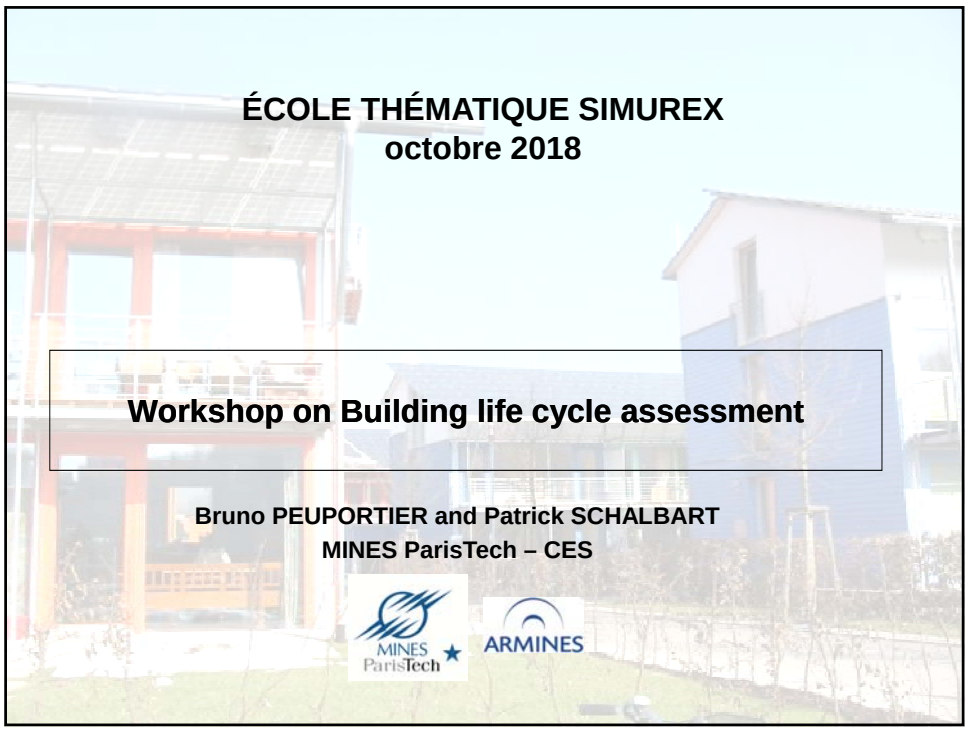

ÉCOLE THÉMATIQUE SIMUREX
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Workshop on Building life cycle assessment

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MINES ParisTech – CES

Structure of the workshop

- **Introduction : objectives of LCA, short presentation**
- **Presentation of the tools used in the workshop**
- **Case study : simple building**
- **Comparison of alternatives (e.g. wood versus concrete structure, gas versus electricity and wood heating…)**
- **Analysis of results**
- **Discussion on some modeling issues (e.g. recycling, biogenic CO2, temporal variation of impacts…)**
- **Research perspectives (uncertainties, optimization…)**

