

**International Symposium on
Life Cycle Assessment and Construction
Session “Dynamic LCA”**

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LCA application in urban design

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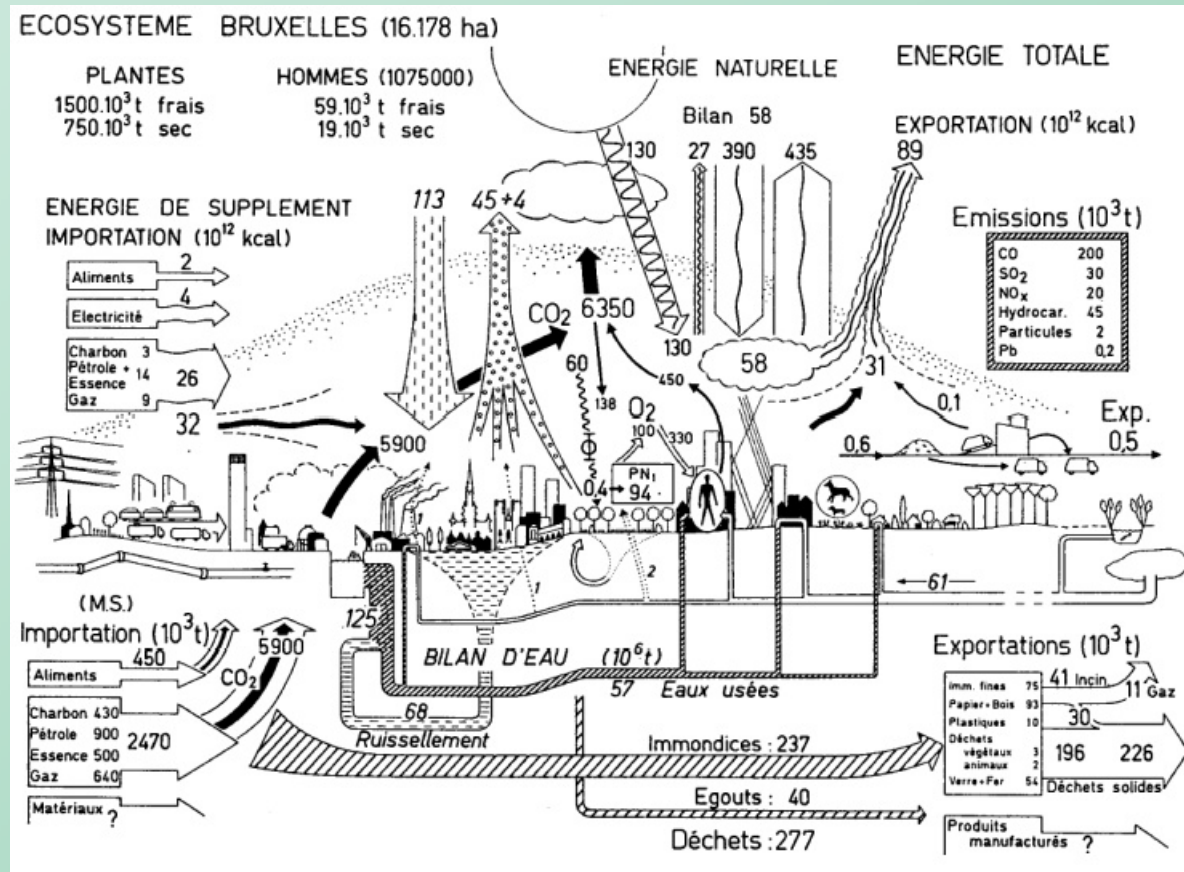
- ▶ **Context and pioneer work**
- ▶ **From buildings to urban blocks**
- ▶ **Model and indicators**
- ▶ **Reliability of models, intercomparison**
- ▶ **Example applications**
- ▶ **Conclusions and perspectives**

Why expanding the scale ?

- ▶ **Large influence of decisions at the urban scale on environmental performance of buildings, e.g. spatial organization (compactness, solar exposure...) has a strong influence on energy and material flows**
- ▶ **Possibility to exchange energy between buildings**
- ▶ **Possibility to study collective equipment like district heating, wastewater treatment etc.**
- ▶ **Transport related impacts are important**

Pioneer work on « urban metabolism »

Abel Wolman (1965), Eugene Odum (1971)

