



Towards a reduced set of indicators in buildings LCA applications: a statistical based method

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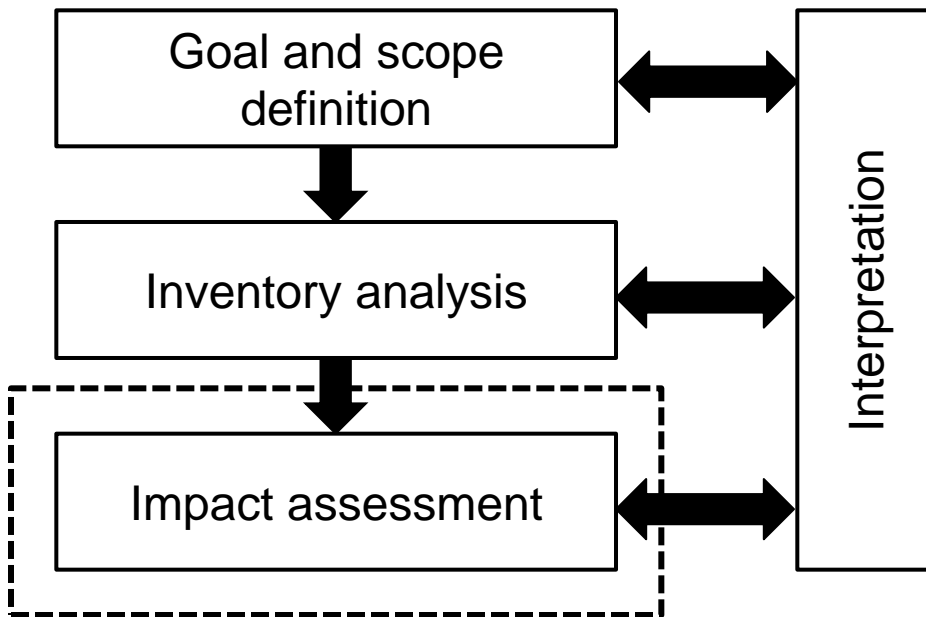
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Session: Methods for Buildings

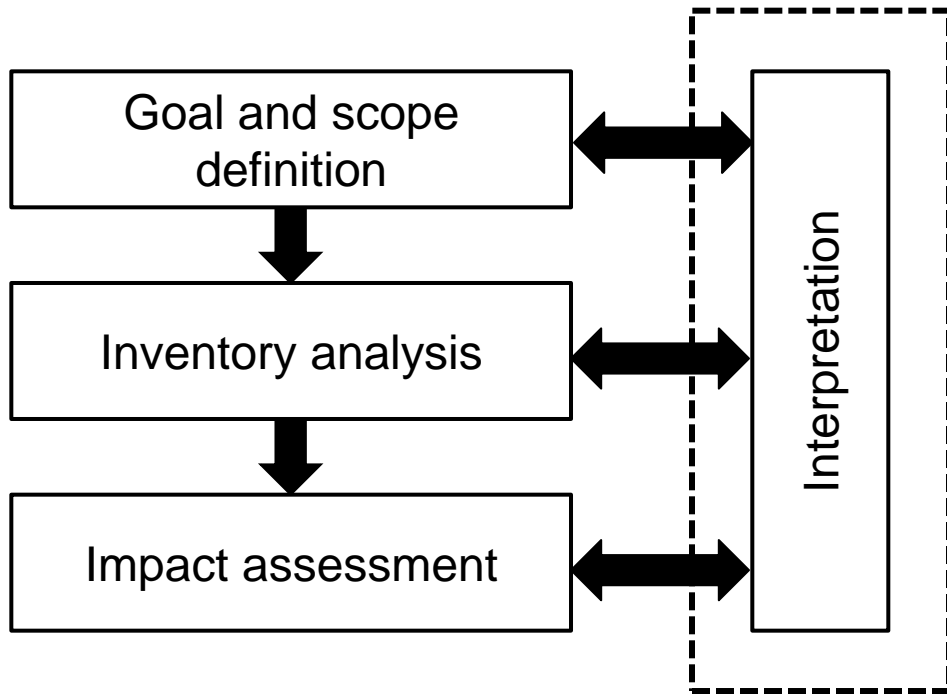


LCA framework according to ISO 14040-44

*LCIA: Life Cycle Impact Assessment

Building's LCA software		Used LCIA* indicators
ATHENA		6
BEES		7
EQUER		12
ELODIE		14
ENVEST		13
LEGEP		9
ECO-QUANTUM		10
ECOEFFECT		9
Eco-Bat		6

How to ease the interpretation of the impact assessment stage?