1

Eco-design of buildings

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

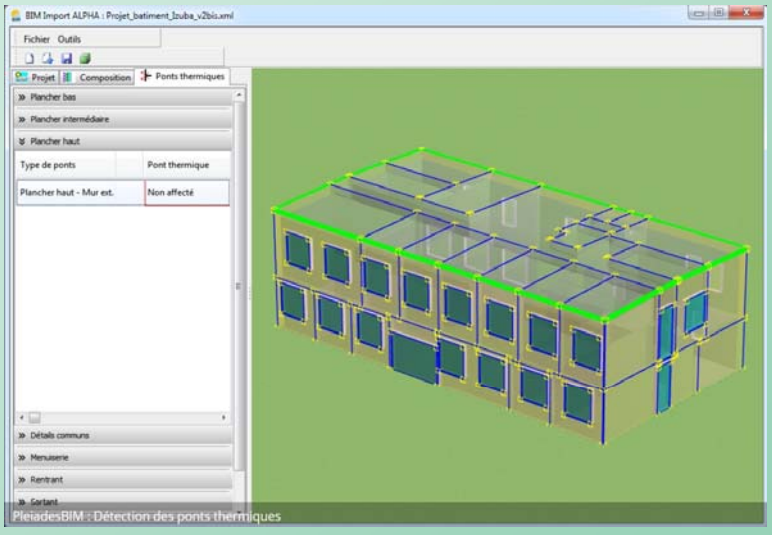
2

Possible objectives of life cycle assessment

- Renovation or new construction ? Building site ?
- Owners can define environmental performance targets
- Architects and building consultants can compare various alternatives during the design phase in order to reduce the environmental impacts of a project
- Comparison of building materials
- Facility managers can study the influence of the users behaviour and advise appropriate measures during the operation phase of a building,
- Decision aid regarding a retrofit project
- End of life, interest of recycling ?

3

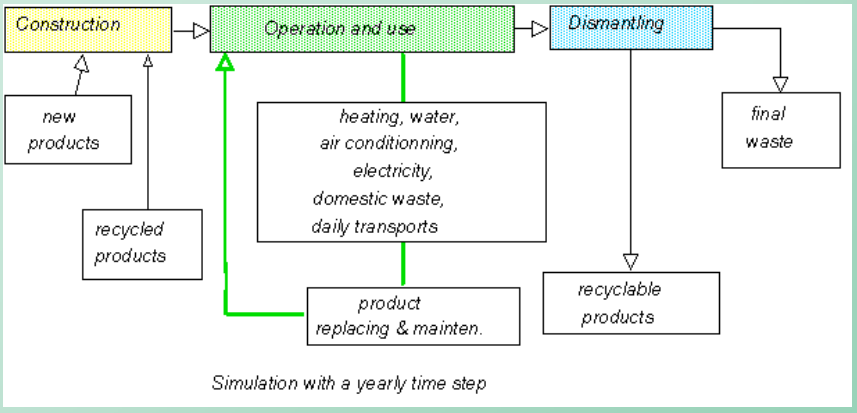
Graphical 3D modeler, possible import of BIM



e.g. detection of thermal bridges, information needed

4

Life cycle assessment simulation tool, Equer



Simulation of the life cycle, accounting impacts year by year

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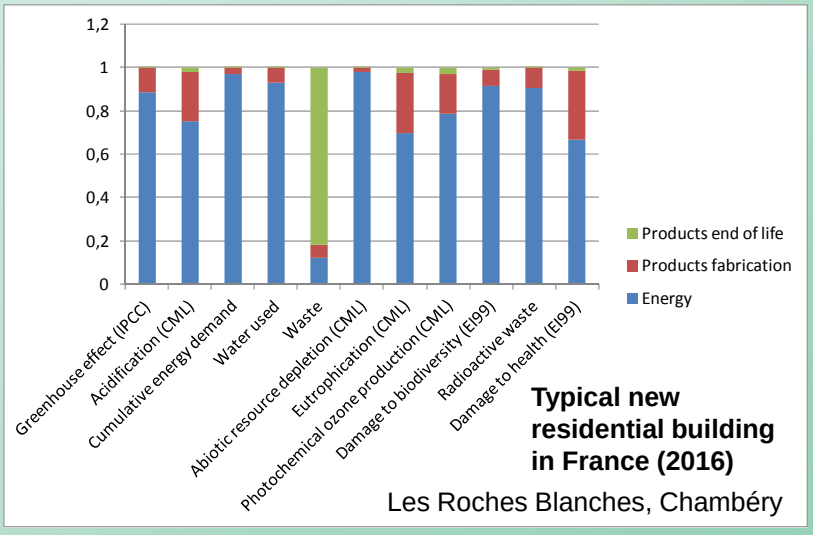
Link with Building energy simulation