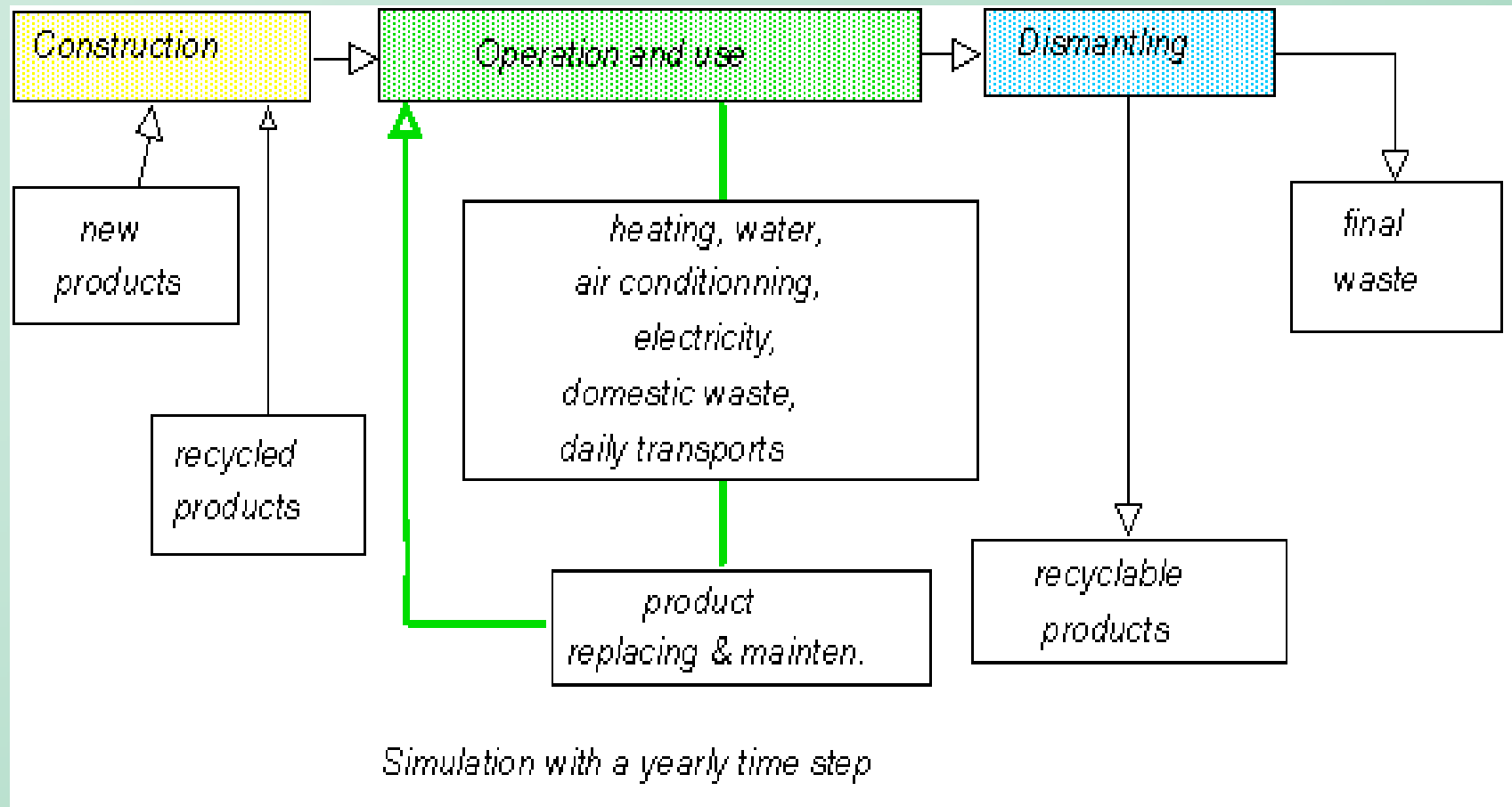


Duvigneau, Denaeyer-De Smet, 1977

Pioneer and previous work on LCA

- ▶ Building scale
- ▶ Kohler N., PhD, Ecole Polytechnique Fédérale de Lausanne, 1986
- ▶ Cole et al., "Buildings and the Environment", International Workshop, Cambridge, 1992
- ▶ Polster B., PhD, MINES ParisTech, 1995, development of EQUER
- ▶ Mak J., Anink D., Kortman J. et al., ECO-QUANTUM, 1996
- ▶ Similar work in Denmark, Canada then UK, Australia...
- ▶ Urban scale
- ▶ Kohler et al., LEGEP and building stock models
- ▶ Robinson D., development of CitySim
- ▶ Popovici E., PhD, MINES ParisTech, 2006, LCA of urban blocks

Building Life cycle assessment tool, EQUER



Simulation of the life cycle, accounting impacts year by year

Evaluation of environmental indicators

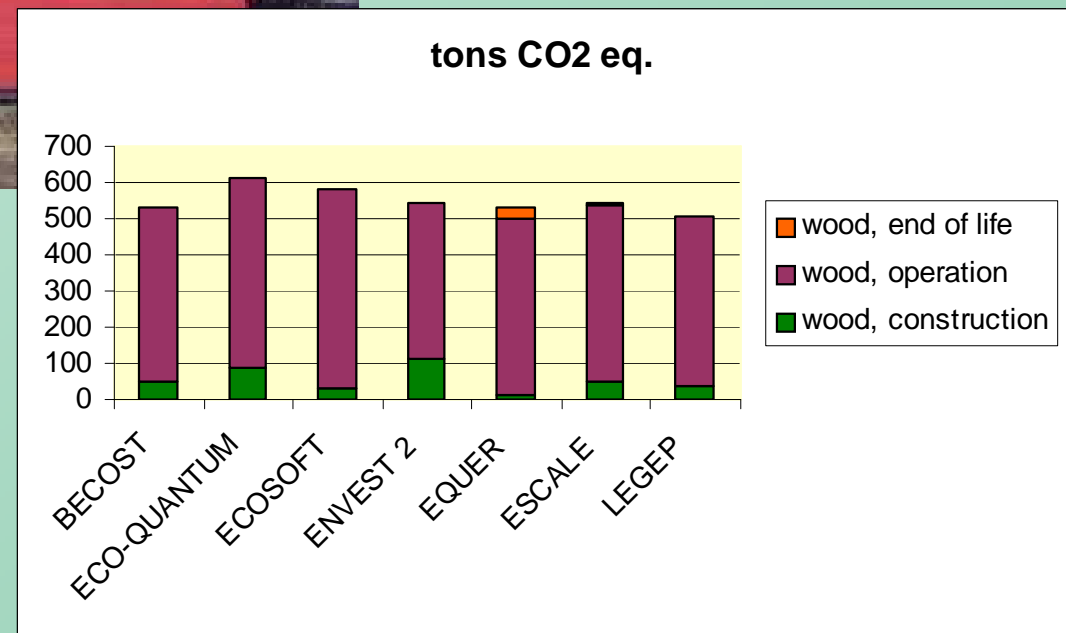
Impact indicator	Unit	Legend
Cumulative Energy Demand	GJ	ENERGY
Water consumption	m ³	WATER
Abiotic Depletion Potential	kg Sb-eq	RESOURCE
Non-radioactive waste creation	t eq	WASTE
Radioactive waste creation	dm ³	RADWASTE
Global Warming Potential at 100 years (GWP ₁₀₀)	t CO ₂ -eq	GWP ₁₀₀
Acidification Potential	kg SO ₂ -eq	ACIDIF.
Eutrophication Potential	kg PO ₄ ³⁻ -eq	EUTROPH.
Damage caused by the ecotoxic emissions to ecosystems	PDF.m ² .yr	BIODIVERSITY
Damage to human health	DALY	HUMAN HEALTH
Photochemical Oxidant Formation Potential (Smog)	kg C ₂ H ₄ -eq	O ₃ -SMOG
Odour	Mm ³	ODOUR

