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Swiss Federal Institute of Technology Zurich

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Identification of building materials' influence on robustness and uncertainty of single houses LCA

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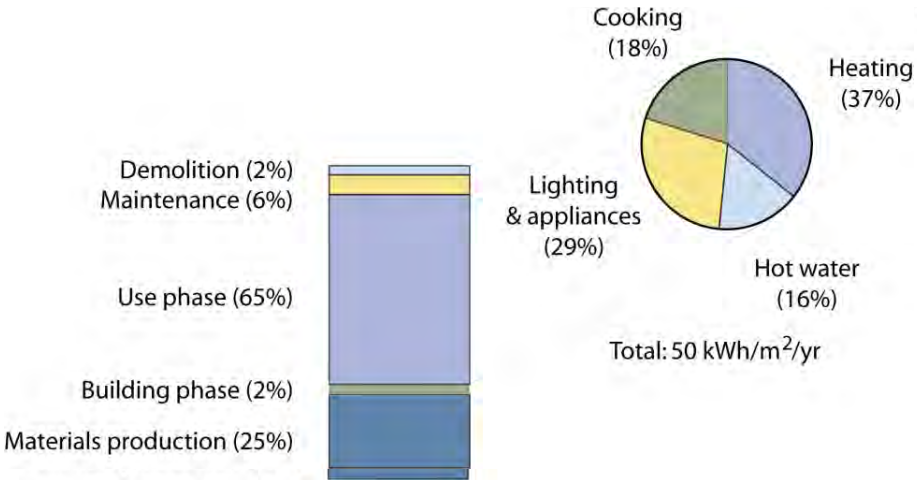
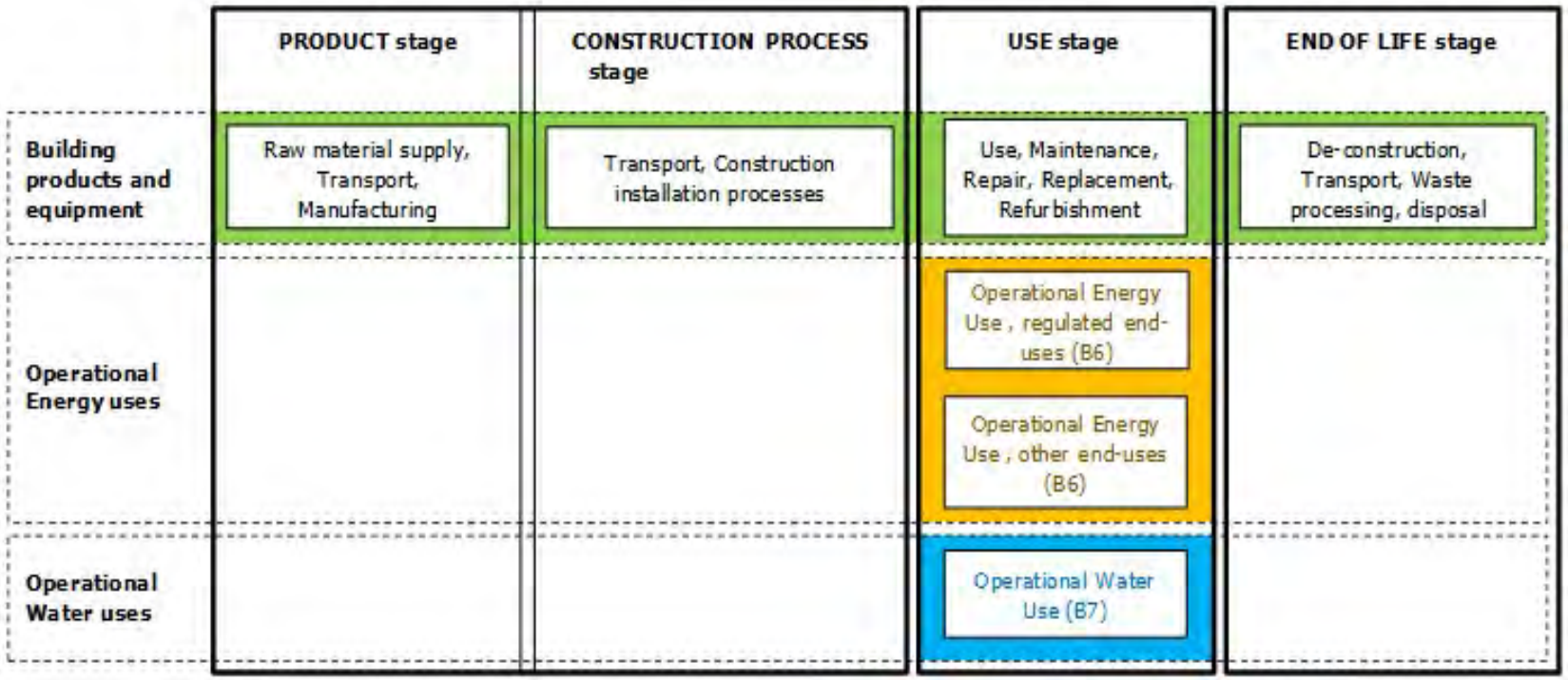
Why ?


