COUPLING GIS AND LCA: THE CASE OF BUILDING RENOVATION AT URBAN SCALE

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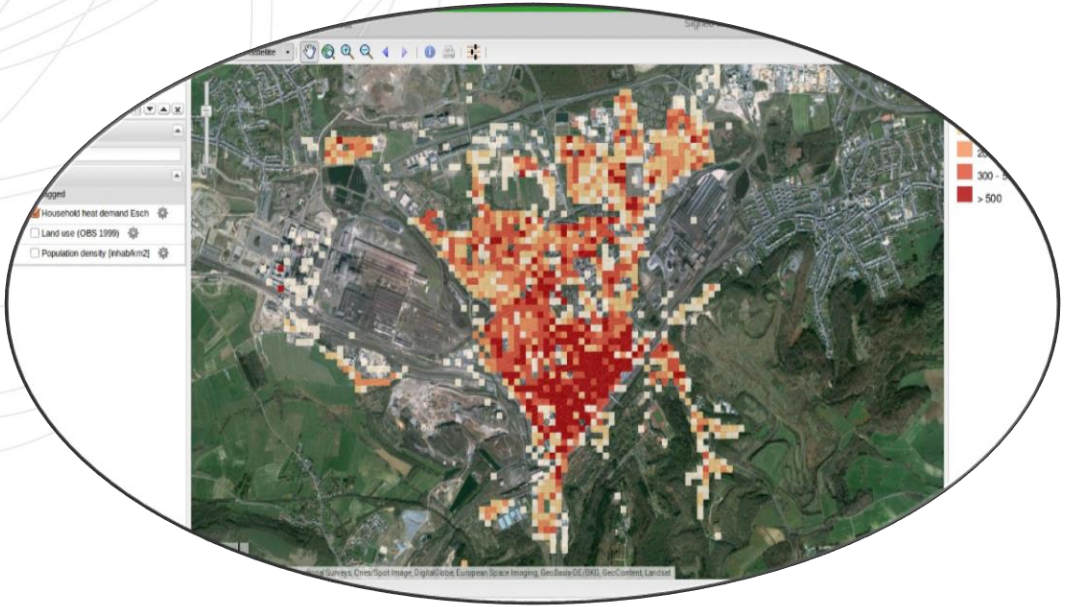

DISCUSSION FORUM ON LIFE CYCLE ASSESSMENT

Zurich (CH),
March 30, 2017

Antonino Marvuglia
LIST - Luxembourg Institute of Science and Technology

Rationale - Objectives

Sustainable retrofitting of urban housing stocks

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Context

- **Building sector:** 40% global energy consumption, 33% global GHG emissions. Need to accelerate and prioritize refurbishment of existing buildings.
- **Local authorities need comprehensive tools** to assess the effect of building refurbishment at the city scale in order to **target sustainable policies.**

Objectives

- **Evaluate the effect of retrofitting residential buildings** on **energy savings** and environmental impact **at the city scale** considering their **whole life cycle** for decision support in sustainable urban planning.

Why LCA at urban scale?