Reliability ? Intercode comparison



*European thematic network PRESCO
Single family house,
210 m², gas heating,
80 years*

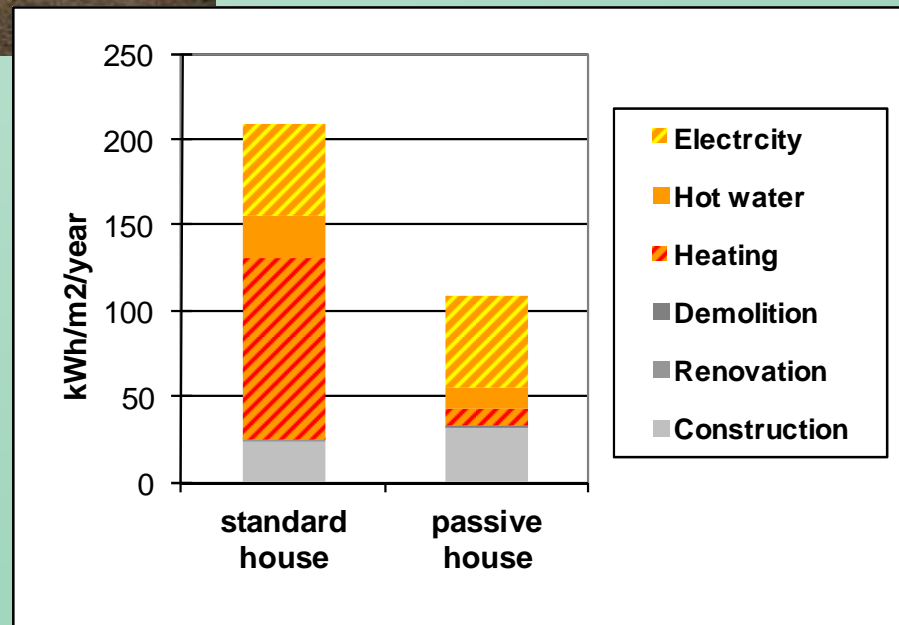
**+ - 10% discrepancy
over the life cycle**



Exemple application : 2 passive houses



Formerie (Oise, France)
2 x 135 m²
Contractor : Les Airelles
Construction
EN ACT architecture



