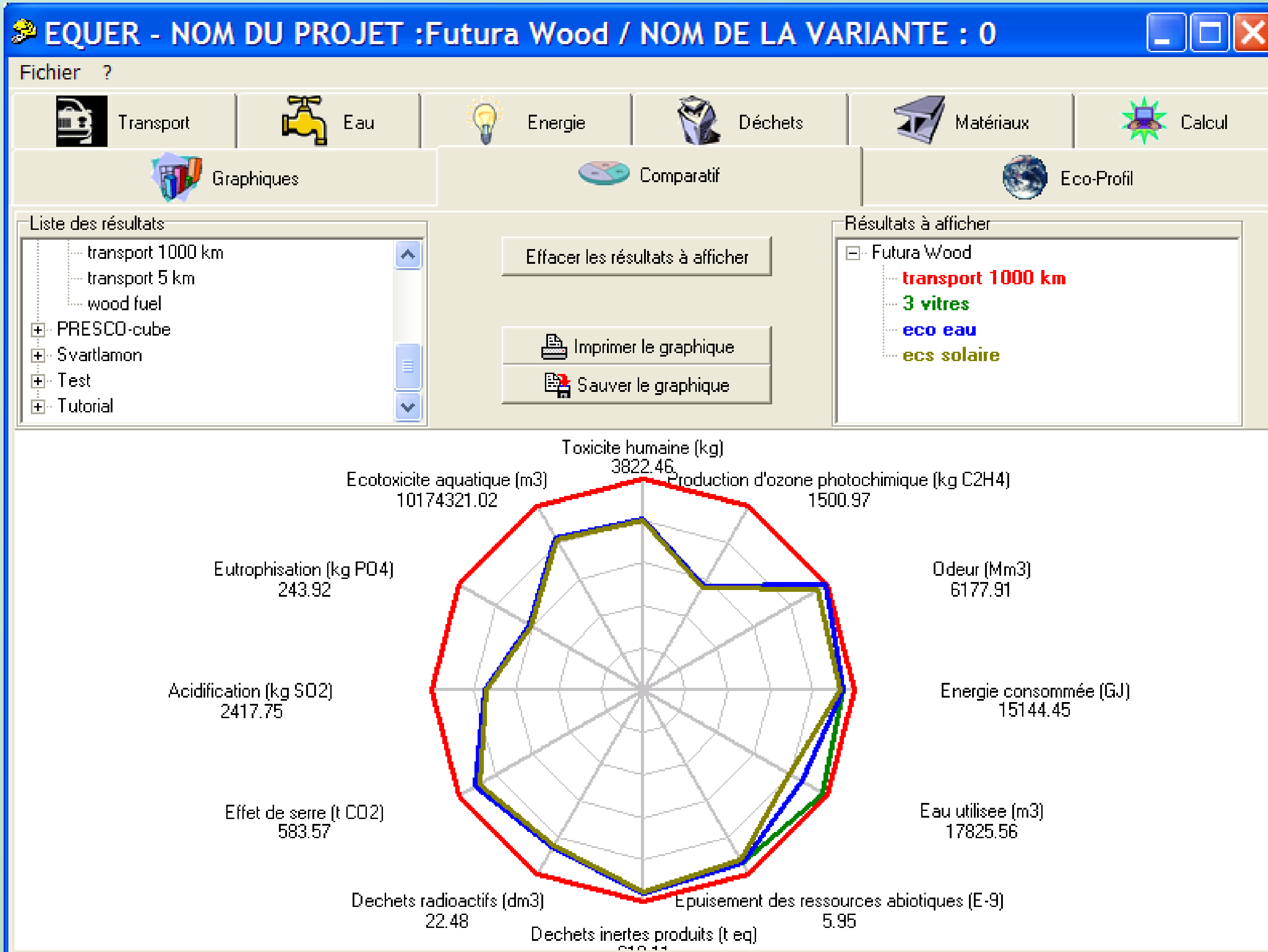
EQUER, example comparison of alternatives



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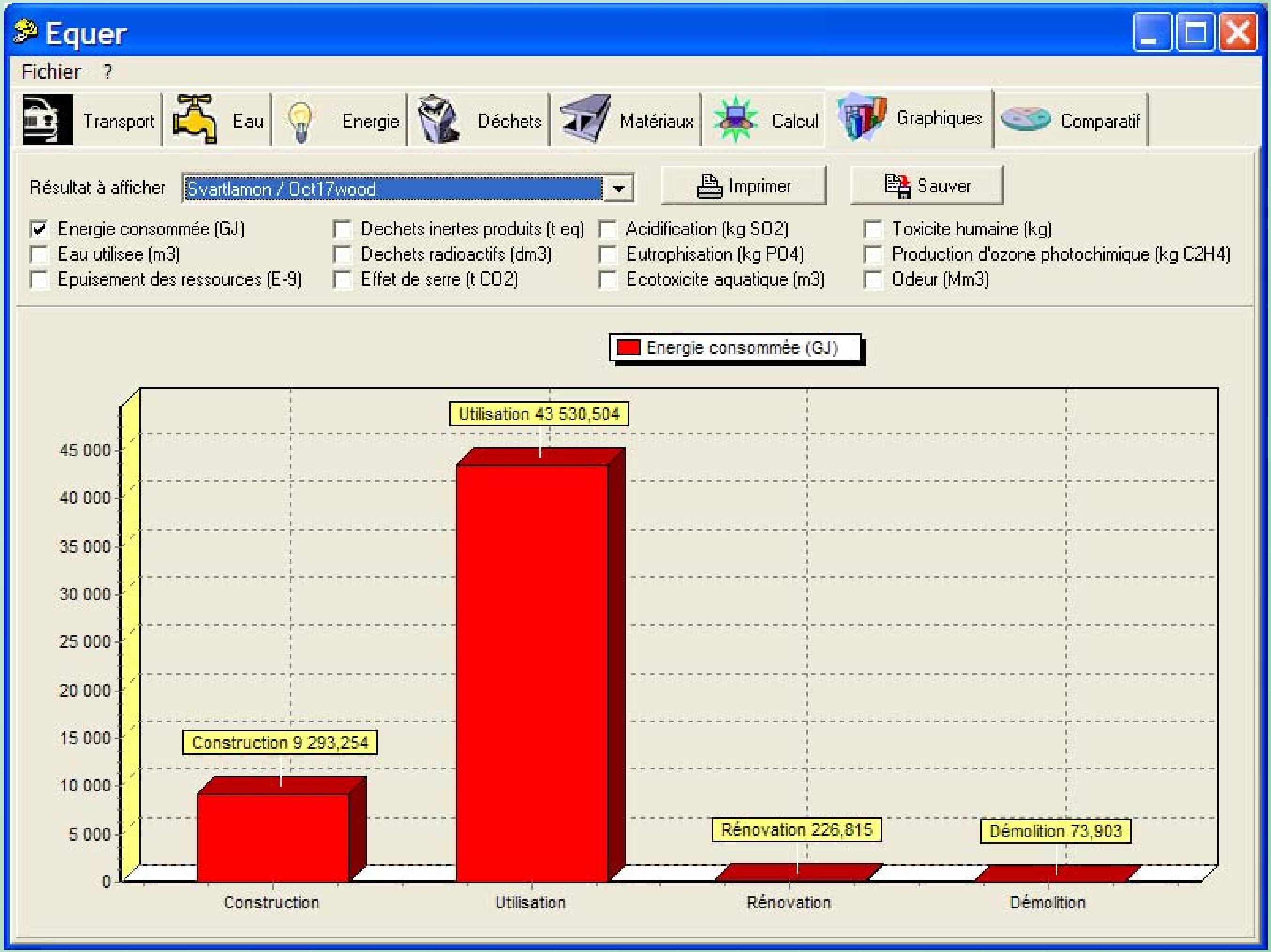
Contribution of life cycle phases

Construction, operation, renovation and demolition



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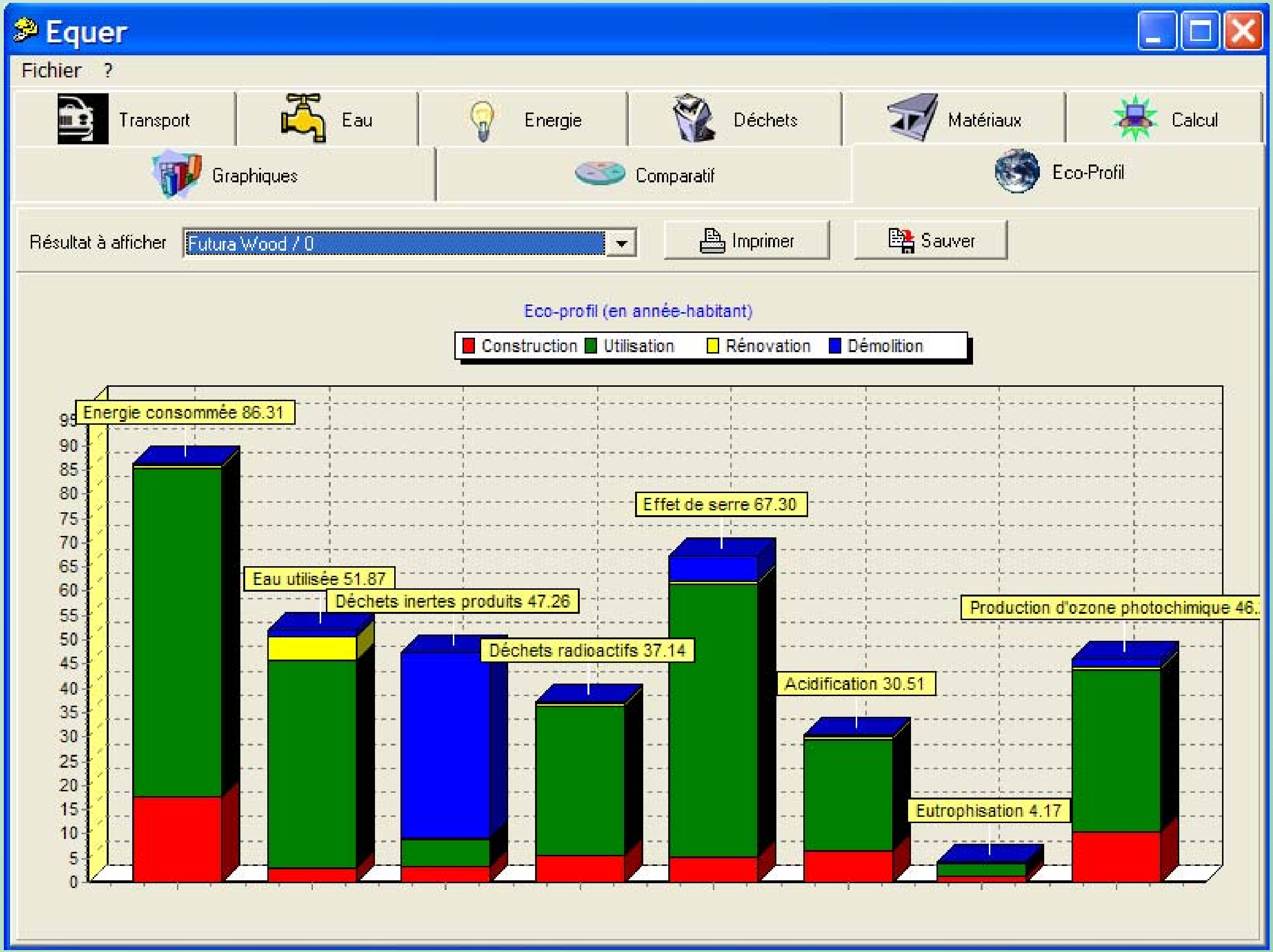
EQUER, example eco-profile