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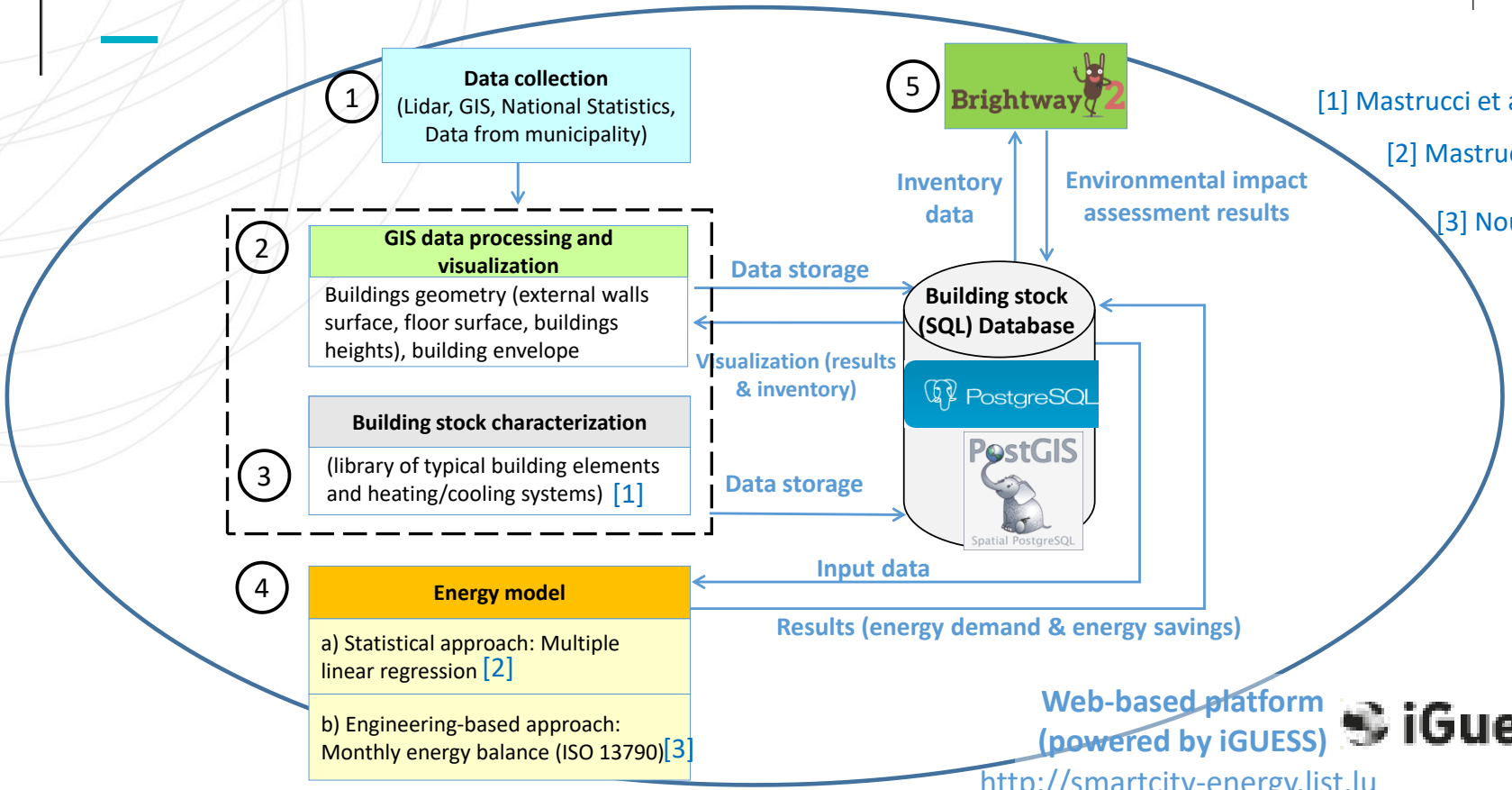
Existing building stocks

- Stages other than then the use phase become more important with the increased energy efficiency of buildings
- LCA allows environmental impact assessment along building life cycle
- Lack of studies at the urban scale due to complexity of building stocks
- More methodological developments are needed to upscale LCA in order to support decision in sustainable urban plans