Demolition (2%)
Maintenance (6%)
Use phase (65%)
Building phase (2%)
Materials production (25%)
Cooking
(18%)
Heating
(37%)
Lighting
& appliances
(29%)
Hot water
(16%)
Total: 50 kWh/m2/yr

Contribution for the Life Cycle Assessment of buildings



Environmental performance of building

$= \Sigma$ [Impact (water & energy used during service life of building)

+ Impact (material and building elements during life cycle of the building)] ***Boundaries of this study***

Life Cycle Assessment of building materials

Environmental performance of a building material

=Impact (production-use-eol of one kg building material) . Mass used in building . Nb of use in building life time

Environmental product declaration (EPD)

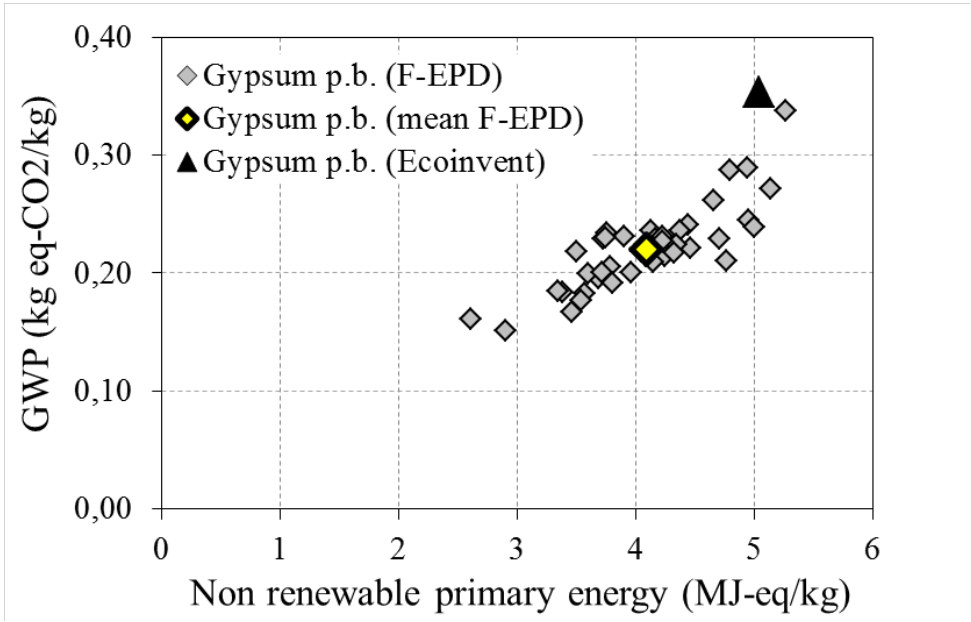
The problem

What is the exact Environmental impact ?

Life Cycle Assessment of building materials

Uncertainty on the elementary environmental impact:

For the production of the same material, different types of technology are used, plants location induce different transport distance, etc...



(Lasvaux et al., 2011)

Life Cycle Assessment of building materials

Environmental performance of a building material

=Impact (production-use-eol of one kg building material) . Mass used in building . Nb of use in building life time

Environmental product declaration (EPD)

The problem

What is the exact Environmental impact ?

What is the exact Mass used on site ?

Life Cycle Assessment of building materials

Uncertainty on the elementary environmental impact:

For the production of the same material, different types of technology are used, plants location induce different transport distance, etc...