Importance of renovation

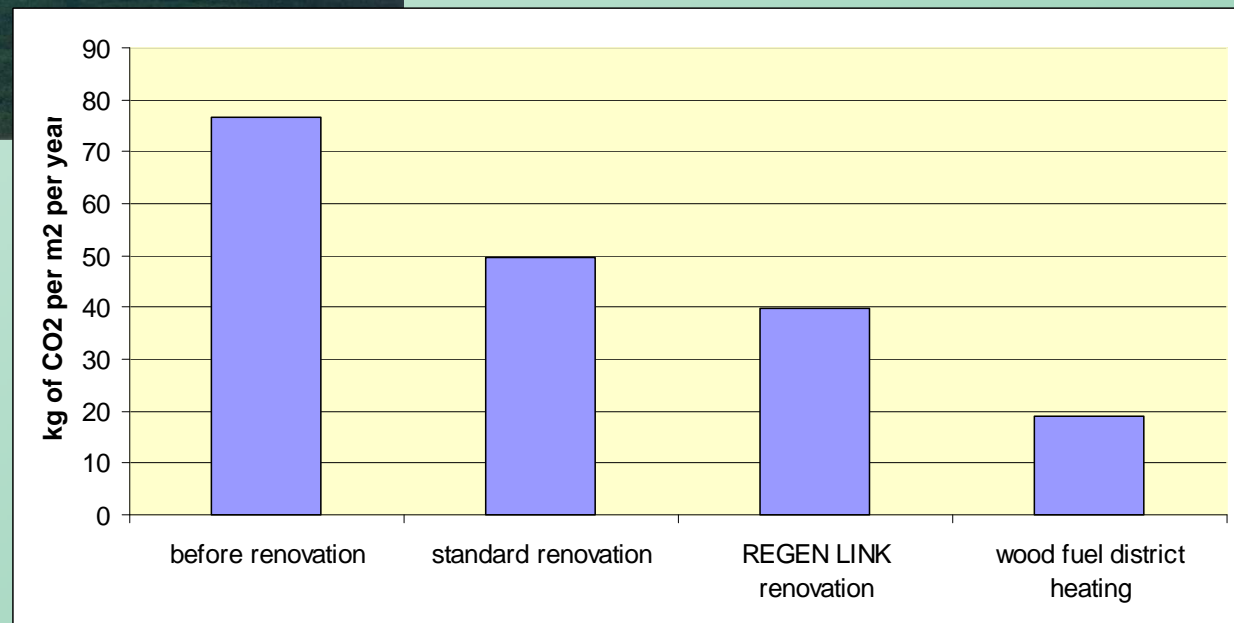


Construction : 1969

not insulated, single glazing

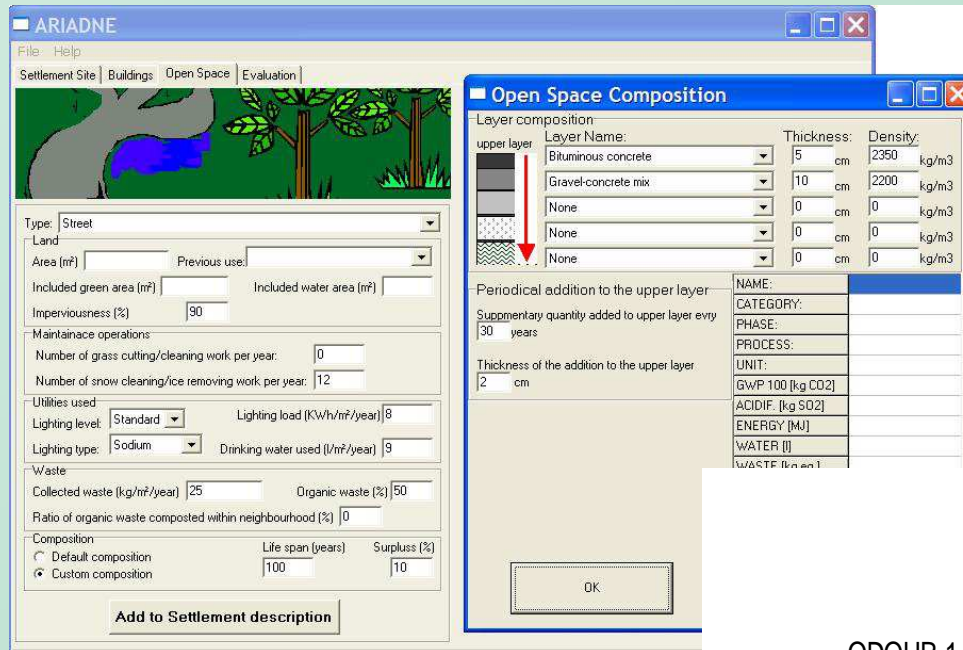
heating load : 160 kWh/m²/an

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



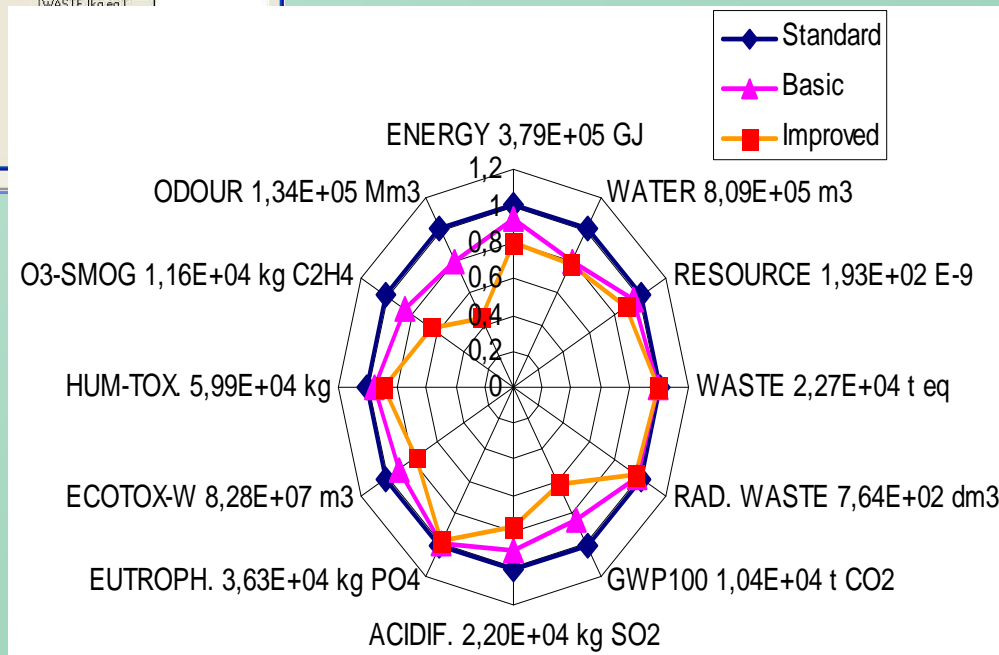
CO₂ emissions per m² and per year

Extension to urban blocks

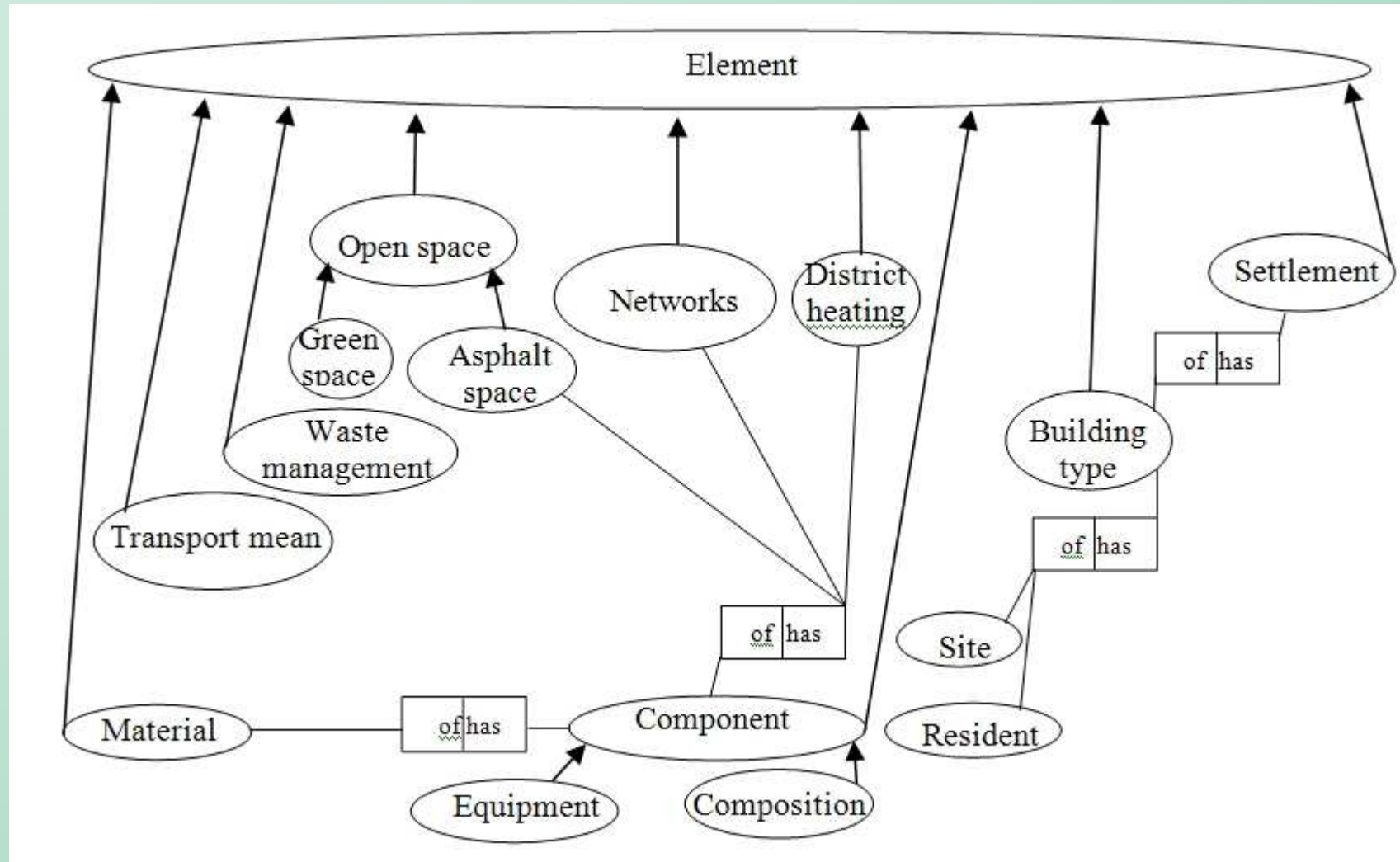


Several building types
 Streets
 Parks
 Networks

Comparison of alternatives



Urban block model, object oriented programming



Exemple application