Our framework



[1] Mastrucci et al., 2016

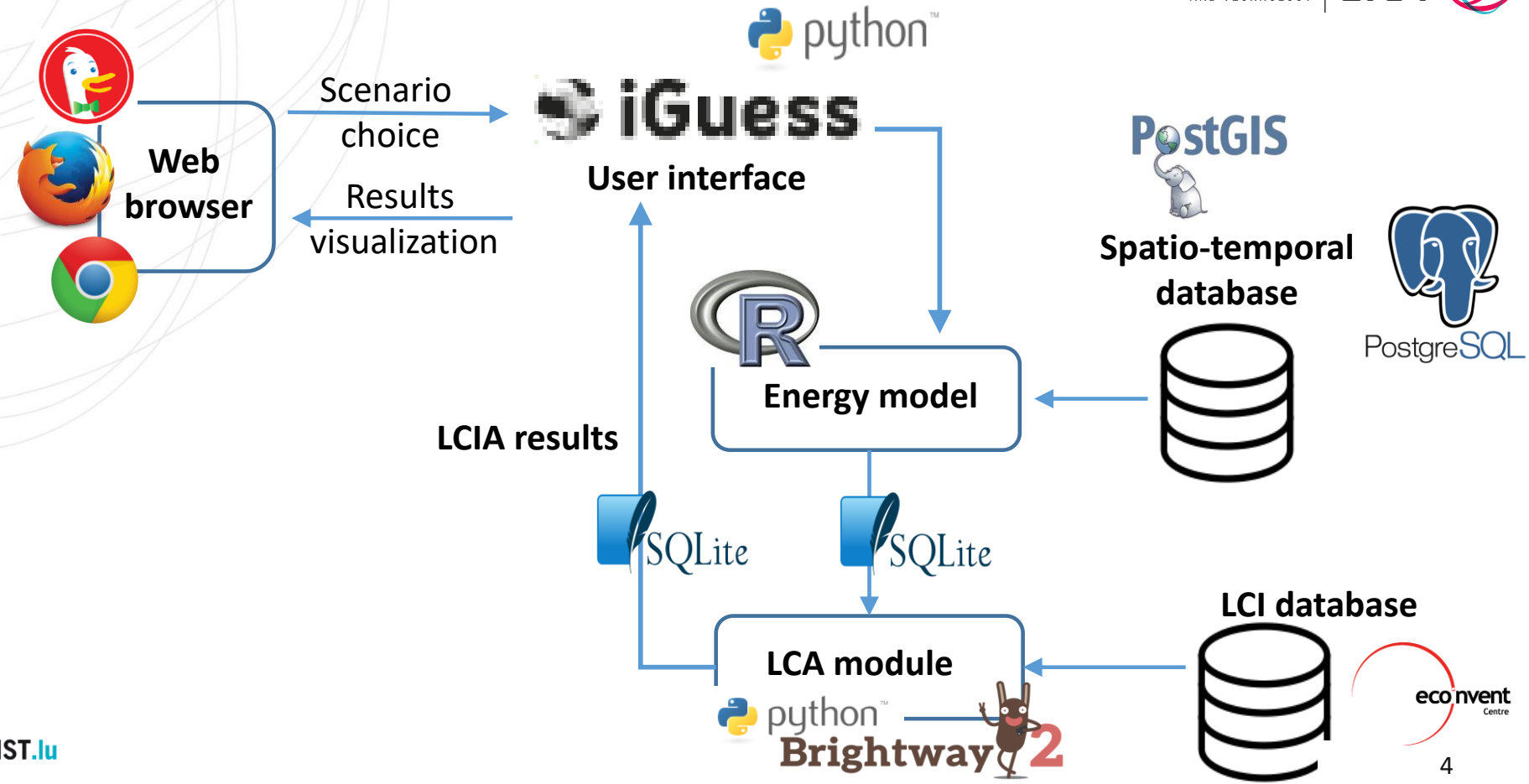
[2] Mastrucci et al., 2014

[3] Nouvel et al., 2015

Web-based platform (powered by iGUESS) iGuess