Uncertainty on the effective mass used:

In reality never will be used the same quantity of material as it is defined in the project

Life Cycle Assessment of building materials

Environmental performance of a building material

=Impact (production-use-eol of one kg building material) . Mass used in building . Nb of use in building life time

Environmental product declaration (EPD)

The problem

What is the exact Environmental impact ?

What is the exact Mass used on site ?

What is the exact Service life ?

Life Cycle Assessment of building materials

Uncertainty on the elementary environmental impact:

For the production of the same material, different types of technology are used, plants location induce different transport distance, etc...

Uncertainty on the effective mass used:

In reality never will be used the same quantity of material as it is defined in the project

Uncertainty on the effective service life:

is influenced by factors which can be classified in degradation (durability) and dissatisfaction (user behaviour)

Life Cycle Assessment of building materials

Environmental performance of a building material

=Impact $_{\text{(production-use-eol of one kg building material)}}$. Mass $_{\text{used in building}}$. Nb of use $_{\text{in building life time}}$

Environmental product declaration (EPD)

The problem

What is the exact Environmental impact ? → **Δk**

What is the exact Mass used on site ? → **Δm**

What is the exact Service life ? → **Δn**

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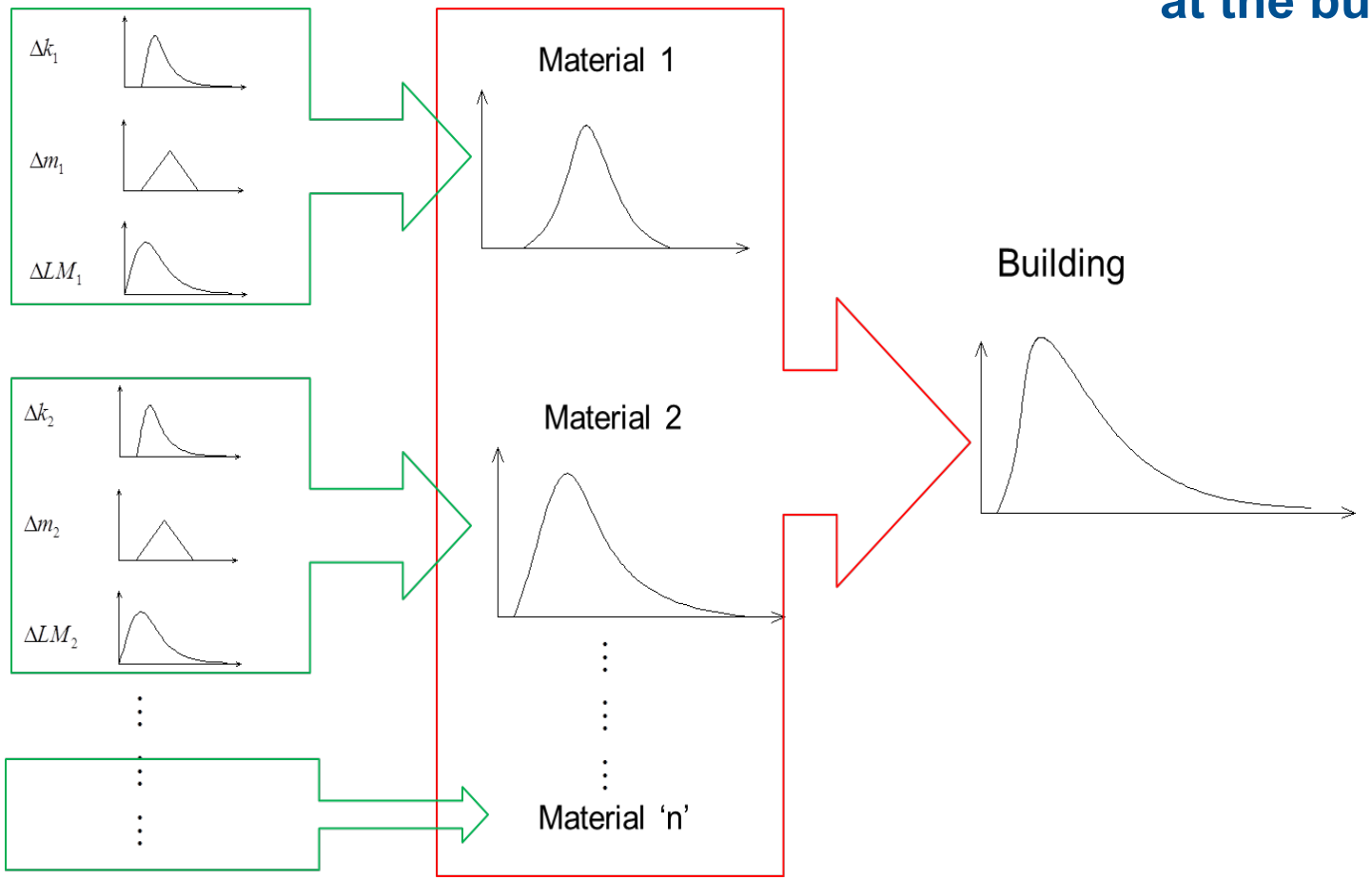
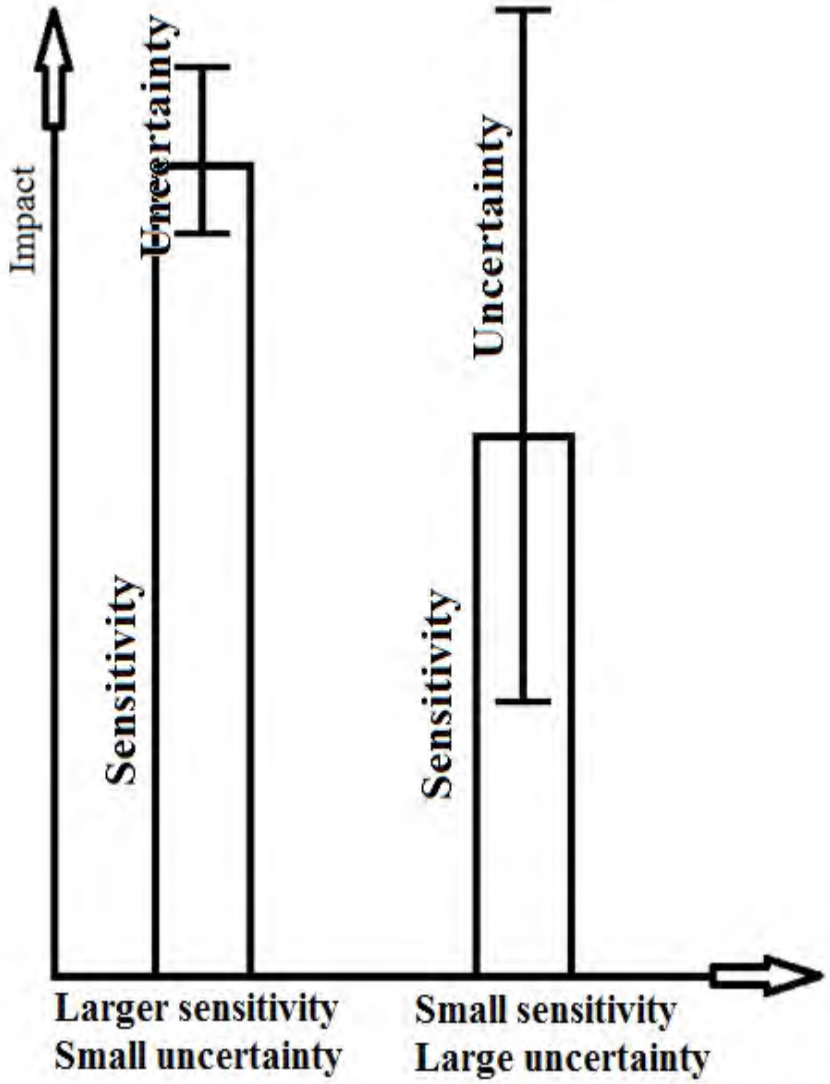
Life Cycle Assessment of building materials at the building scale



The question:

Which is the material that has the highest influence on the environmental performance of the building ?