Normalisation -> same unit for all indicators : equivalent-person-year

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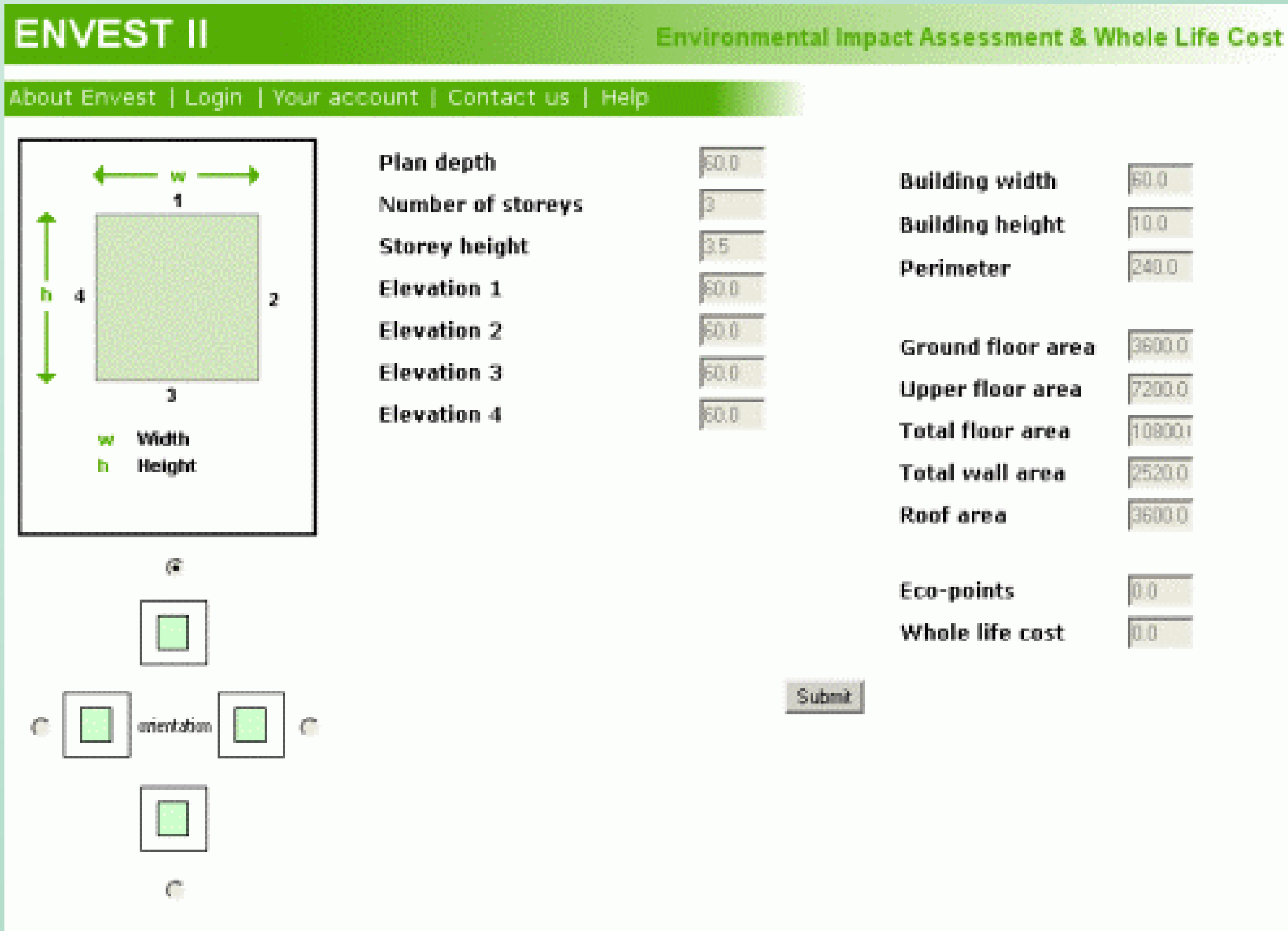
ENVEST, United Kingdom

www.bre.co.uk/services/ENVEST.html



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Envest, normalized profile

Issues	One UK Citizen	Normalised Data
Climate Change	12270 kgCO2 eq (100yr)	0.022
Acid Deposition	58.88 kgSO2 eq	0.037
Ozone Depletion	0.28595 kgCFC11 eq	0
Pollution to Air: Human Toxicity	90.7 kg.tox	0.036
Pollution to Air: Low Level Ozone Creation	32.23 kg ethene eq (POCP)	0.0024
Fossil Fuel Depletion and Extraction	4.085 toe	0.012
Pollution to Water: Human Toxicity	0.02746 kg.tox	0.000021
Pollution to Water: Ecotoxicity	837600 m3 tox	0.0000013
Pollution to Water: Eutrophication	8.006 kg.PO4 eq.	0.022
Minerals Extraction	5.04 tonnes	0.2
Water Extraction	417600 litres	0.0036
Waste Disposal	7.194 tonnes	0.015
Transport Pollution & Congestion: Freight	4140.84 tonne.km	0.062

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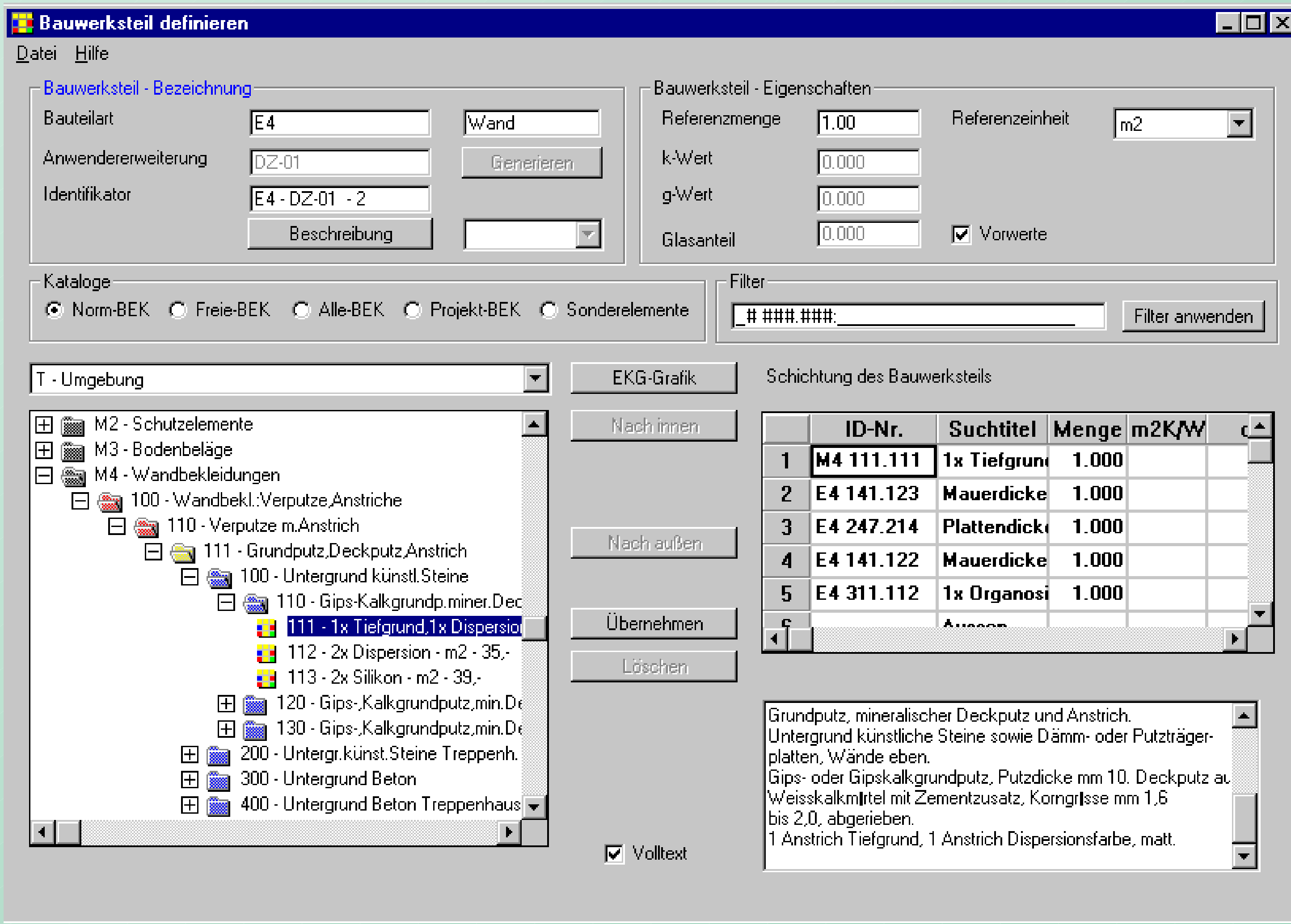
LTE OGIP, http://www.ogip.ch/