http://smartcity-energy.list.lu

Design of the platform



Geospatial data processing

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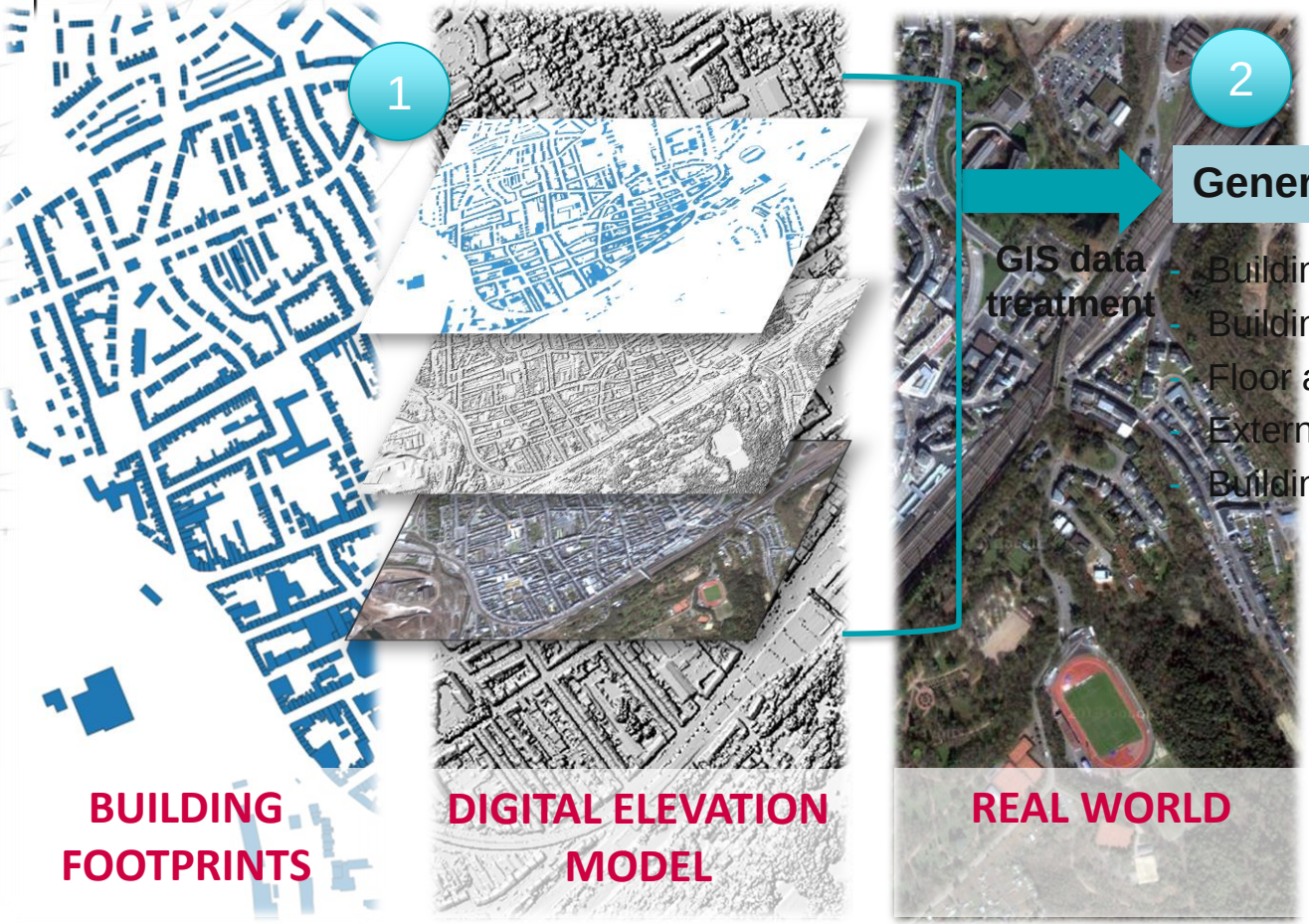