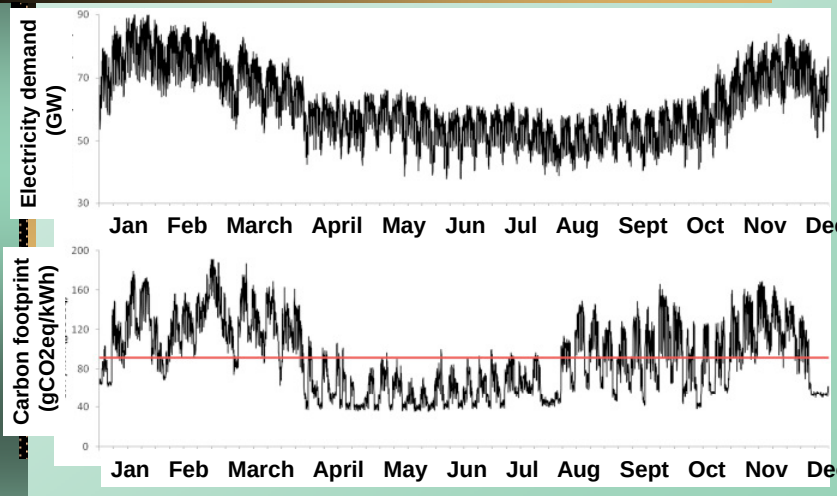
Typical new residential building in France (2016)

Les Roches Blanches, Chambéry

Energy consumption for heating, cooling, ventilation, lighting, hot water, appliances, corresponding to a typical year

6

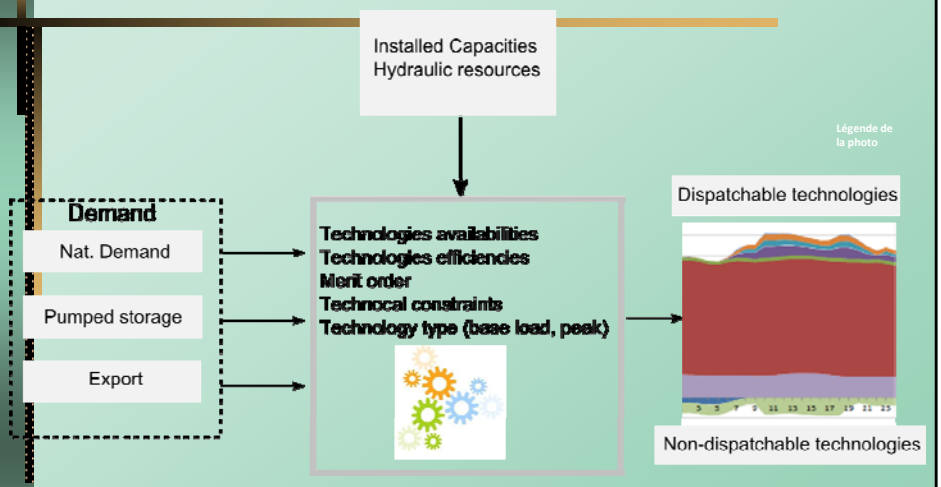
Electrical system, dynamic LCA



Total electricity consumption in France in 2013 (top) and carbon footprint per kWh (bottom) - Roux et al. 2016

7

Electrical system simulation model



- Same typical meteorological year building/grid
- Averaging climatic and economic hazards of real years
- Technology explicit : easy update to follow e.g. renewable energy capacity evolution (prospective model or scenarios)