LCA framework according to ISO 14040-44

- **Usual approaches for the interpretation stage in LCA**
 - Normalization of impacts
 - Eco-indicator
 - Multi-criteria decision analysis

Aim of this study

- **Complementary approaches: statistical methods**
 - Multivariate data analysis (e.g. Principal Component Analysis)

➔ Identification of a relevant and simplified set of indicators for buildings LCA applications

- LCI data of building materials and products
- Environmental indicators
- Statistical method (Principal Component Analysis)
- Sample of materials and building's case study

- **LCI data of building materials and products**

- Data taken from the LCI database used for building LCA applications developed at CSTB gathering ~ 500 data:

- LCI data of the French building industry (EPD)
- LCI data of generic data (ecoinvent 2.0)

- Functional units (FU): 1 kg, 1 m²

- System boundary:

- Impacts related to the building materials and products from cradle-to-grave



- **Environmental indicators**

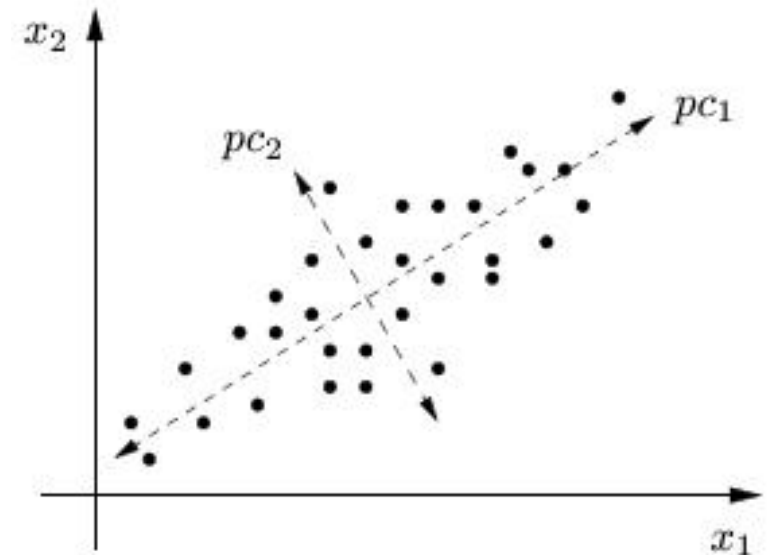
- LCI indicators

- Total primary Energy (PE), non renewable (PE-NRe)
 - Total Mass Requirement (TMR)
 - Total water consumption (WC)
 - Final waste
 - Radioactive waste (RadW)

- Mid-point indicators

- Abiotic Depletion Potential global (ADP), elements (ADP_elements)
 - Global Warming Potential, fossil 100 years (GWP)
 - Photochemical Ozone Creation Potential (POCP)
 - Acidification (AP)
 - Air Pollution (AIP)
 - Water Pollution (WAP)

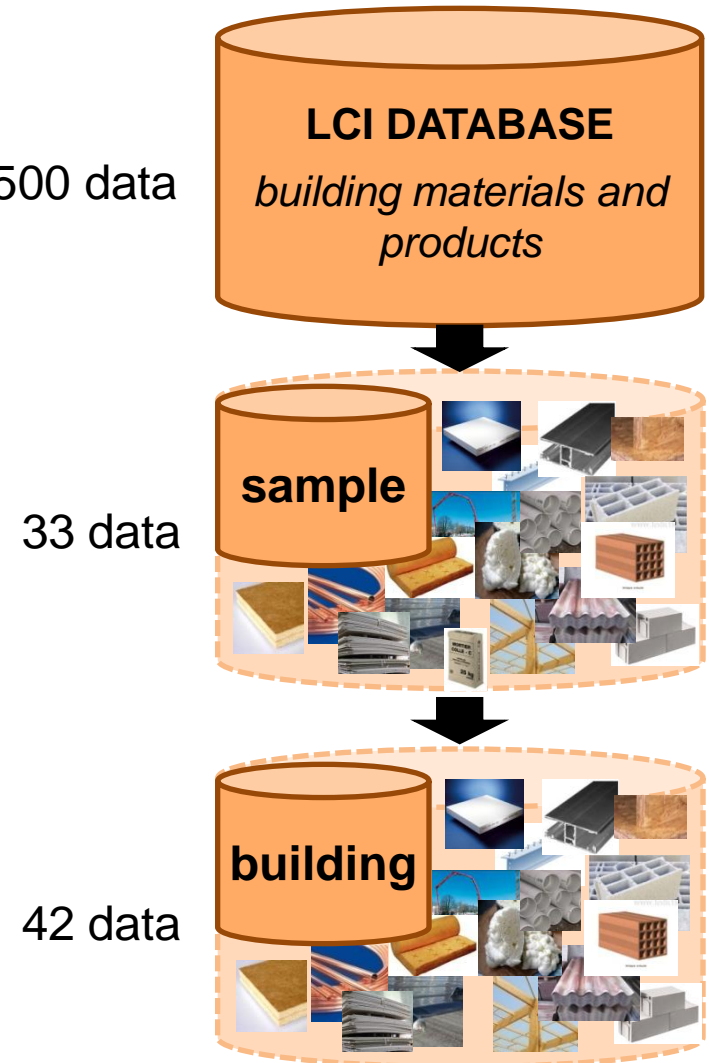
- **Statistical method**
 - Principal Component Analysis
 - Multidimensional data reduction technique
 - % of variance of the first PCA component used as a measurement of the colinearity of the overall set of indicators
 - Varimax rotation gives new (rotated) components, each one being easily interpretable (i.e. linear combination of fewer indicators)