Building stock characterization

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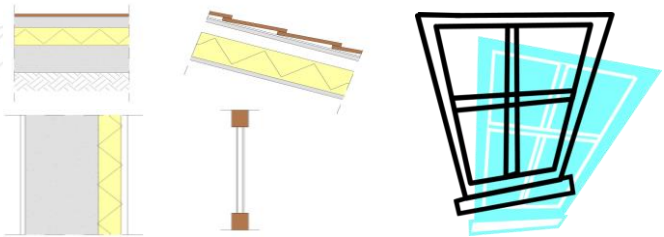
- Identification of representative building elements - retrofitting operations



- Distribution of building elements in the stock based on GIS data, building permits and statistics

3 City of Esch/Alzette (LU)

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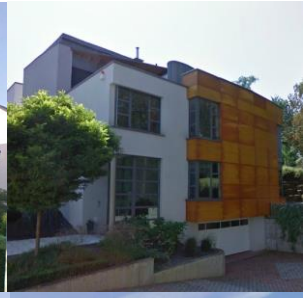
HOUSING TYPES

	< 1949	1949-1968	1969-1994	>1994
SFH SINGLE FAMILY HOUSE				
RH ROW-HOUSE				
MFH MULTI-FAMILY HOUSE				

Web-based platform

http://smartcity-energy.list.lu

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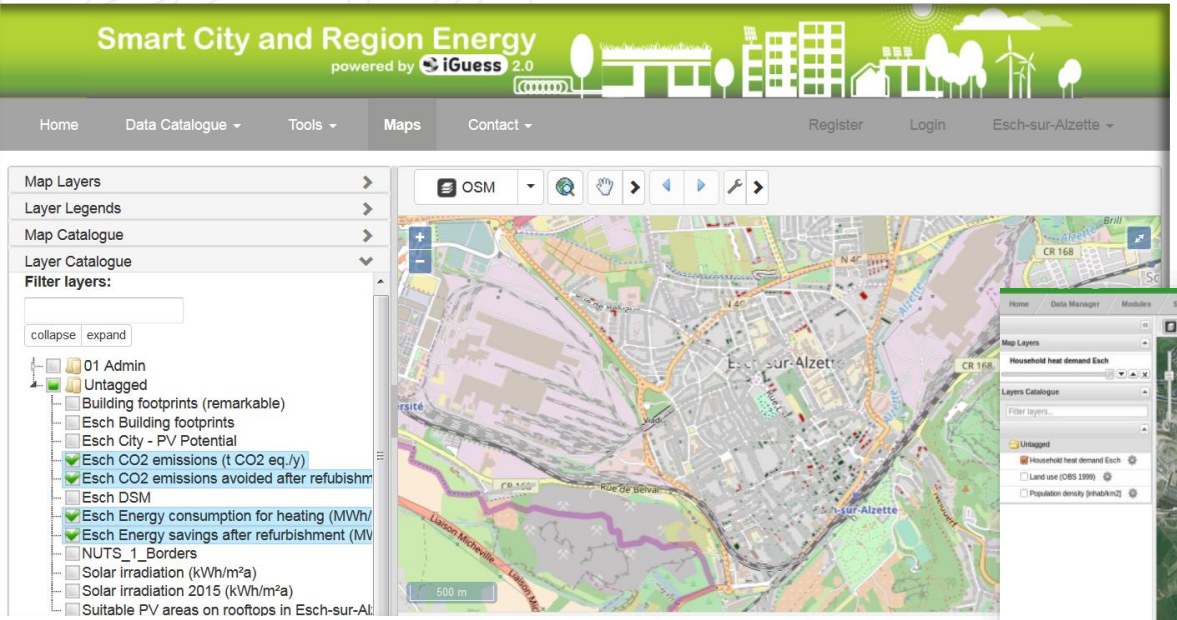
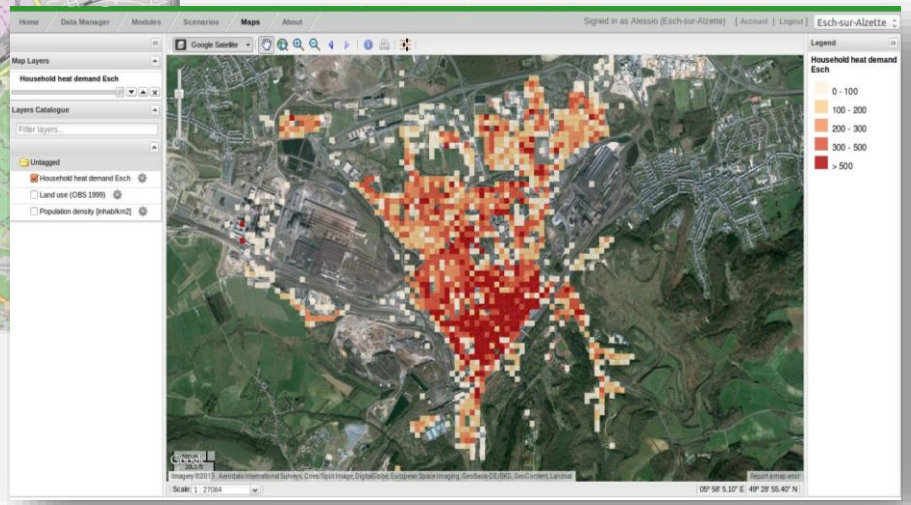
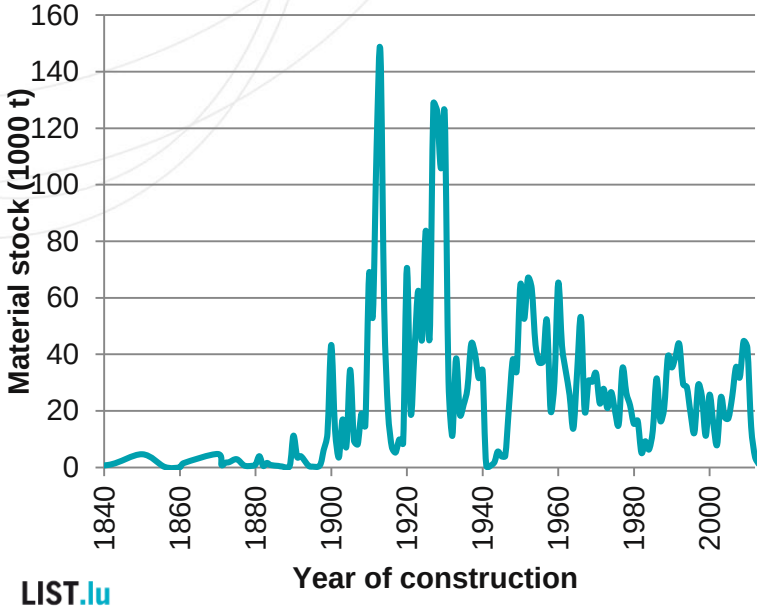
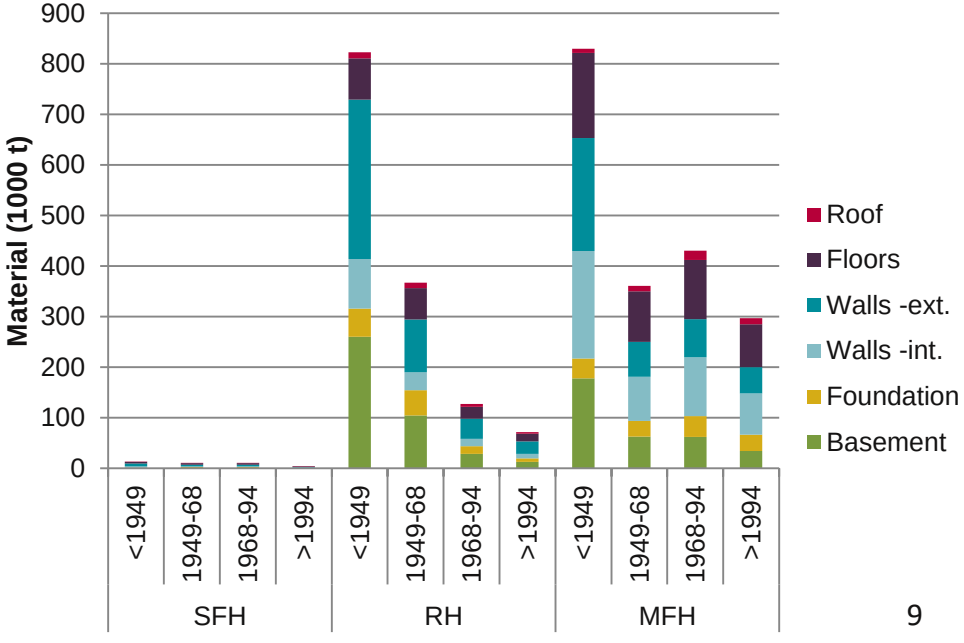