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INPUT

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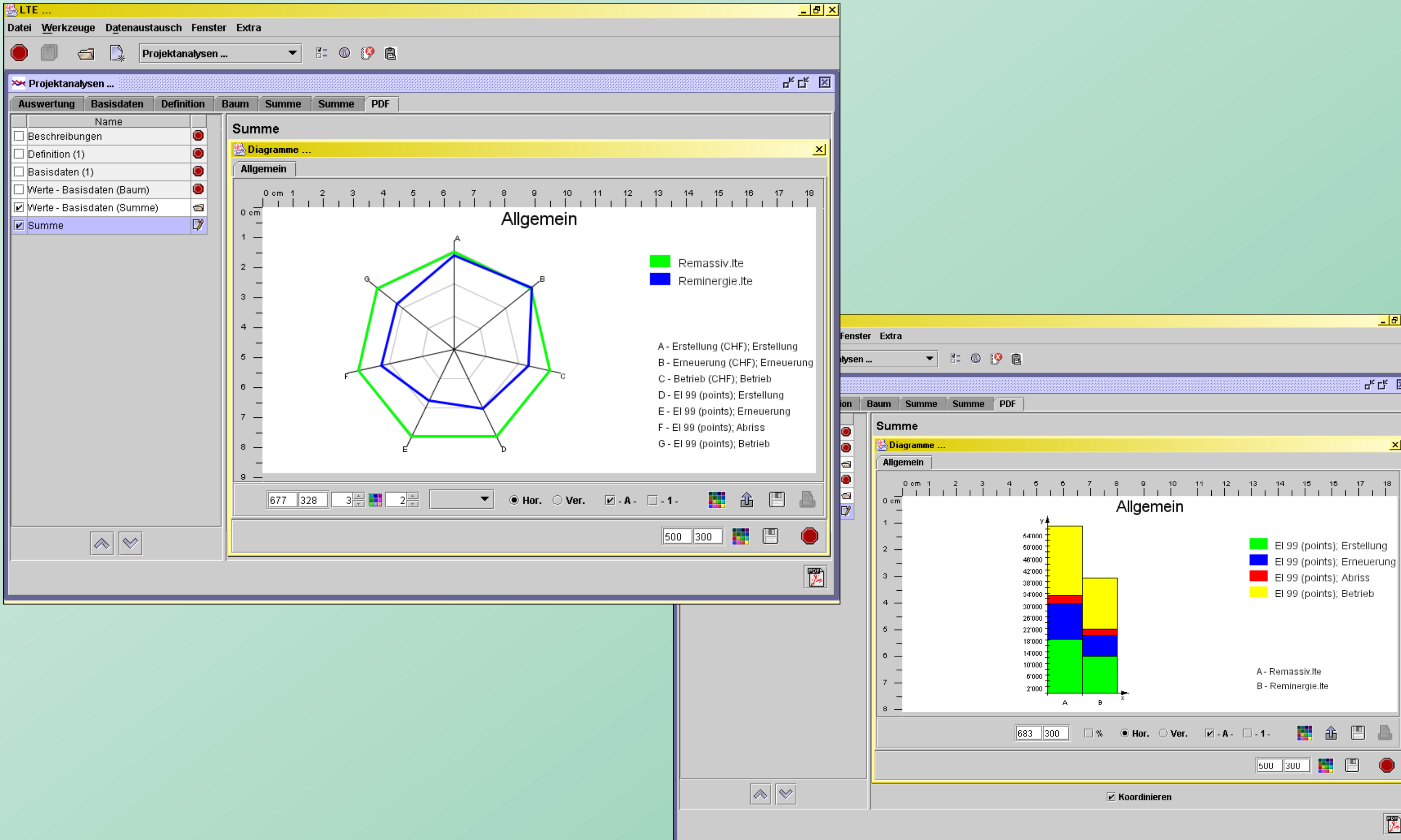
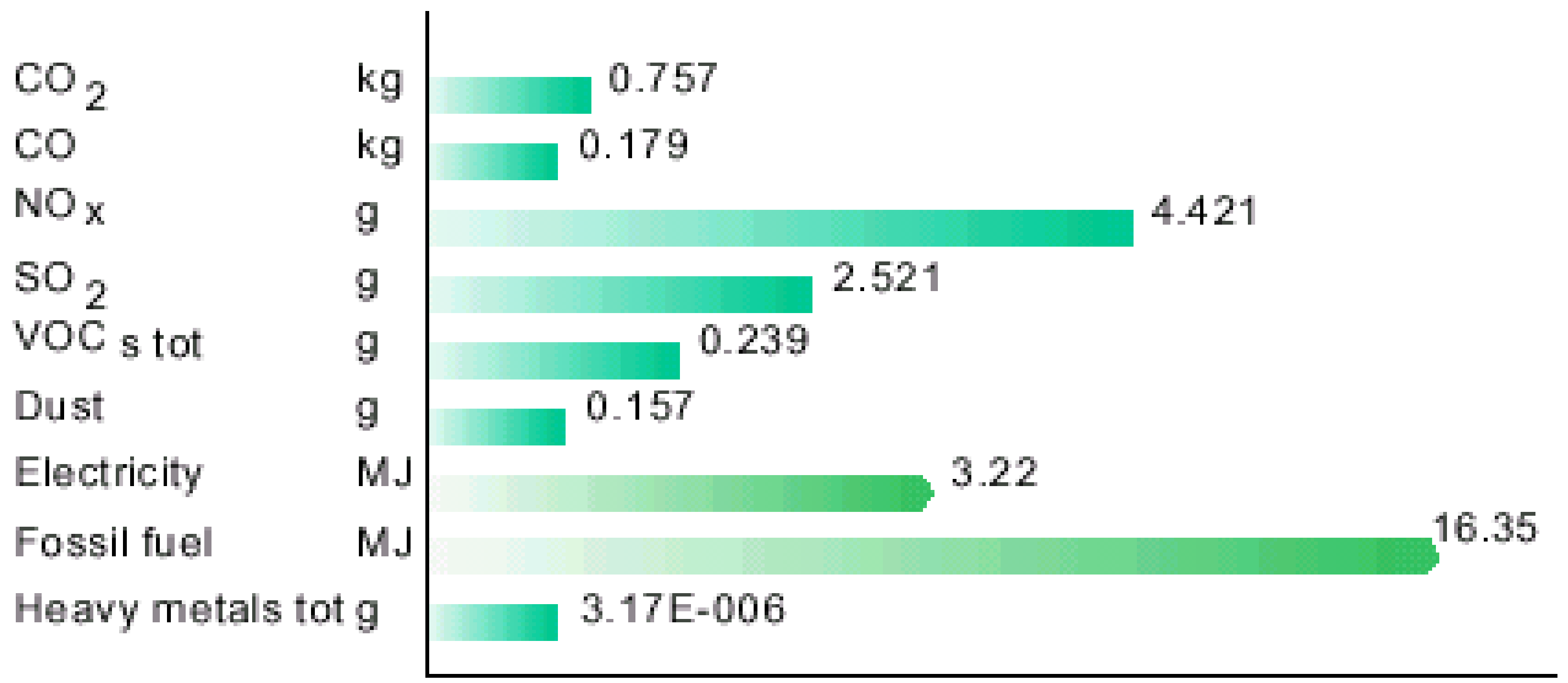
LTE OGIP, OUTPUT



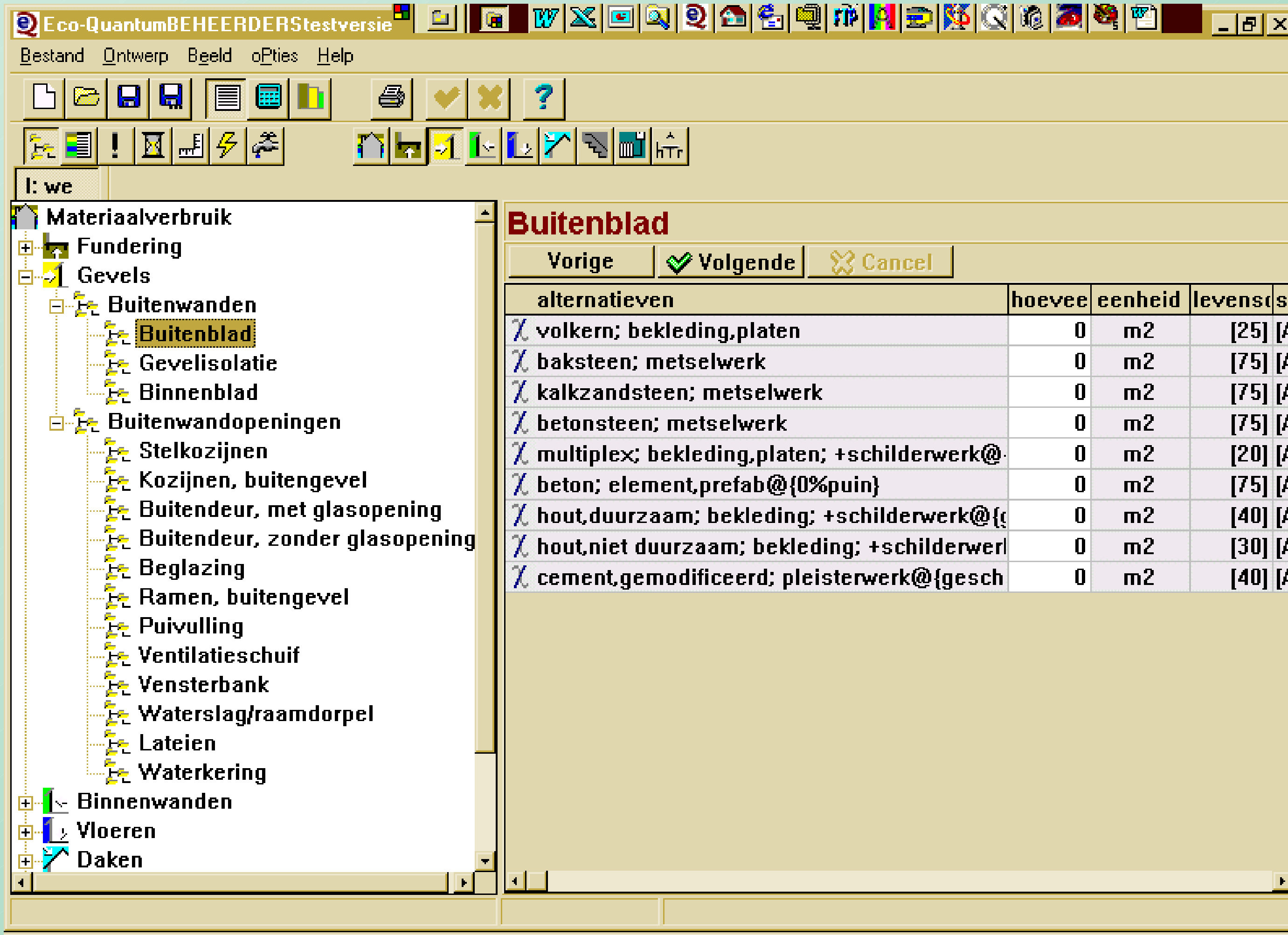
BECOST, Finland : http://www.vtt.fi/environ



Elinkaarianalyysi voidaan esittää ympäristöprofiilina - toiminnallisen yksikön vaikutuksena ympäristöön.