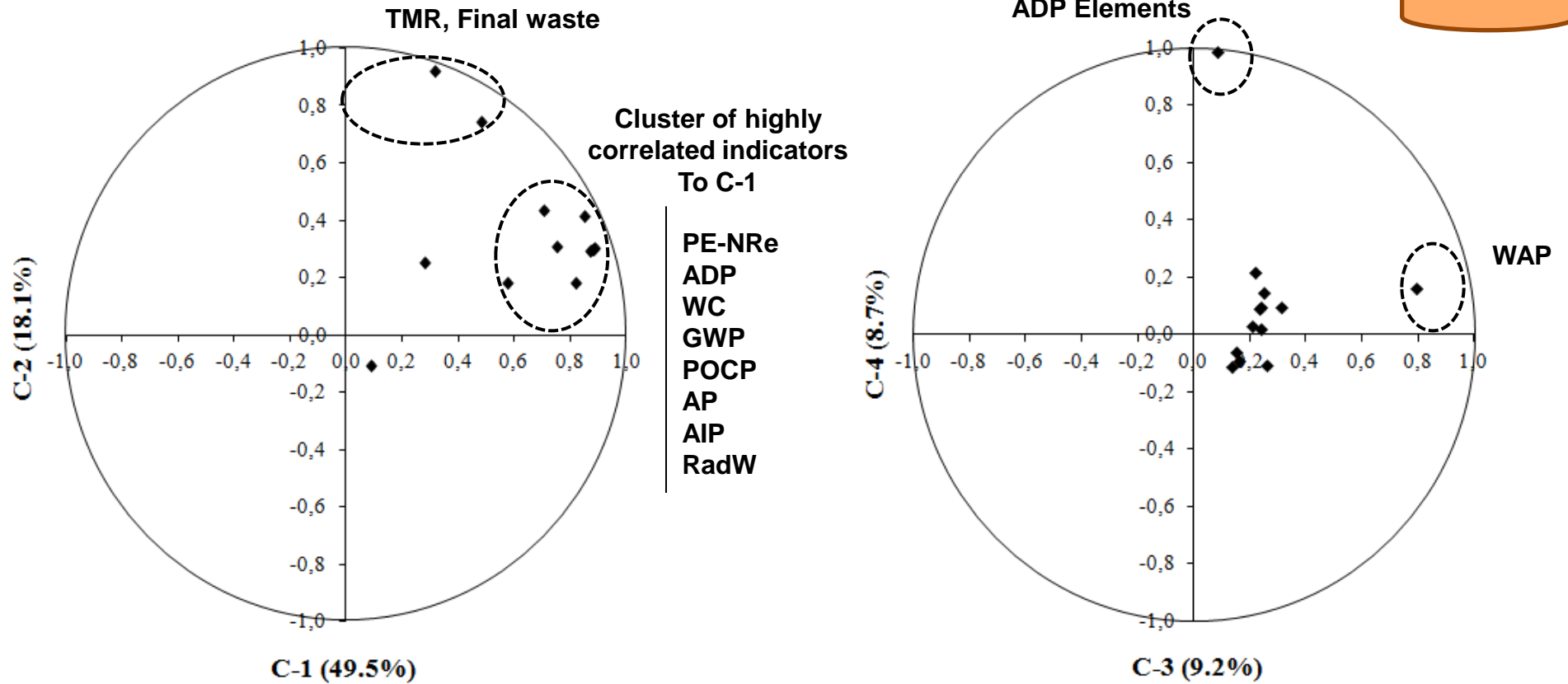
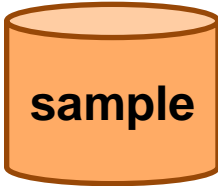
Screenshot taken from <http://lion.cs.uiuc.edu/projects/wmn.html>

- **Sample of building materials**
 - Type of materials not homogeneously ~ 500 data represented in the database
 - 1 LCI data selected at each time
 - Unweighted functional units (FU)
 - Resampling done 10 times