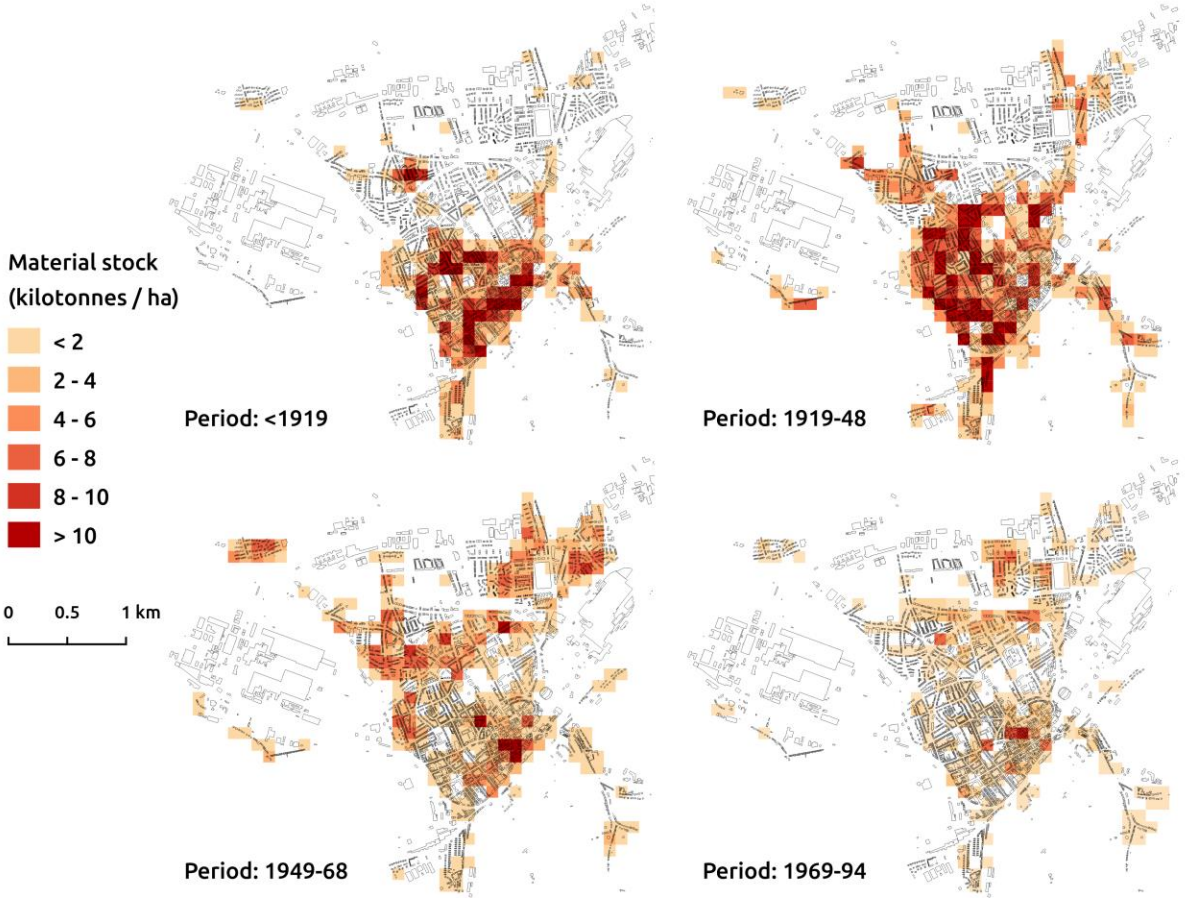
Results (1)
Mass distribution

- Distribution of material in residential buildings over the time
- Total mass of material for different housing types





Results (2)
Spatial mass distribution

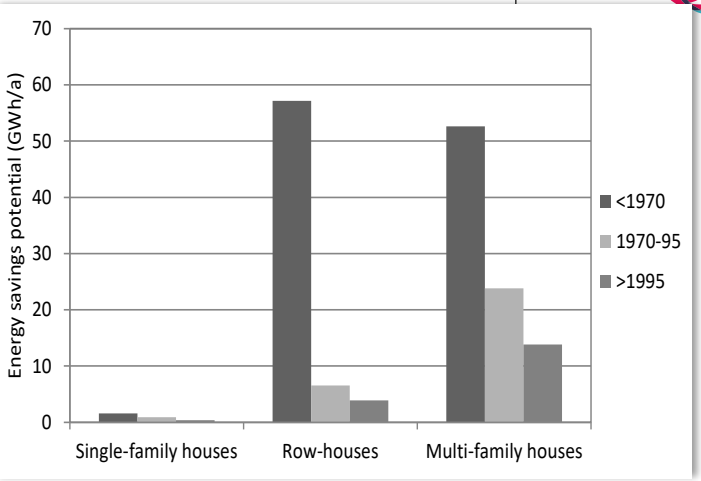


Material stock of Esch-sur-Alzette per period of construction of buildings

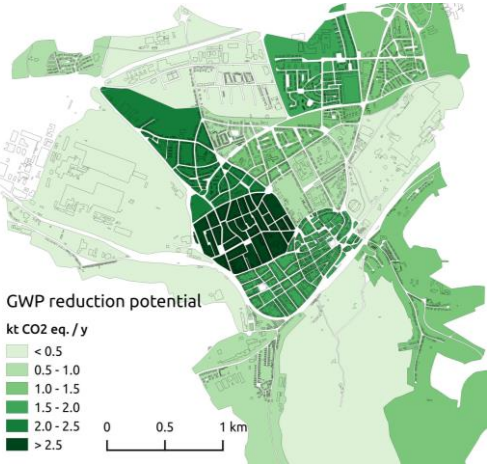
Results (3)
LCA of housing retrofitting

- **The energy saving potential** after retrofitting of the entire residential stock is 87.7 GWh/y, corresponding to 35.3% of the current energy consumption.

Energy saving potential for retrofitting

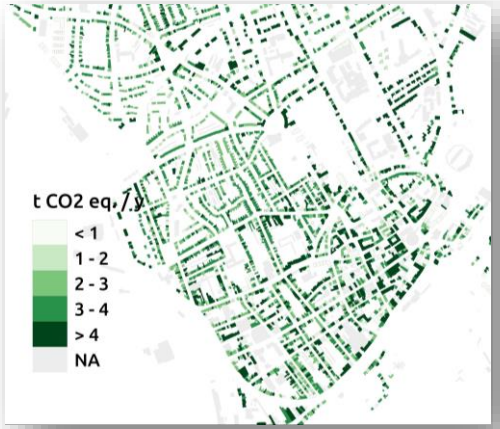


- **City of Esch/Alzette**
  -37 % CO2 eq./y
  reduction potential by refurbishing residential building