Contribution analysis includes:

- Sensitivity analysis
- Uncertainty analysis

The appoach:

Perform an environmental assessment on 16 residential houses with calculating uncertainty for each materials

Impact of the building for the impact category f $I_f = \sum_{i=1}^{c} I_{f,i}$

Impact for the building material i $I_{f,i} = m_i \times k_{f,i} \times n_i$

Uncertainty for the building material i

$$\Delta I_{f,i} = \sigma_{k_{f,i}} \left| \left(\frac{\partial I_{f,i}}{\partial k_{f,i}} \right)_{X^0} \right| + \sigma_{m_i} \left| \left(\frac{\partial I_{f,i}}{\partial m_i} \right)_{X^0} \right| + \sigma_{n_i} \left| \left(\frac{\partial I_{f,i}}{\partial n_i} \right)_{X^0} \right|$$

Uncertainty for the building

$$\Delta I\downarrow f = \sum i=0 \uparrow n \blacksquare \Delta I\downarrow f,i$$

- σ obtained by compilation of data:
  - All EPDs
  - Various service life used in literature
  - Expert advice for waste on construction site

Hoxha et al. to be published.
Method to analyse the contribution of material's sensitivity in buildings' environmental impact, *Journal of cleaner production*

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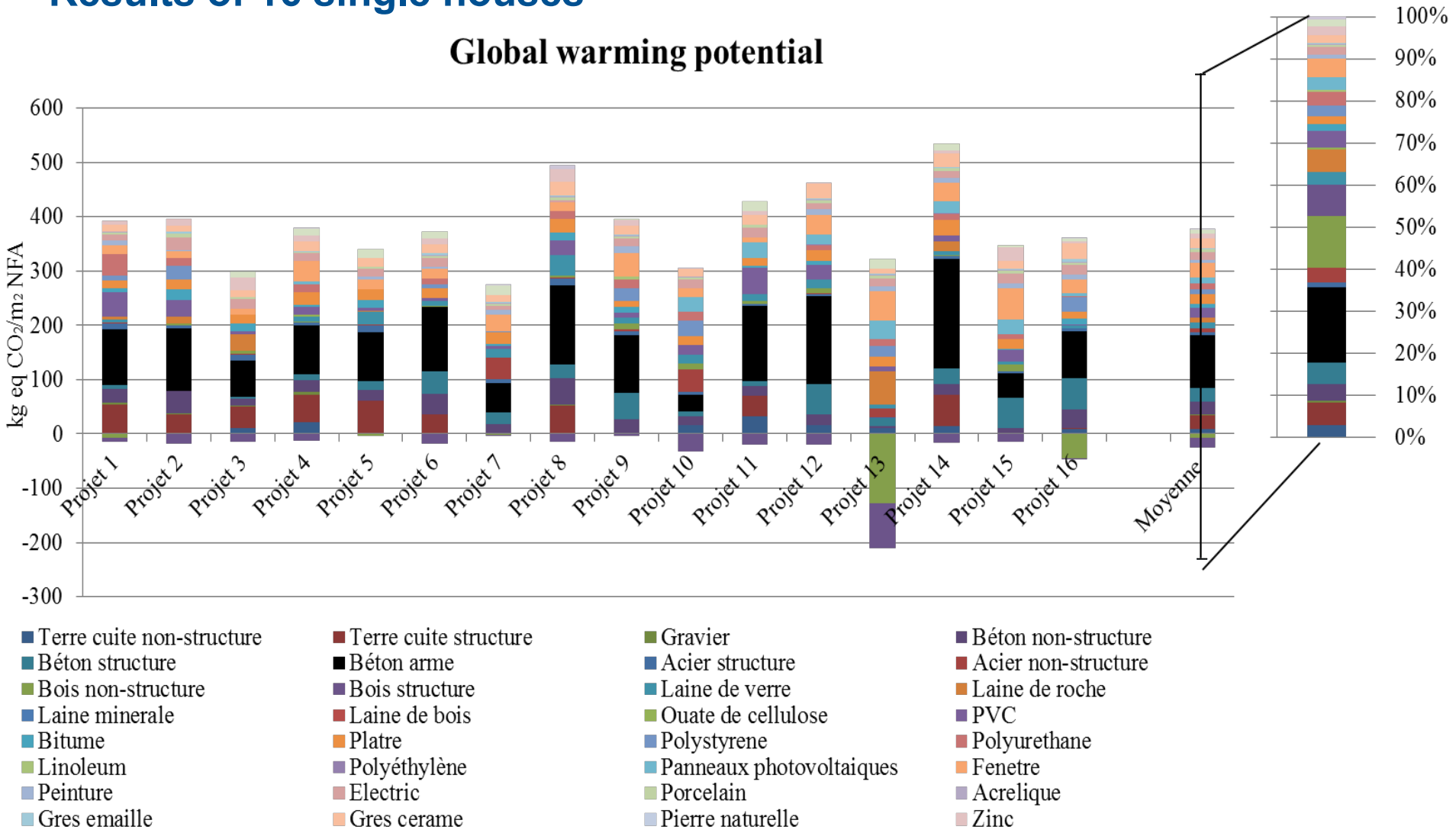
Results of 16 single houses