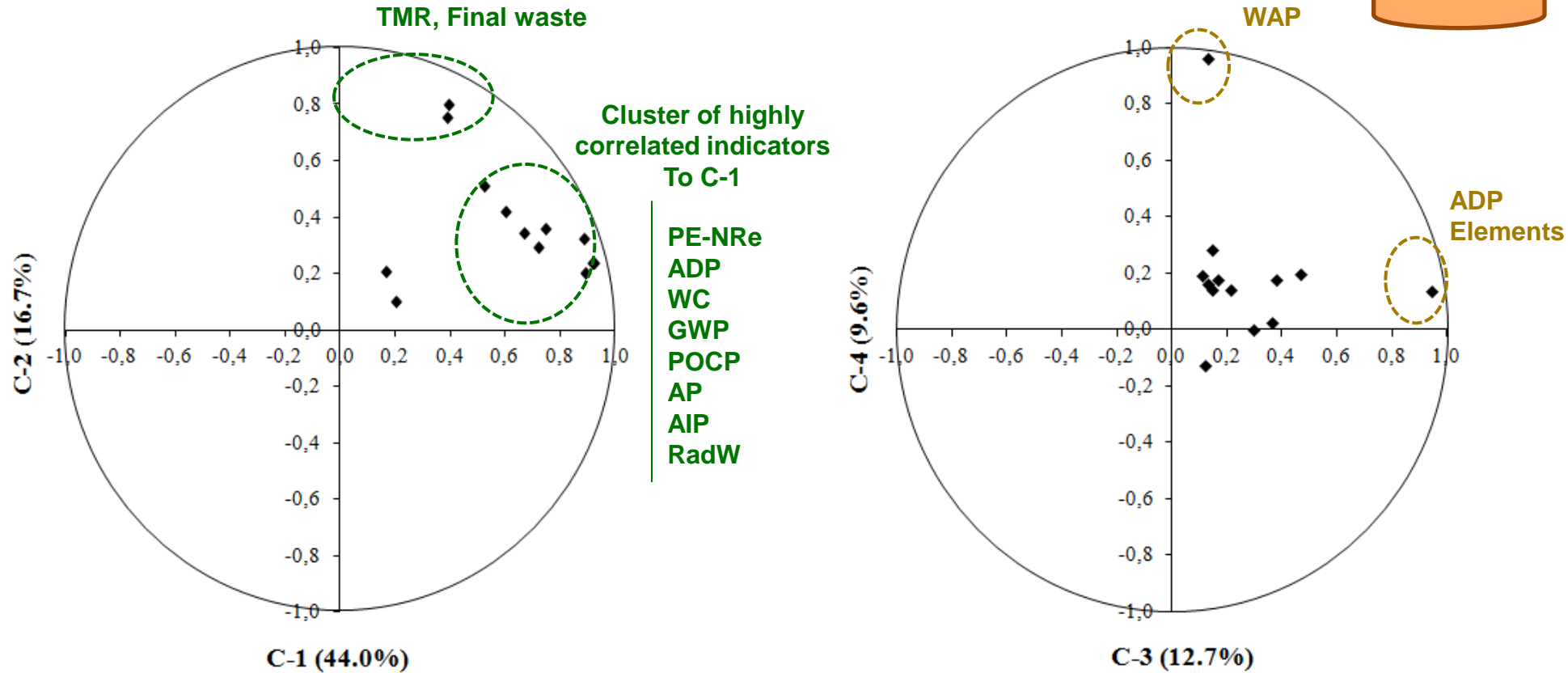
- **Building case study**
 - French low-energy wooden house
 - Weighted FU depending on the mass of each building material implemented in the building.



PCA with Varimax rotation (unweighted LCA data)



PCA with Varimax rotation (weighted LCA data)



In green, similar results between the sample of data and the building case study
In orange, inversion of ranking between the sample of data and the building case study

- PCA used here as a complementary approach for helping the interpretation phase in LCA of buildings (decision making).
 - 13 indicators → sum up in 4 dimensions only !
- ADP (global or fossil) and ADP elements are not correlated and should not be confused.
- The 4 major dimensions to include in a relevant and not correlated set of indicators are :
 - Non renewable energy and air emissions based-indicators
 - Resources consumption and waste generated
 - Water Pollution
 - Mineral depletion

- Choice of the indicator for component C-1
 - One aggregated indicator or one among the correlated indicators (e.g. the non renewable primary energy used as a screening)
- Test needed in comparative LCA with complete set and the reduced set of indicators to see if the results can be validated
- Sensitivity analyses in progress
 - Number of indicators and type of indicators: end-point (e.g. ReCiPe) instead of mid-point oriented LCIA indicators?
 - Robustness of the sample of the database (resampling)?
 - Other building's case studies?
- Extend the approach (PCA) to a full LCA of buildings (with the other impact sources such as the operationnal water/energy use)



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THANK YOU VERY MUCH FOR YOUR ATTENTION

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