- ▶ **Study of a new urban block in Cité Descartes (east of Paris)**
- ▶ **23,000 m² dwelling, 10,000 m² offices, 5,000 m² shops, 2,000 m² school, 38,000 m² park, 13,000 m² street**
- ▶ **Objective : early design aid**
- ▶ **Compare performances with best practice : Vauban (Freiburg), low or plus energy ?**

Comparison with best practice



Cité Descartes

**Low energy
(Quartier Vauban)**



**Plus energy
(Architect Rolf Disch)**



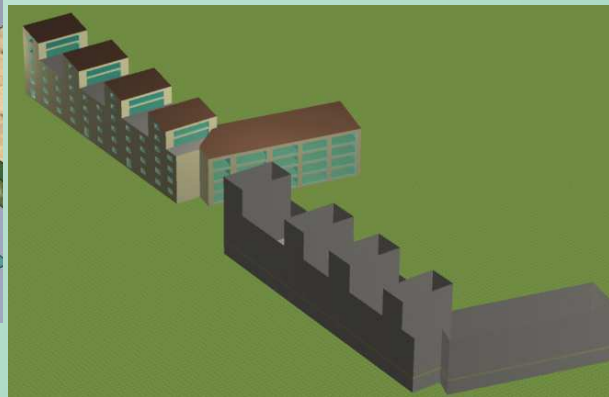
Graphical modeller (information model)

► **Alcyone** (3D model, accounting for interaction between buildings):