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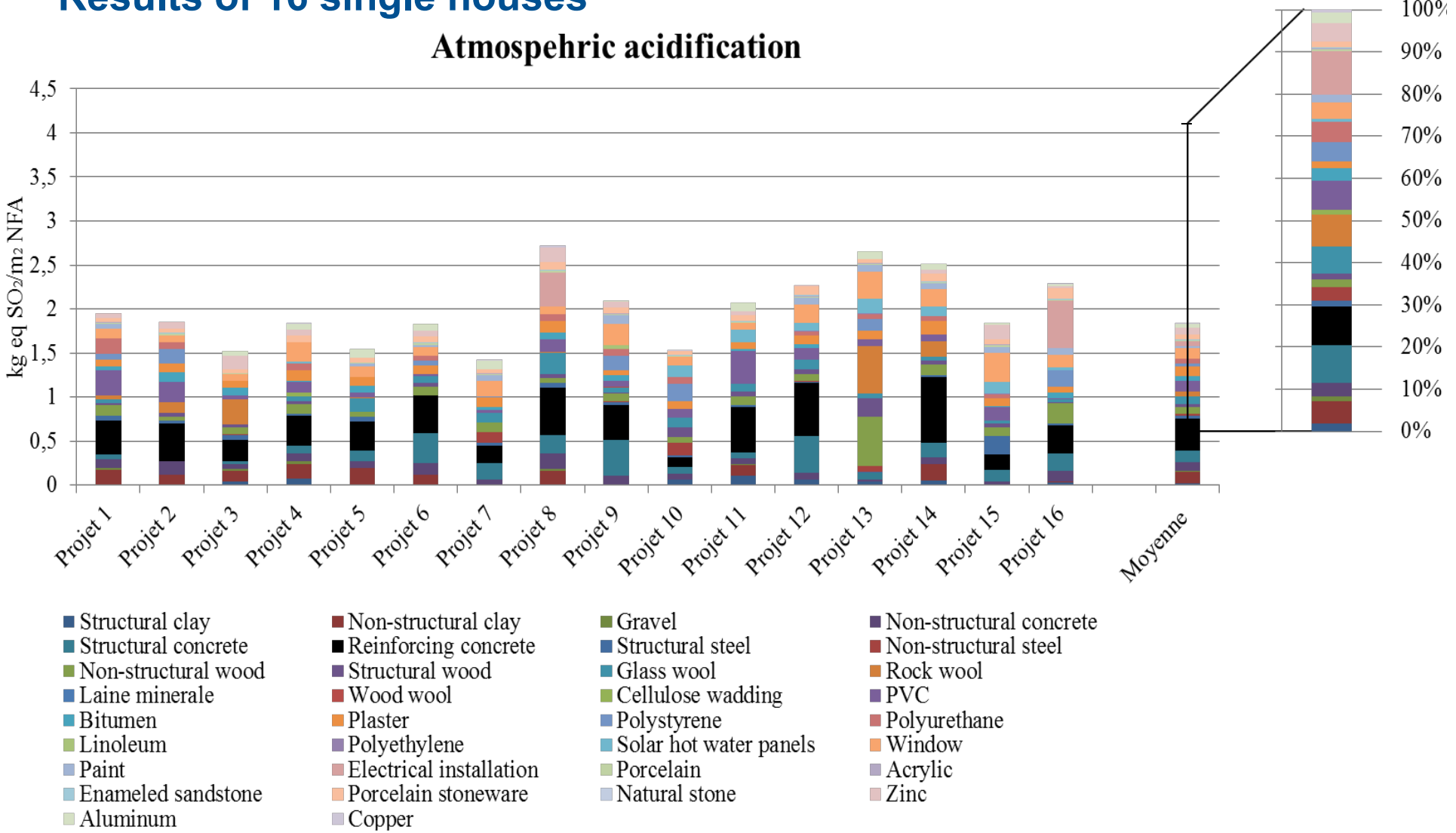
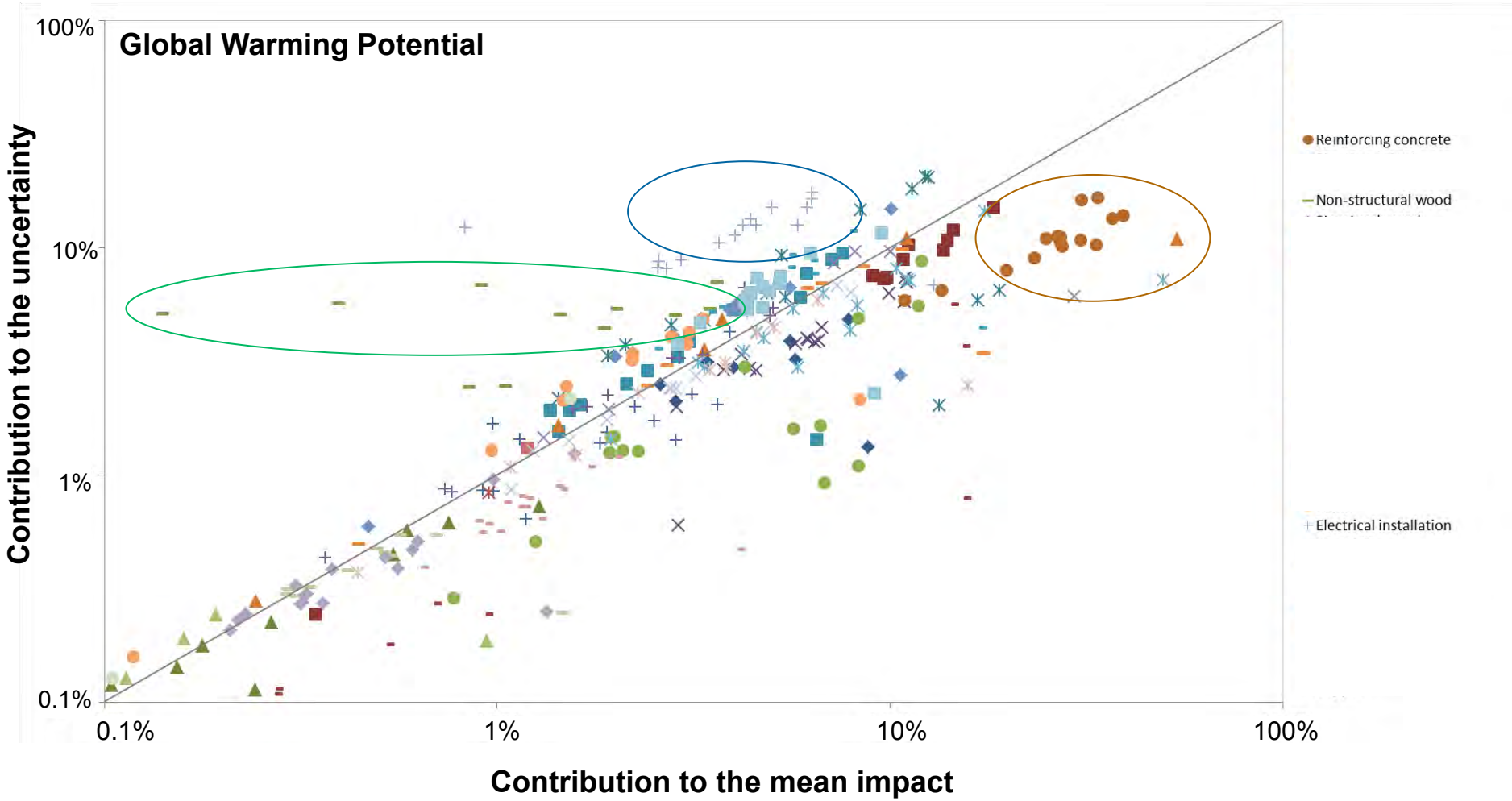
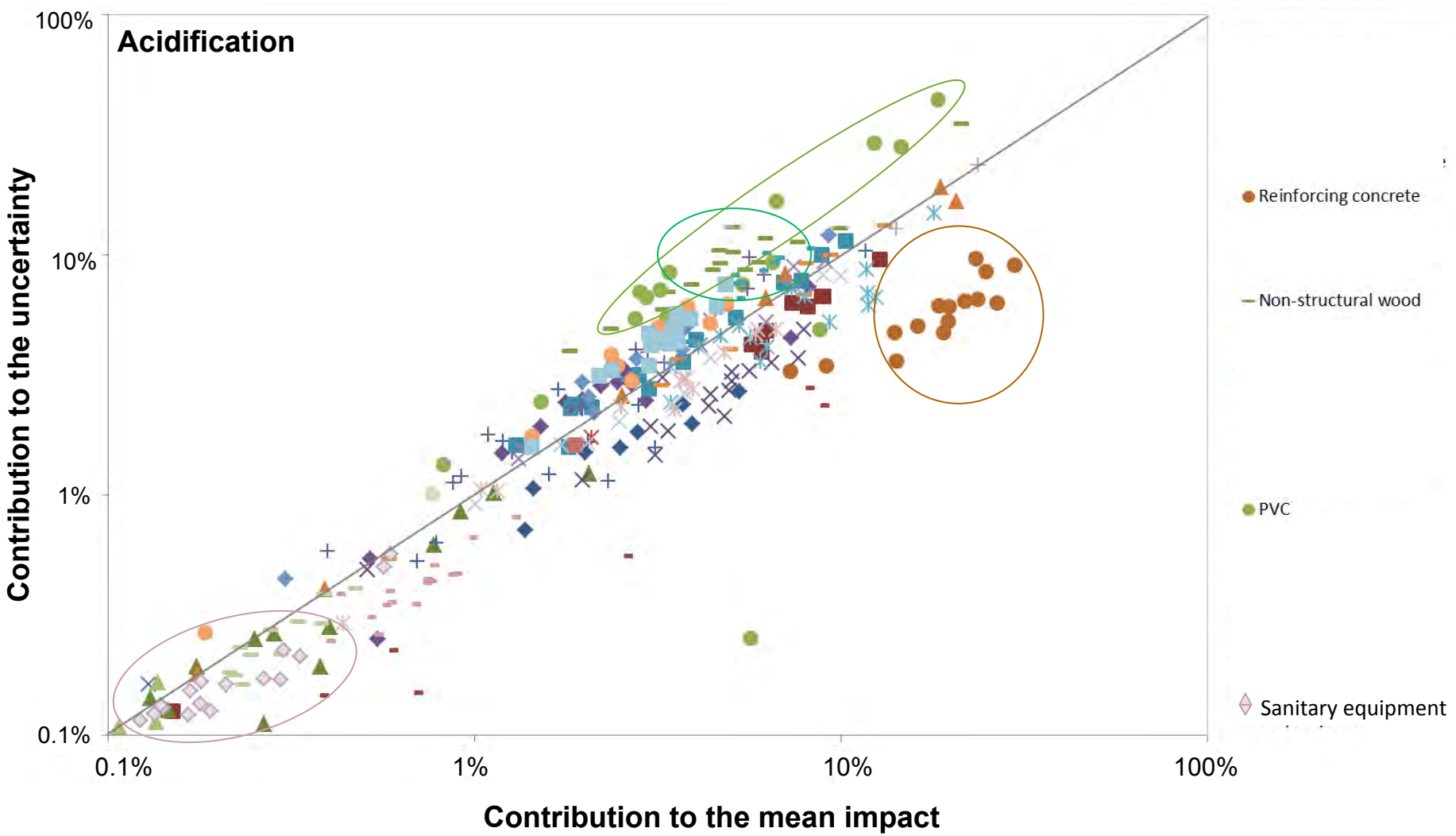


Identification of key parameter



Identification of key parameter



Conclusion

Contribution analysis allows to identify which materials:

✓have the greatest contribution to the environmental impacts of the building.

✓have a high contribution to the over all impact AND a significant contribution to the uncertainty.

✓that are highly uncertain but do not often contribute to the impacts

✓where generic data are sufficient (no contribution to uncertainty and sensitivity)

Thank you for your attention