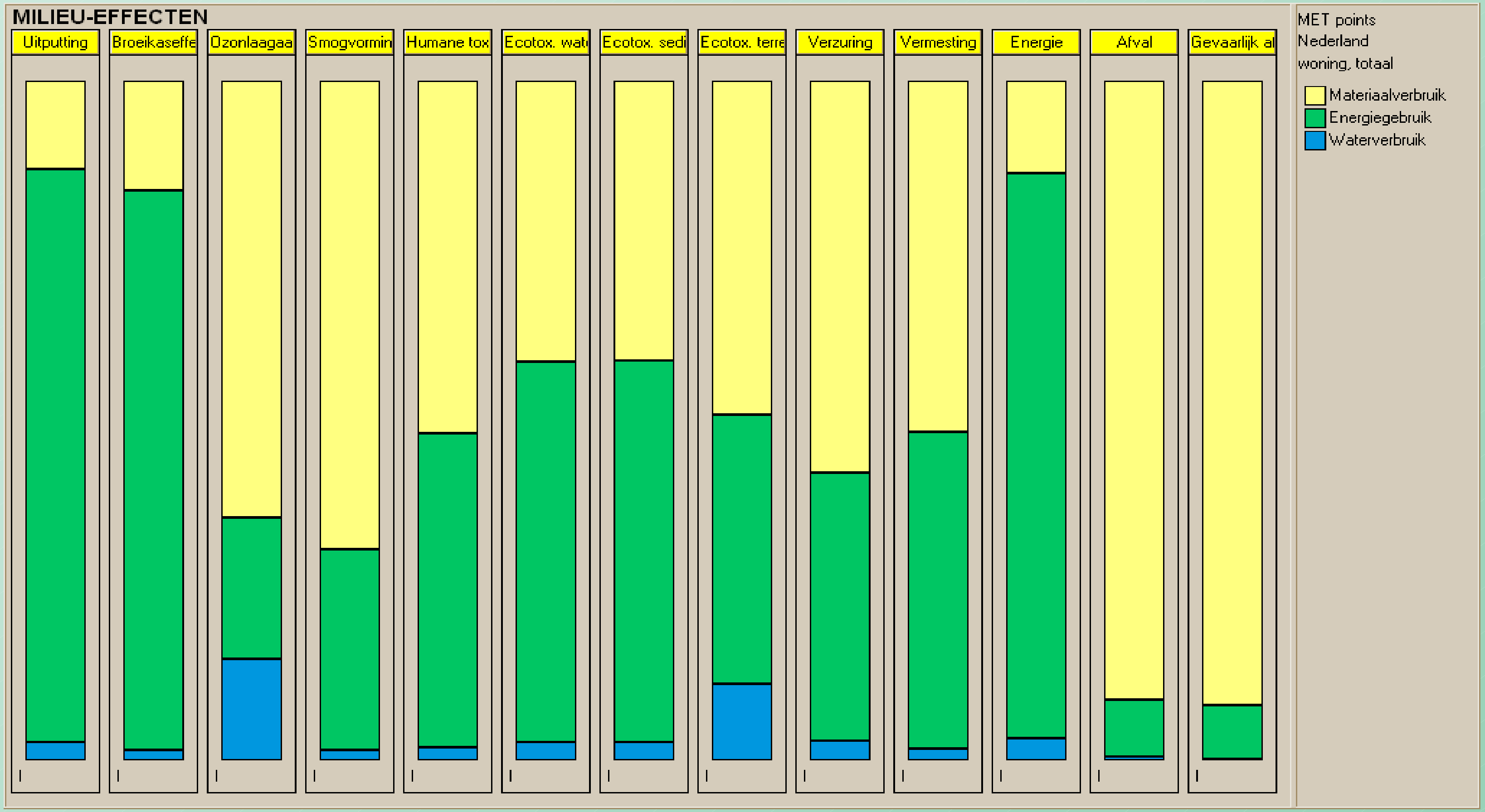
TREES

ECO-QUANTUM, The Netherlands, www.ecoquantum.nl



INPUT

Eco-Quantum, output



Contribution of different elements (floors, walls…)

12 environmental effects, 4 scores, 1 indicator

TREES

MINES PARIS ARMINES

ECOSoft, Austria

AW_brick_ExternalWall.xls

Baustofftabelle	Baustoffe.xls
Kategorie	Wählen Sie aus
Baustoff	Wählen Sie aus

Eintrag löschen | Update | Speichern

Schicht Nr.	Benennung der Schicht	Katalog	Dicke	Anteil	Dichte	Masse	Nutzungsdauer	global warming (GWP100)	ozone layer depletion (ODP)	photo-chemical oxidation	acidification	eutrophication	PEI nicht erneuerbar	PEI erneuerbar
			m	%	kg/m³	kg	Jahre	kg CO2 eq.	kg CFC-11 eq	kg C2H2	kg SO2 eq.	kg PO4 eq	MJ	MJ
1	Gipsputz	Baustoffe.xls	0,005	100%	1100	5,5	80	0,583	1,3915E-07	0,00005104	0,00159	0,000173	11,02	0,15
2	Hochlochziegel hochporosi	Baustoffe.xls	0,25	100%	750	135	80	33,750	0,000010449	0,0016065	0,1404	0,010679	370,74	6,52
3	Mörtel	Baustoffe.xls		100%		10	80	2,080	0,000000753	0,000159	0,00676	0,000673	15,78	0,72
4	Mineralischer Kleber	Baustoffe.xls		100%		5	80	1,040	3,765E-07	0,0000795	0,00338	0,000337	7,89	0,36
5	Holzweichfaserplatte	Baustoffe.xls	0,17	100%	210	35,7	80	-34,568	1,81237E-05	0,0088298	0,243593	0,011127	682,55	731,05
6	Glasfaserarmierung	Baustoffe.xls		100%		0,2	80	0,312	0,000000117	0,0000228	0,001904	0,000149	6,50	0,26
7	Silikatputz	Baustoffe.xls	0,01	100%	1800	18	80	3,744	1,3554E-06	0,0002862	0,012168	0,001211	28,41	1,30

Betrachtungszeit 80	6,941	3,13138E-05	0,01103484	0,409795	0,024348	1122,89	740,37
Materialkosten							
Arbeitskosten							
Gesamtkosten 0							

AW_brick_ExternalWall / Statistik

TREES

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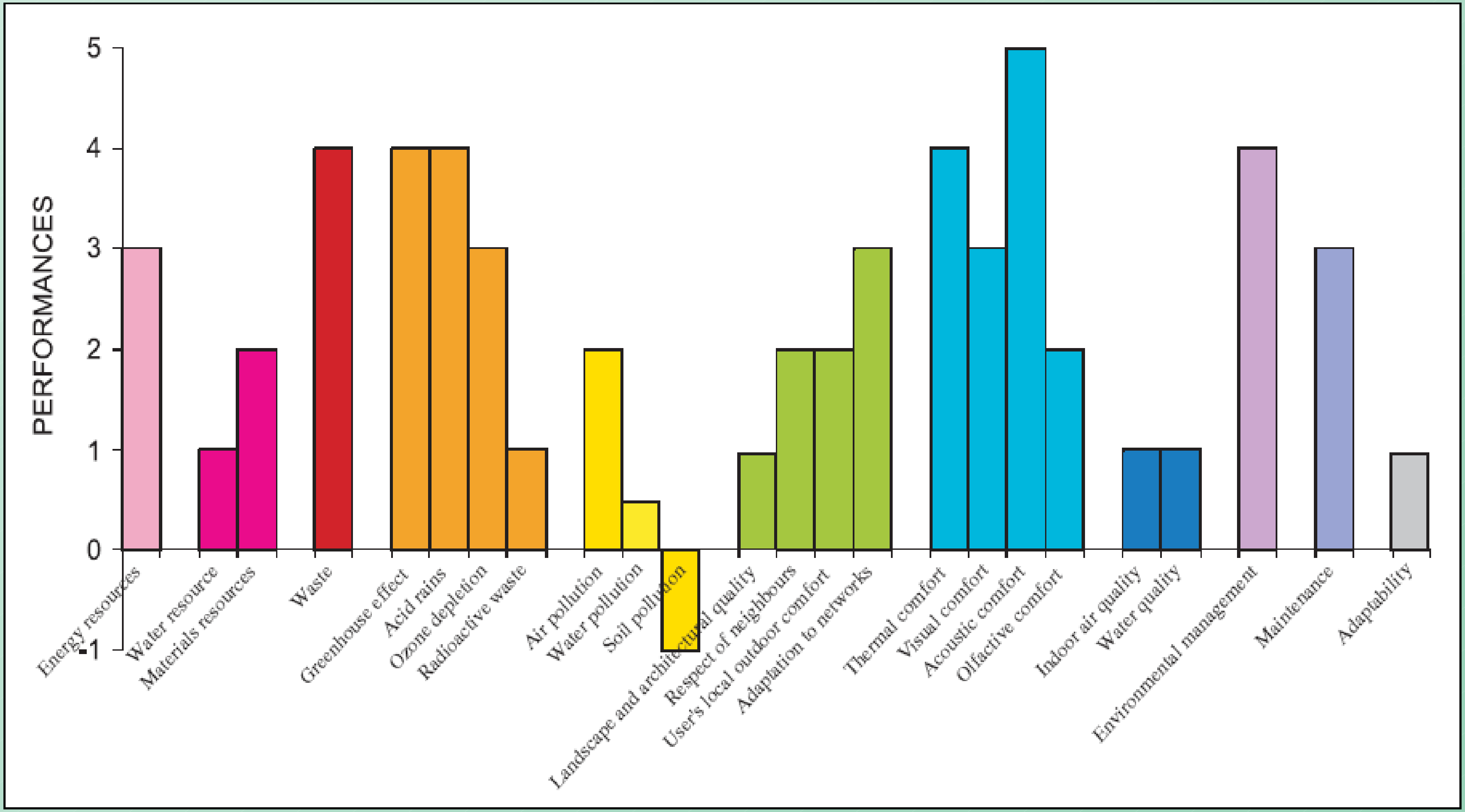
ESCALE, France