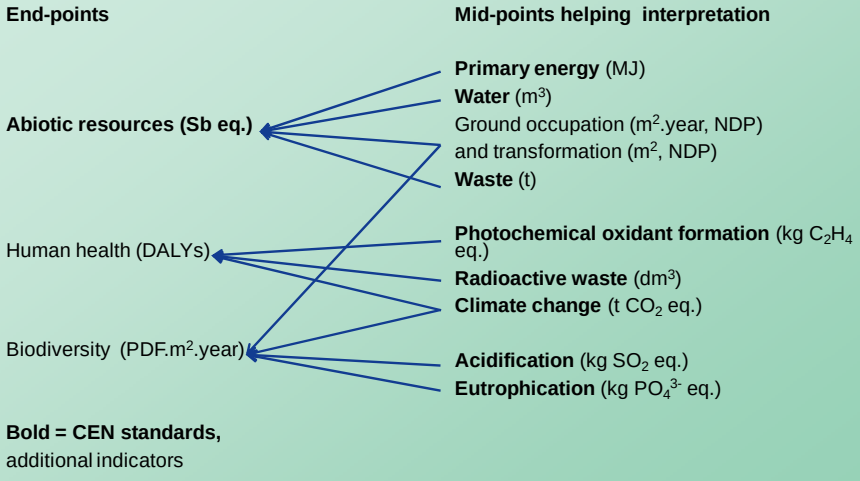
8

Inventory phase

- Ecoinvent database: www.ecoinvent.org
- Consistent and transparent
- Generic data, adapted to early design
- Including upstream processes (e.g. extraction and transport of energy, raw materials…)
- Including downstream processes (e.g. waste)
- Problems with the French database INIES : only 168 fluxes, no matrix calculation, little information on assumptions, « E+C- » experiment in progress

9

LCIA, system of environmental indicators



Bold = CEN standards,
additional indicators

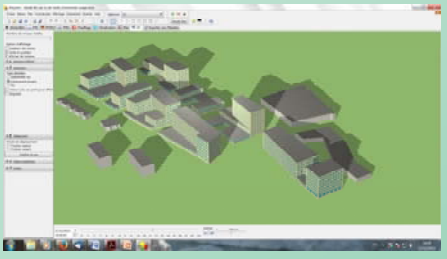
Use of normalisation to contribute in priorisation

10

Application in case studies -> benchmarks

- Single family houses, apartment buildings (new of renovation)
- Office buildings, highschools
- Urban projects

wood or concrete

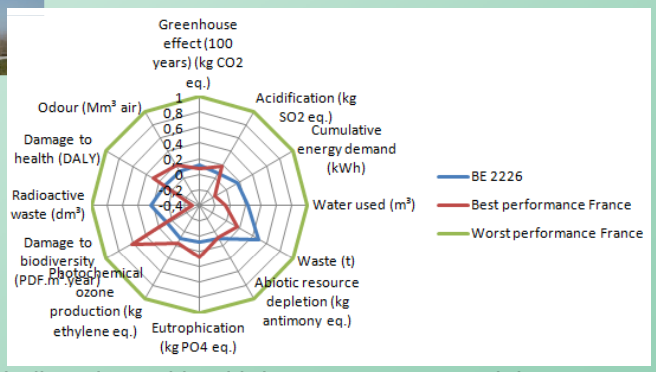


gas versus electricity and wood heating -> lowest and highest impacts

11

Example study of be2226

- Using the same functional unit and use scenario as in the benchmark
- 50 years study period



- Near the best performance of the French benchmark
- Better on e.g. biodiversity and health because no PV modules
- Not as good on primary energy, radioactive waste and water (no PV), waste (insulating bricks instead of wood and straw)

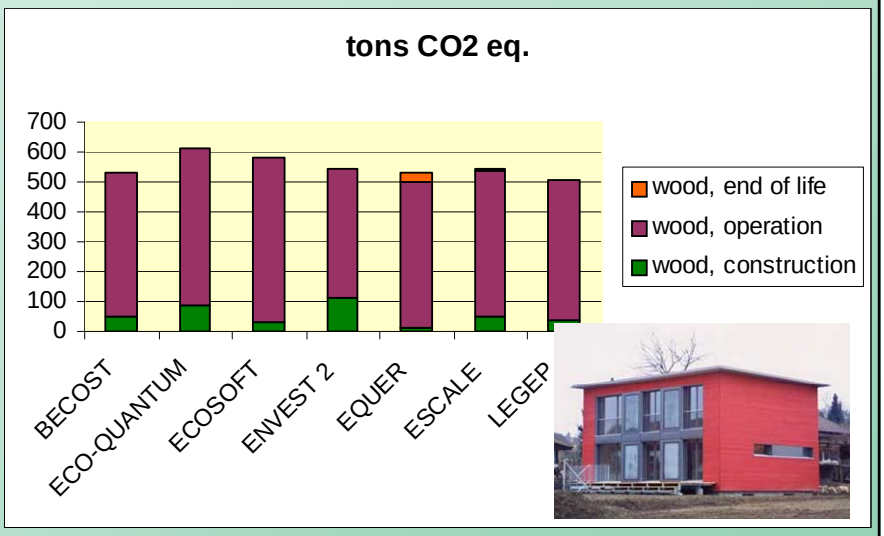
12

Practical exercise

- Very simple building 10 m x 10 m
- Drawing, using default values (simplified input)
- Energy simulation and LCA
- Comparing alternatives (e.g. wood versus concrete structure, gas versus electric heating etc.)
- Interpreting results