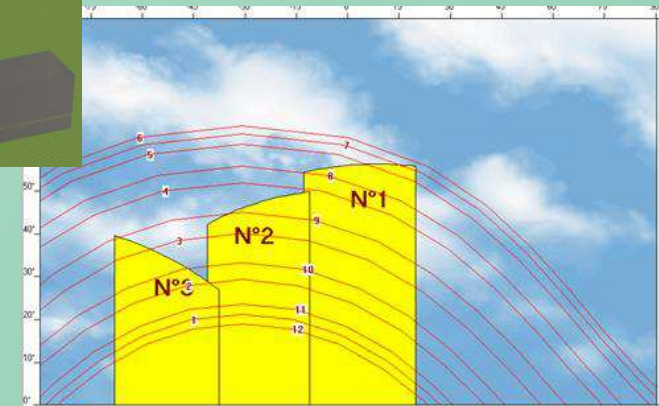
Sketchup



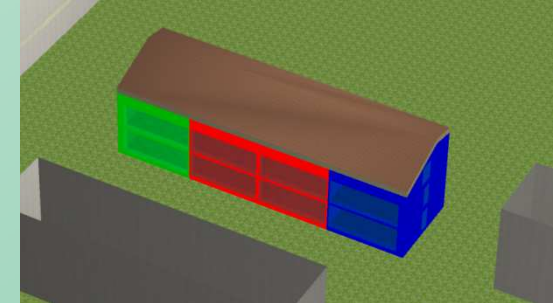
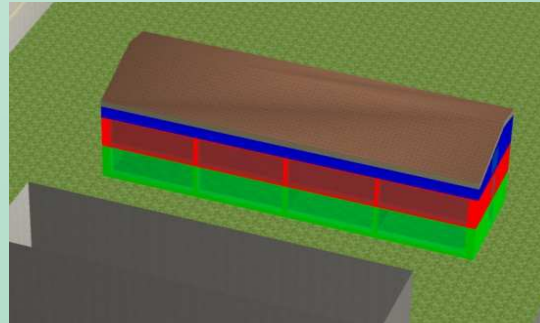
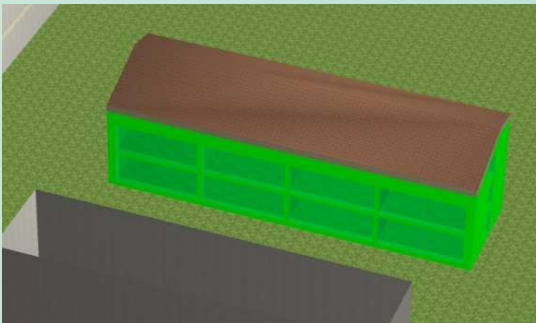
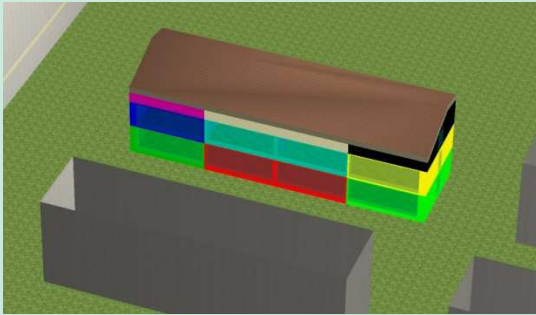
Alcyone



Solar path



► Simplification of the model, thermal zones



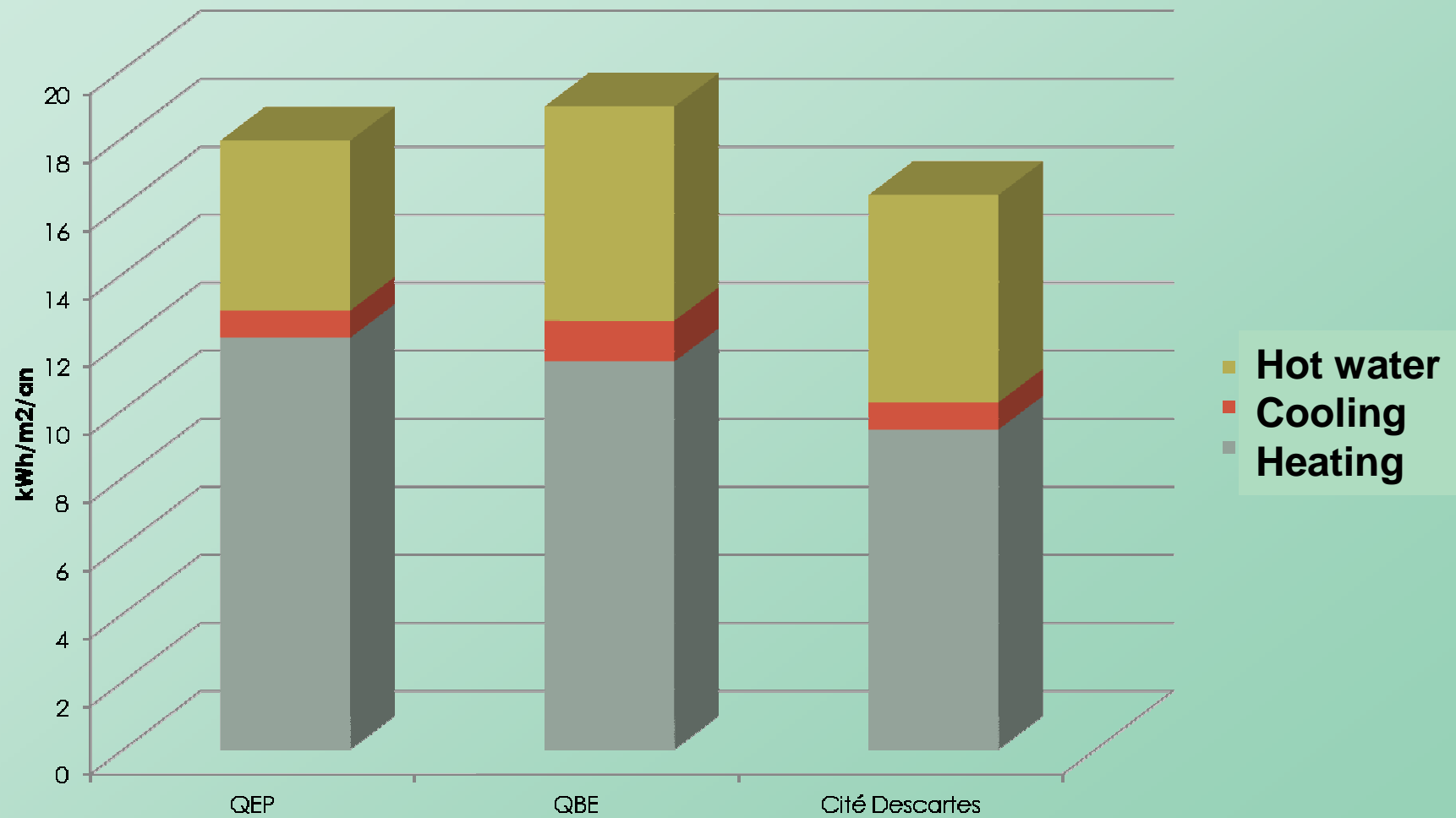
	1 zone	3 zones (3 floors)	3 zones (3 columns)
Heating load	-12,1%	-2,9%	-10,1%