combined with INIES and SIMA-PRO



TREES

Notes between 0 and 5 for 12 criteria

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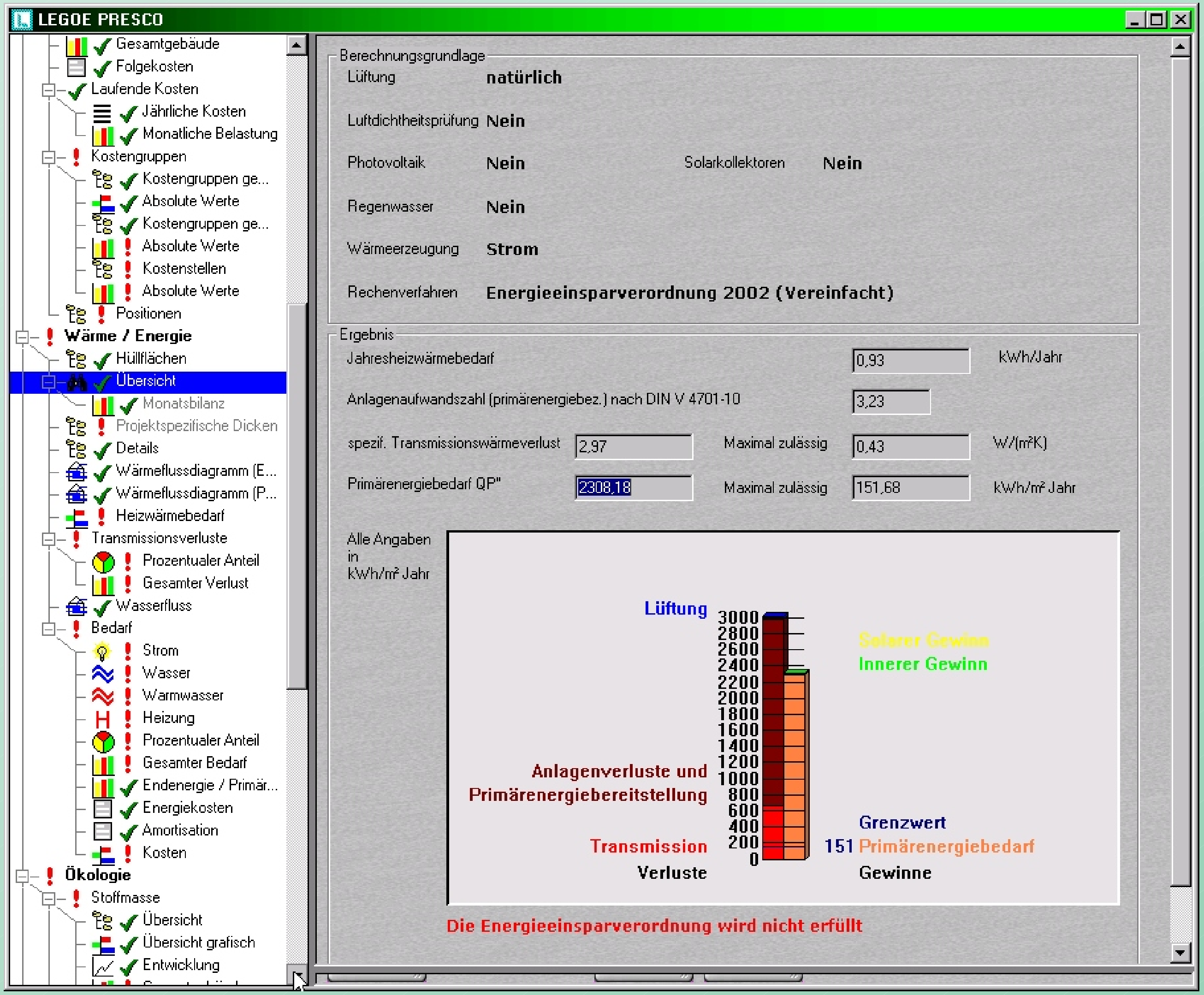
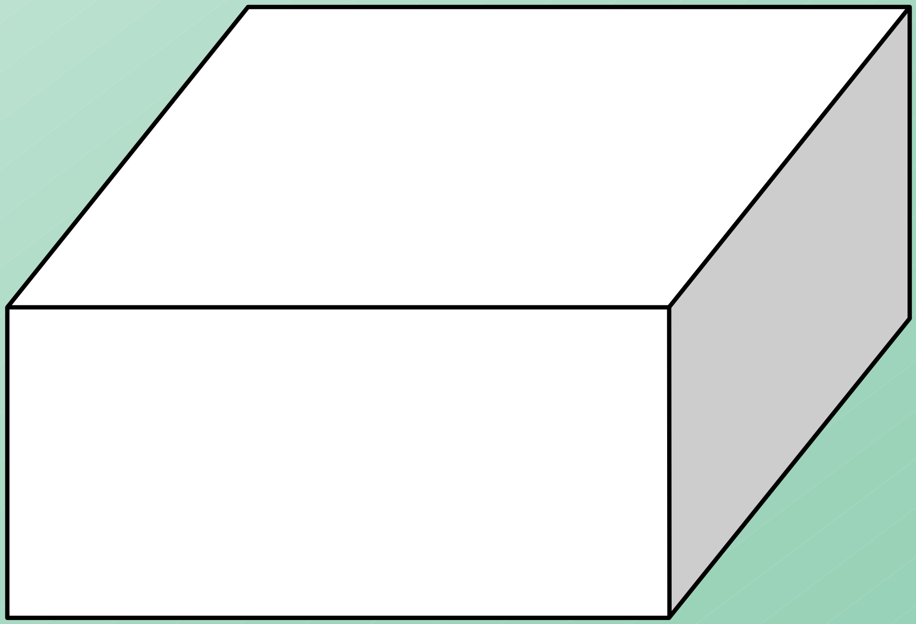
LEGEP, Germany, www.legep.de



First study : « cube »

Steel reinforced concrete, 20 cm thick
Electric heating
(E.U. electricity mix)
50 years
Transport
Construction
End of life



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Main assumptions (1)

- **Transport of materials**
- **Quantity and management of construction waste**
- **Electricity production and transport**
- **Occupants related impacts (e.g. water consumption, domestic appliances, home-work transport, domestic waste)**

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Main assumptions (2)

- **Energy calculations (EN 832, simulation)**
- **Refurbishment processes**
- **Demolition processes**
- **Transport of waste**
- **End of life processes**

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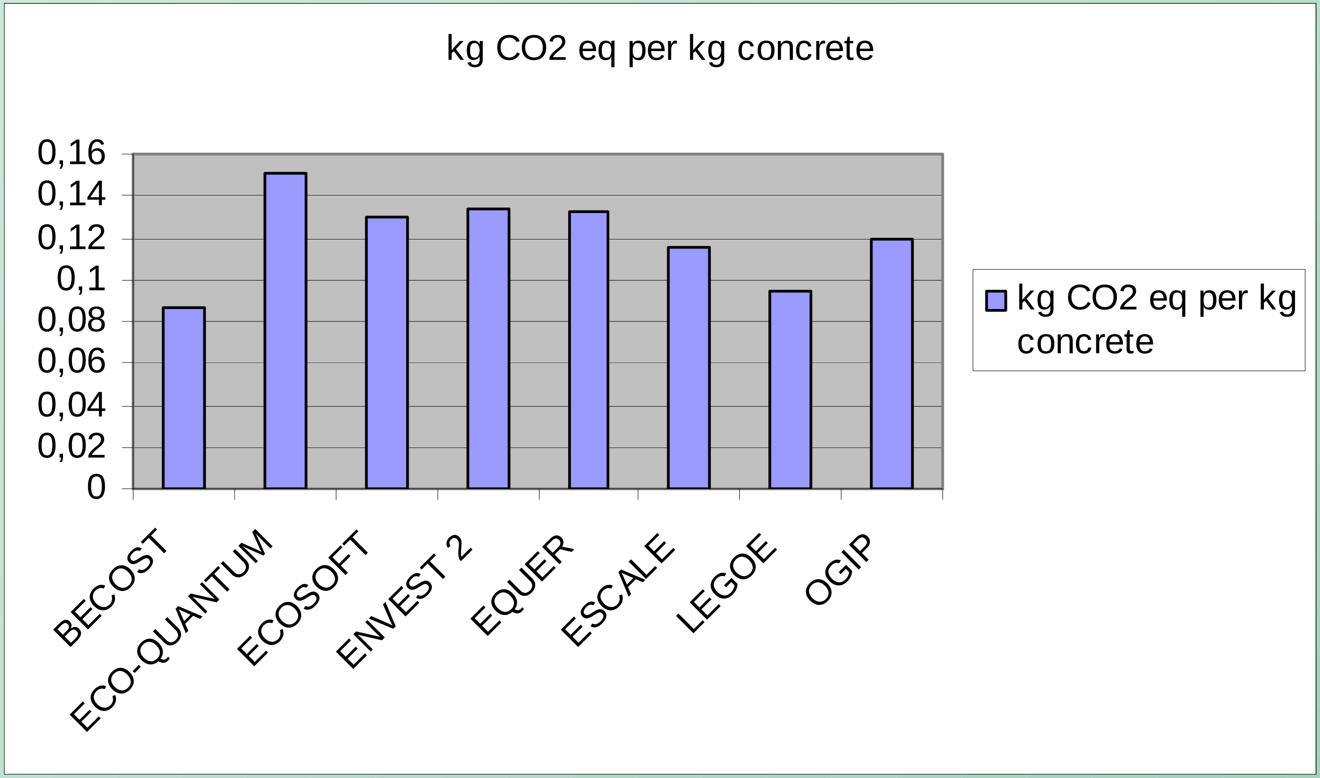
Example, LCI of concrete



Different qualities, cement content 120-300 kg/m³
Different processes (prefabricated) and energies
Different indicators : IPCC, CML… + alloc. (ash)