13

Research perspectives, comparison of LCA tools

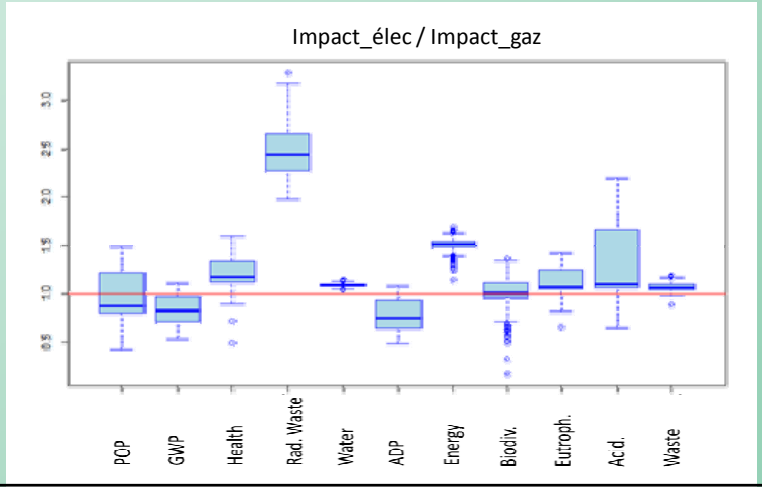


+- 10% discrepancy over the life cycle

14

Uncertainty analysis

- Identification of the most important parameters (sensitivity, Morris)
- Probability distribution, Uncertainty propagation (Monte Carlo)
- Influence on the comparaison of alternatives (ex. gas/electric heating)

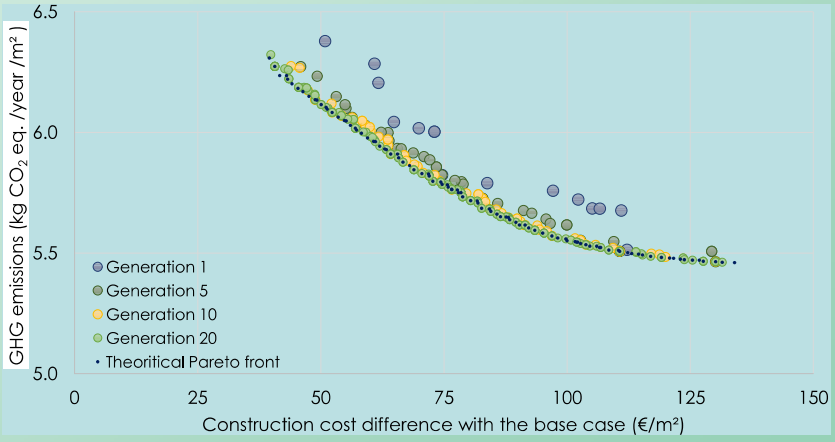


15

Optimisation using a genetic algorithm

→ **Good convergence of the algorithm (8,000 runs out of 4,194,304)**

→ **Reasonable computation time (≈ 2 hours for energy sim. + LCA)**



16

Conclusions and perspectives

- **Design tool already operational**
- **Environmental targets in client's brief**
- **Consequential LCA (increased flows by new buildings, decreasing flows by retrofit) -> marginal processes**
- **Dynamic LCA (2050 scenarios, hourly variations)**
- **Spatialisation (e.g. indoor emissions)**
- **Biogenic CO2 (long term storage in timber, forests)**
- **Allocation (e.g. recycling, heat recovery from waste)**
- **Indicators (health, biodiversity, resources)**

17

Thank you for your attention !

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18