Comparison with the reference model (9 zones)

Main hypotheses in the LCA study

- ▶ Considered life span: 80 years, 30 years for windows, 10 years for painting, 25 years for equipment
- ▶ Building materials -> inert waste except metals (recycled), 5% surplus in construction works
- ▶ Transport distance: 100 km (fabrication -> site), 20 km (site -> landfill)
- ▶ Electricity production mix : 78% nuclear, 14% hydro, 4% gas, 4% coal, 9% losses in the grid
- ▶ District heating with cogeneration, 61% thermal and 26% electric efficiency), 20% gas and 80% wood, 50% solar fraction for domestic hot water, COP=3 for cooling, 15% PV efficiency (inverter : 90%)
- ▶ Domestic waste and transport assumed equivalent in all alternatives
- ▶ 100 l/person/day cold water consumption in dwellings (40 hot water), 50 and 4 in offices, 20% losses in the mains

Energy calculation results



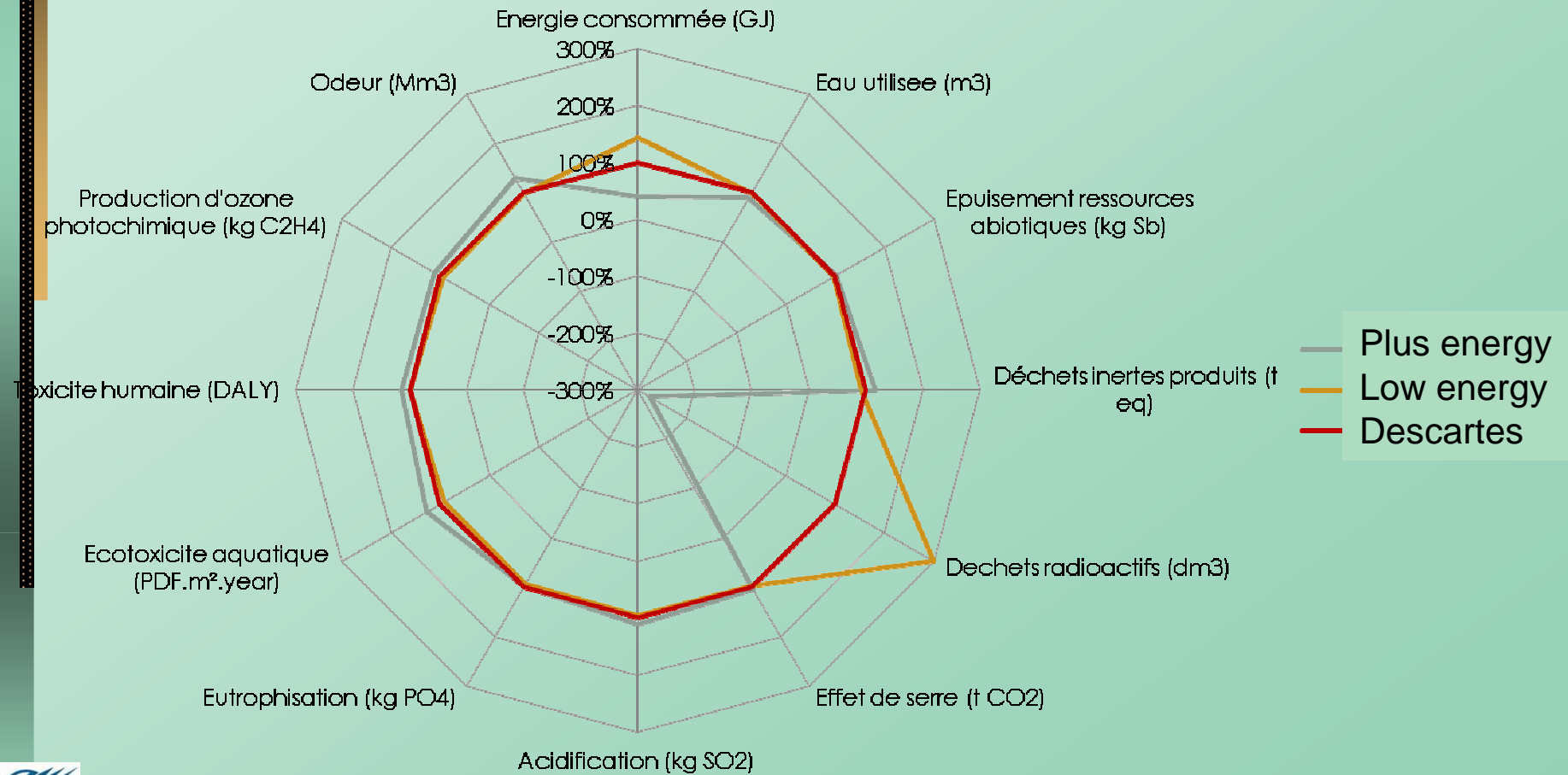
Plus energy

Low energy

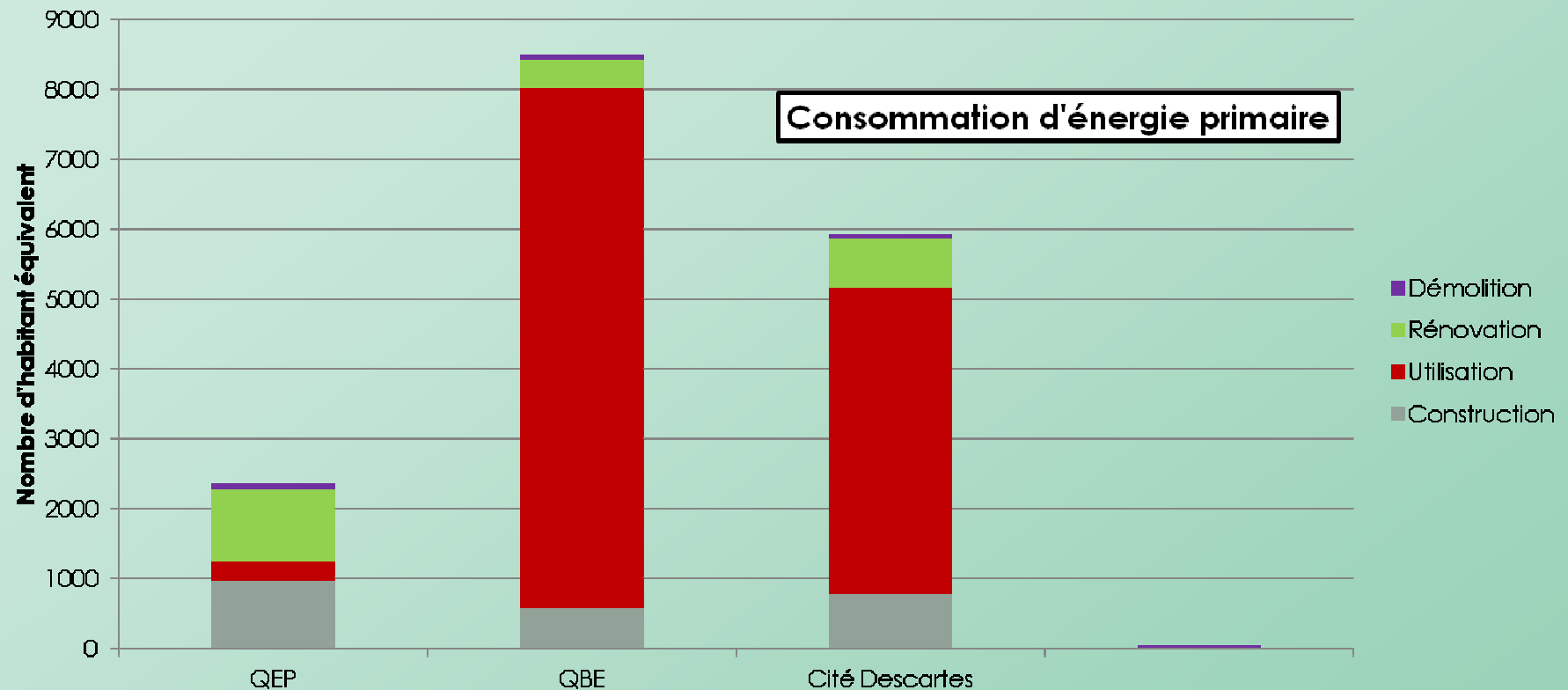
Project

LCA results

Comparatif global des 3 quartiers sur les 12 indicateurs



LCA results, primary energy balance



- Use phase = 87% of total for Low energy, 74% for Cité Descartes, but only 12% for Plus Energy
- Plus energy: 11 kWh/m²/y (embodied energy, street lighting...), Low energy: 49 kWh/m²/y, Cité Descartes: 34 kWh/m²/y

Conclusions and perspectives

- ▶ **Operational tools, being tested and improved**
- ▶ **Request of simplification, need to keep a high sensitivity to design/decision parameters**
- ▶ **Reliability ? Model comparison**
- ▶ **Dynamic and consequential aspects**
- ▶ **Inter-sectorial intégration (building-energy-transport)**
- ▶ **international development platforms**