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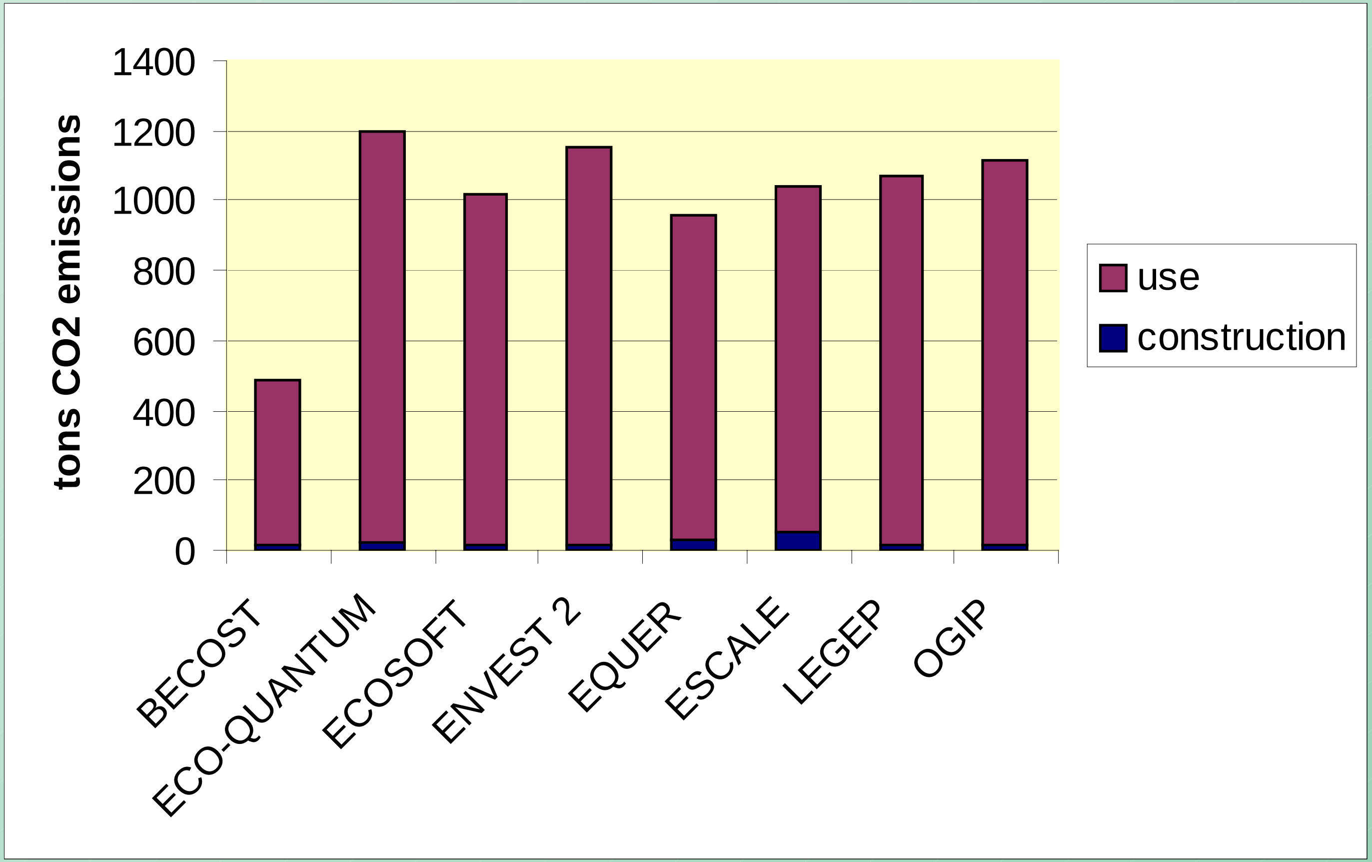
Results for climate change



+ / - 10% discrepancy except Becost (use of Finnish electricity mix)

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Uncertainties, discrepancies

- **Quantities (internal / ext. Dimensions)**
- **Steel % in reinforced concrete 0.83 to 3%**
- **% surplus during construction (0 to 10%)**
- **Transport of materials : 0 to 50 km**
- **Life span of materials and components**
- **Transport of waste : 0 to 20 km**
- **End of life : landfill**

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Second study : FUTURA House

Single family house, 210 m2, gas heating, 80 years

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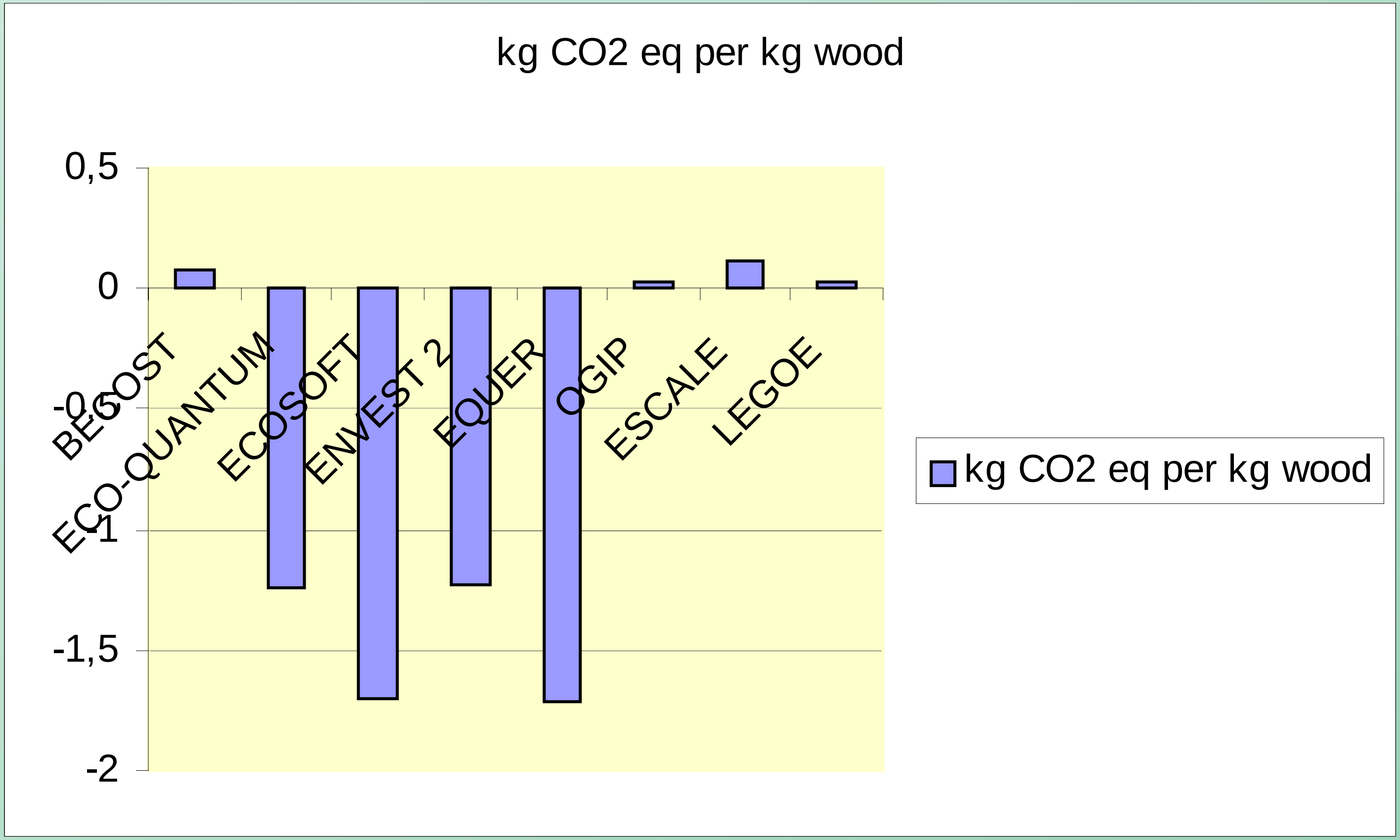
LCI of wood production



2 groups of tools : 0 CO_2 balance versus storage

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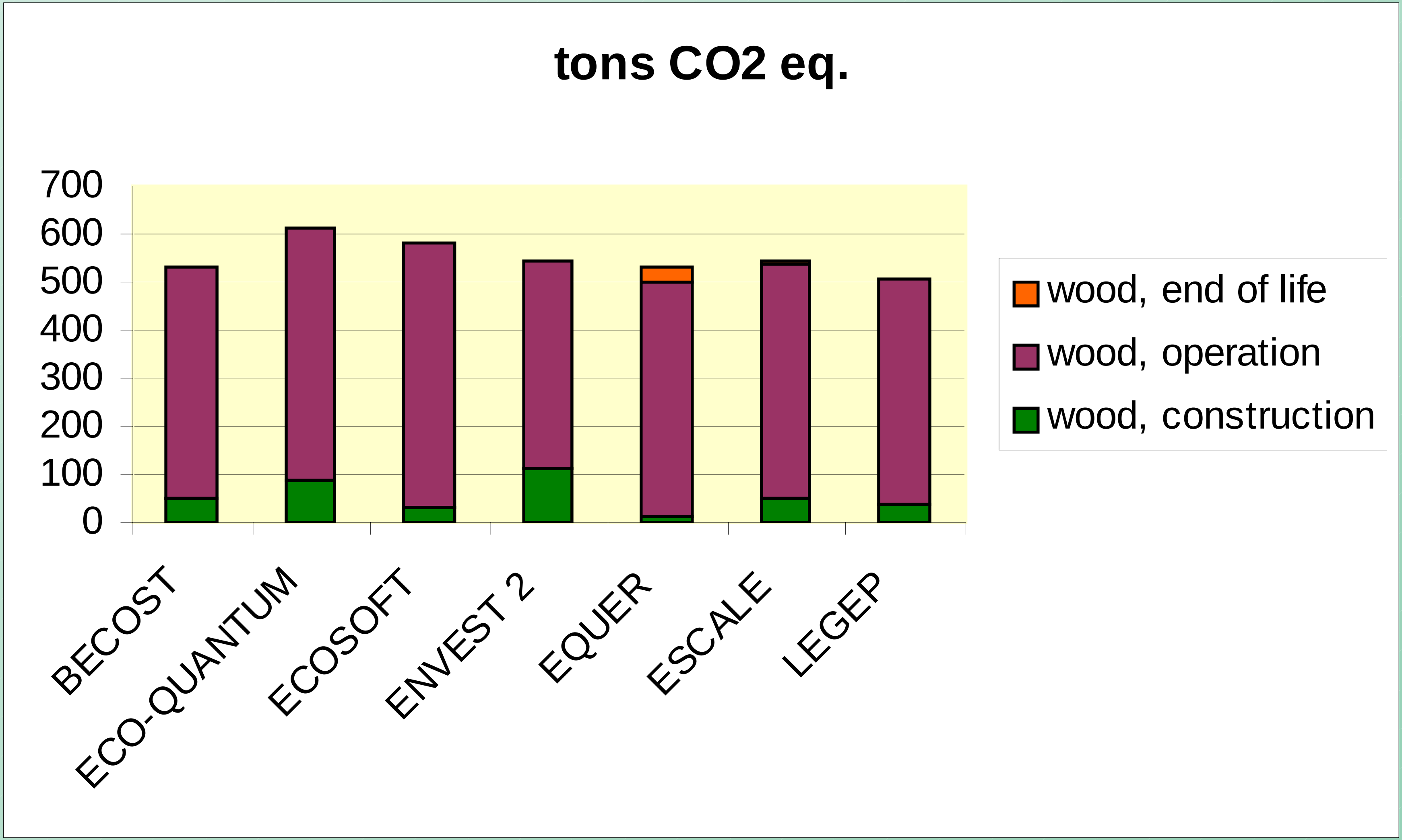
Comparison of LCA tools



+- 10% discrepancy over the life cycle

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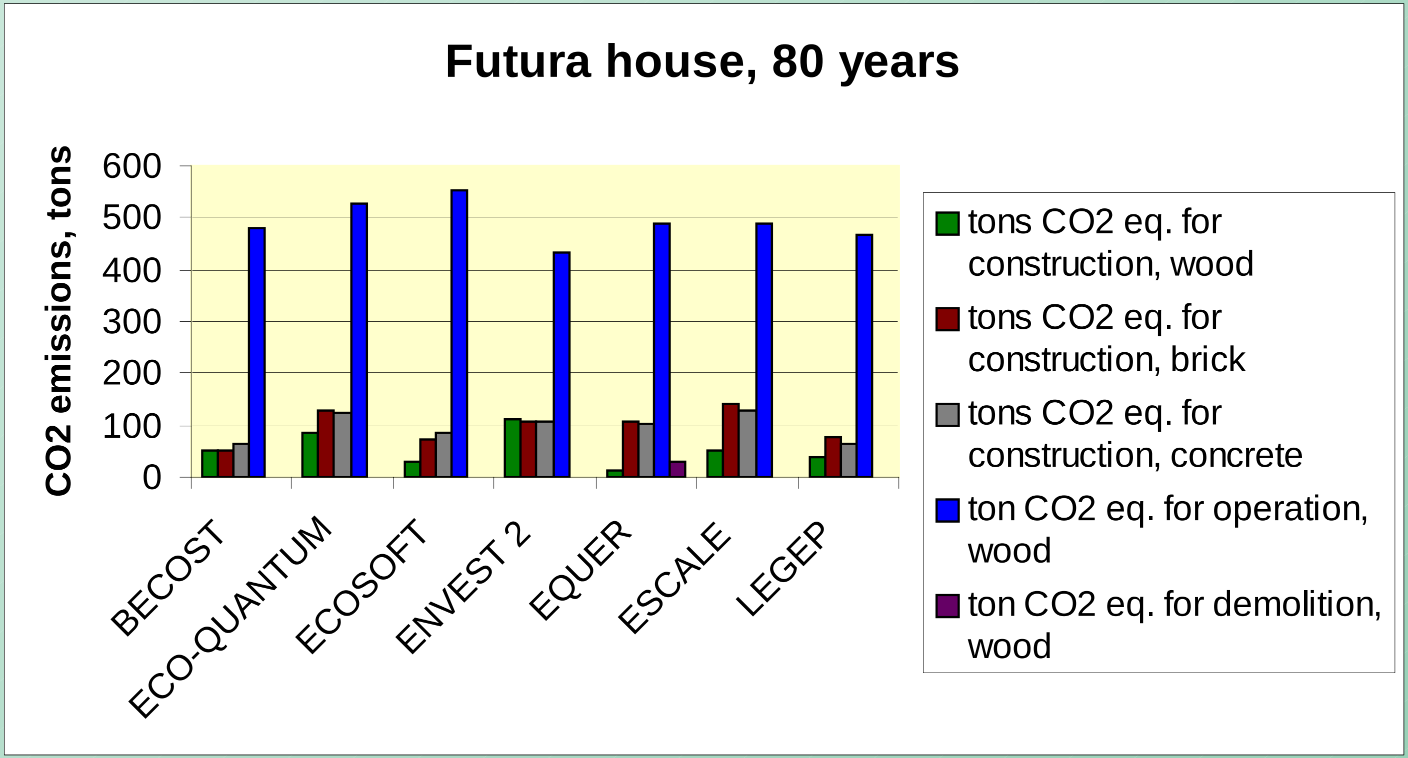
Comparison of wood, brick and concrete constructions, CO_2

+/- 10%



CO_2 emissions with wood <= other materials

CO_2 with brick > CO_2 with concrete ?

yes for 4 tools, no for 3 tools

TREES

Examples of good practice

- **scope, assumptions and methodology should be transparent**
- **recent and specific data with consistent methods**
- **promote the use of recycled materials + recycling at the end of the life cycle**
- **default value for transport to site and for each type of waste treatment process (incineration, landfill, recycling, ...), product specific values if available data**
- **water : should be included in the results --> can promote water saving measures**
- **Aggregated weighting factors (e.g. ecopoints) not recommended**

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Example LCA application, renovation of a social housing block near Paris

Construction : 1969, not insulated, single glazing

Heating load : 150 kWh/m2/an

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Comparison of alternatives

- **Before renovation**
- **Standard renovation : 6 cm external insulation, standard double glazing**
- **European project REGEN LINK : 10 cm insulation, low emissivity glazing, moisture-controlled ventilation, air preheating in glazed balconies, low flow rate sanitary equipment**
- **Use of biomass in district heating**

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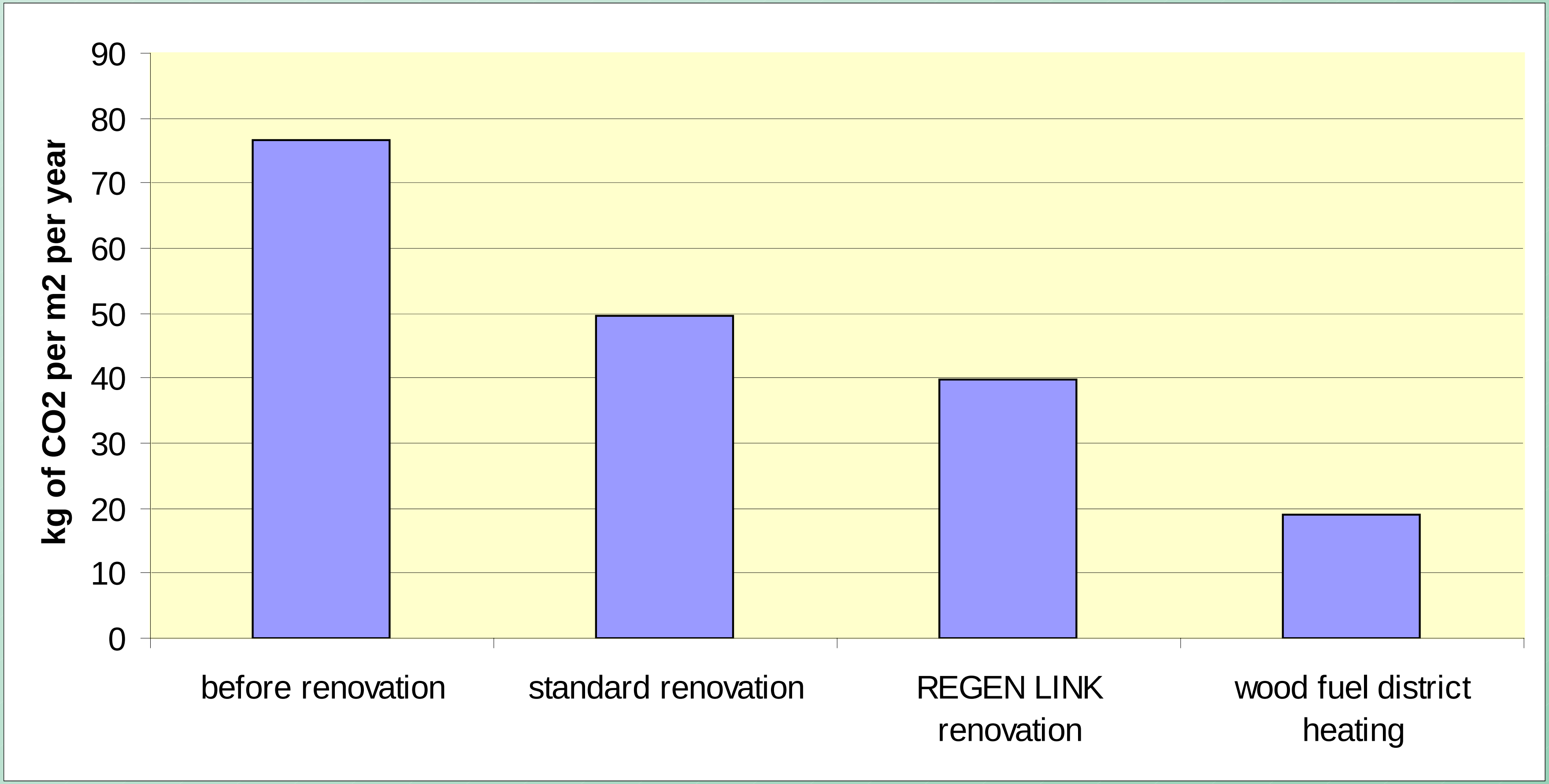
Results of life cycle assessment, EQUER



CO_2 emissions per m^2 and per year

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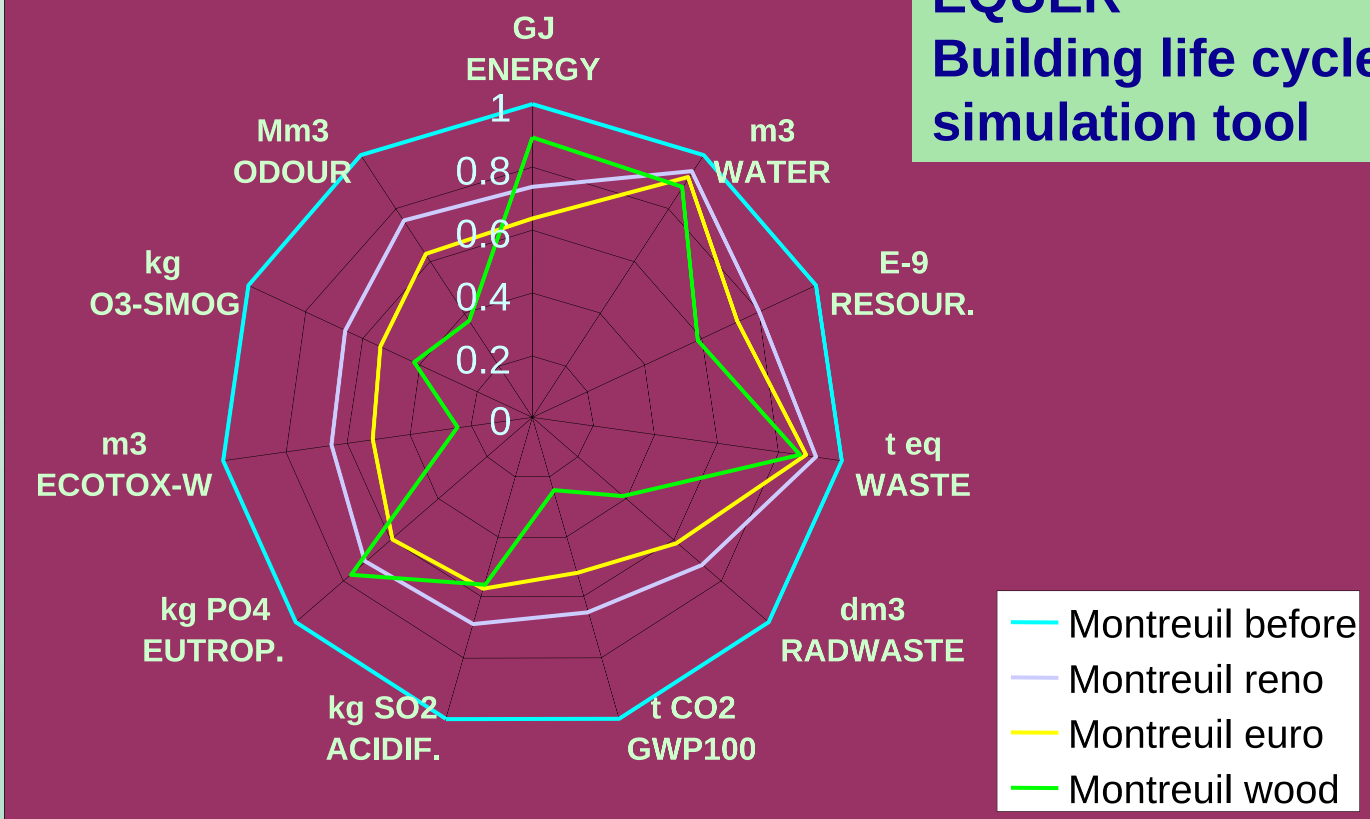
Results of life cycle assessment, EQUER



EQUER
Building life cycle simulation tool

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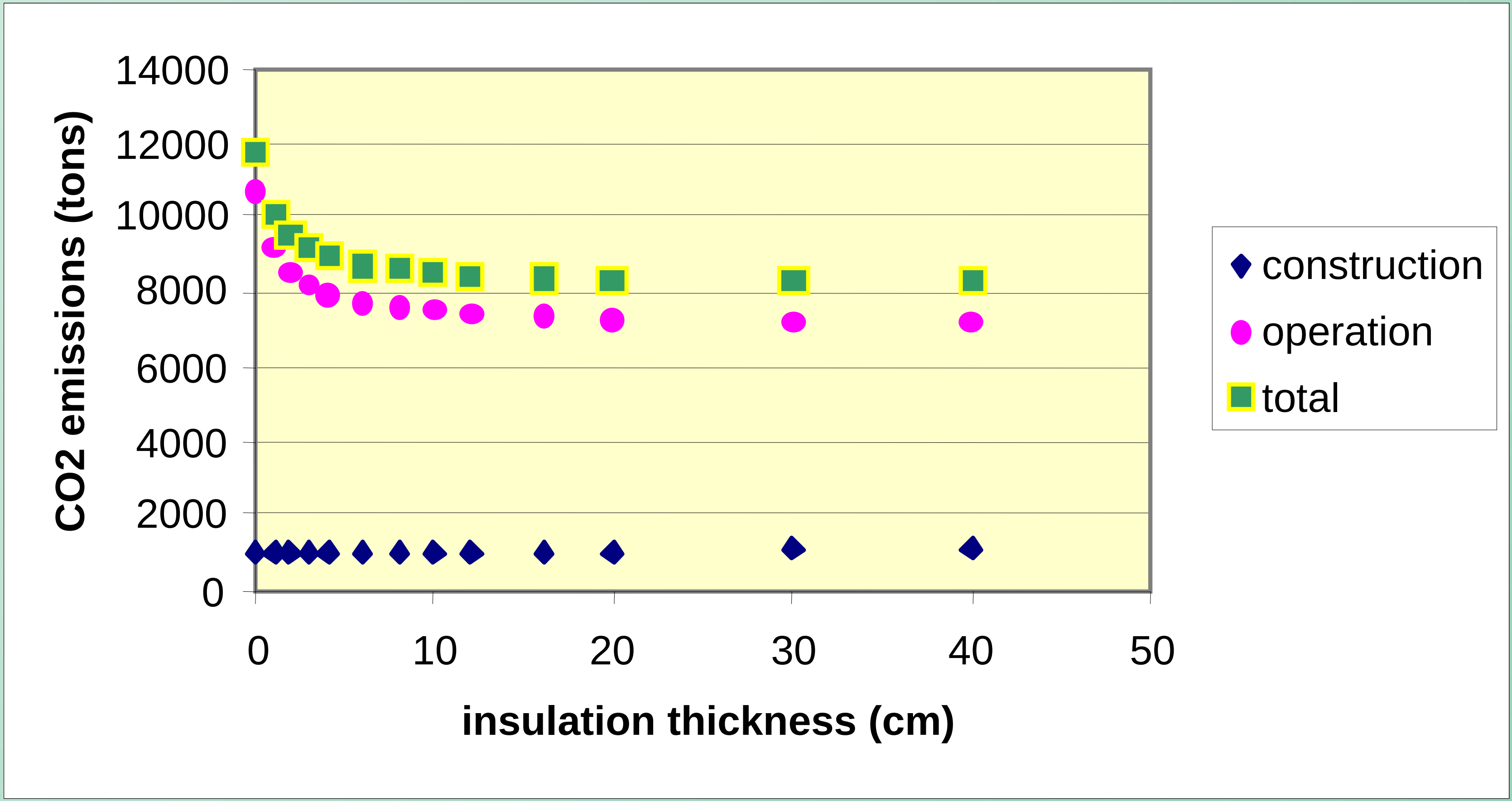
Facade insulation



Life cycle assessment, example : CO_2 emissions

Optimum 20-40 cm (CO_2), 10 cm (cost)

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Influence of building design and occupants behaviour on environmental performance

- **2 building designs**

Standard house in France

Higher environmental quality house

- **2 types of occupants' behaviour**

« Economical »

« Spendthrift »

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2 building designs

Component	Reference (REF.)	"Higher environmental quality" (HEQ)
insulation	8 cm internal	12 cm external
glazing area	10 m2, north oriented	25 m2, south oriented
controlled ventilation	without exchanger	heat recovery, efficiency 0.5
sanitary installations	standard	reduced water flow rate (of 50%)
waste sorting equipment	only for glass	for paper and glass

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2 types of occupants' behaviour

Parameters	"Economical"	"Spendthrift"
Set point temperature	varying between 14°C and 19°C	21°C constant
Ventilation	0.5 ACH	1 ACH
Electricity consumption	150 W	300 W
Domestic hot water	40 l/person/day[A]	60 l/person/day [A]
cold water	80 l/person/day [A]	150 l/person/day [A]
urban waste	0.8 kg/person/day	1.5 kg/person/day
paper sorting	60% [B]	0%
glass sorting	80%	0%

[A] ***divided by two for the "Higher environmental quality" case, due to the reduced flow rate.***

[B] 0% for the reference case as there is no paper sorting possibility.

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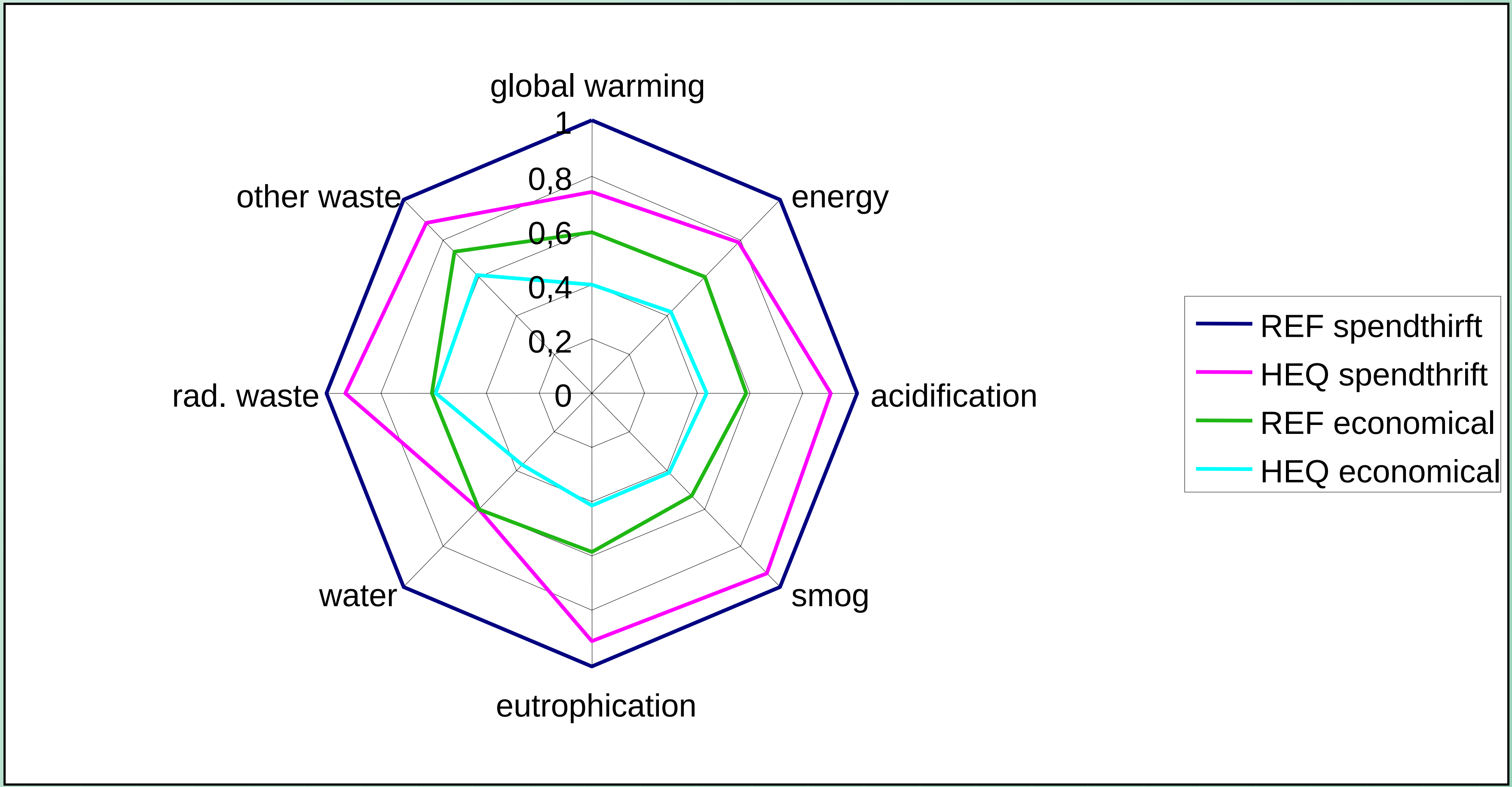
LCA results



Design is not sufficient, information of residents about propper management is essential

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Conclusions

- **Life cycle simulation is operational, though only emerging and used by specialised architects and consultants**
- **LCA could be used to determine appropriate environmental targets according to a context, and to check the compliance of projects**
- **Environmental benefit from RE in buildings, materials become important with lower energy use**
- **Retrofit can be compared to rebuilding**

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