Potential yearly CO_2 eq. reduction

Average at district level



Results (4)
LCA of housing retrofitting

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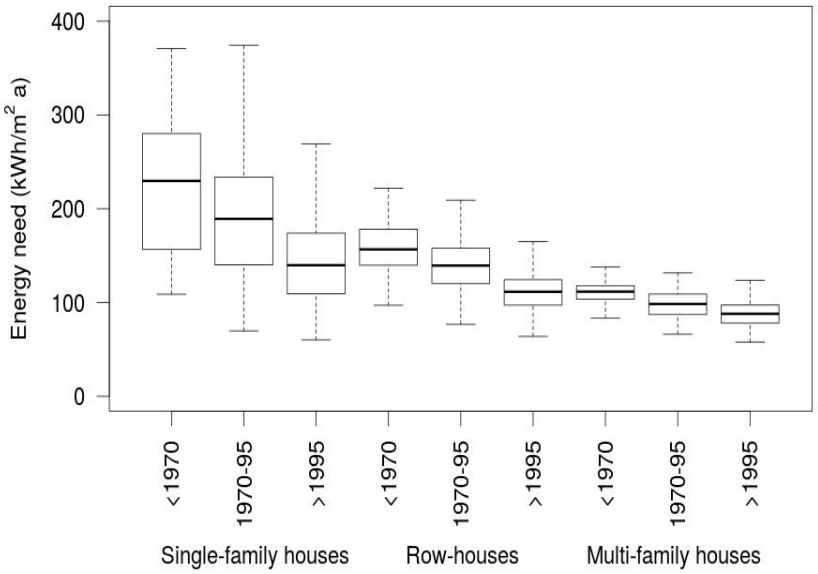
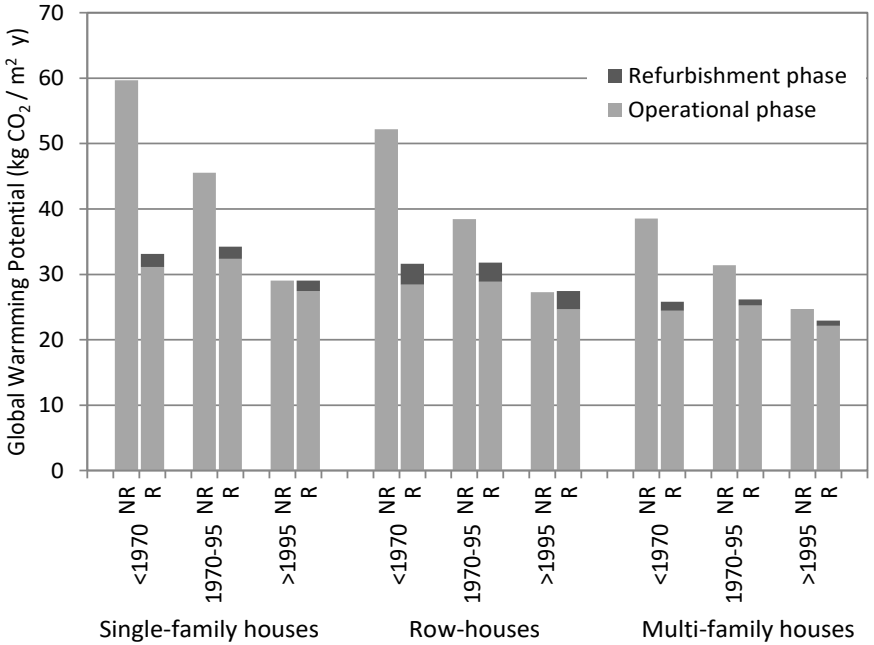
- Distribution of energy needs of buildings for space heating - DHW



- Average GWP with and without implementing retrofitting measures



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Conclusions

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- Integrated framework to evaluate the effect of retrofitting urban building stocks.
- Integration GIS-LCA effective to gather building data in an efficient, automated way and to visualize results for stakeholders.
- Limitation of the building-by-building approach due to calculation time when the spatial scale is increased
- Possible enhancement with 3D CityGML

Thank you for your attention

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References:

- **Mastrucci et al., 2014**. Estimating energy savings for the residential building stock of an entire city: A GIS-based statistical downscaling approach applied to Rotterdam. Energy and Buildings 75: 358–367
- **Nouvel et al 2015.** Combining GIS-based statistical and engineering urban heatconsumption models: Towards a new framework for multi-scalepolicy support. Energy and Buildings 107: 204–212
- **Mastrucci et al 2016.** Geospatial characterization of building material stocks for the lifecycle assessment of end-of-life scenarios at the urban scale. Resources, Conservation and Recycling
- **Mastrucci et al 2017.** Life Cycle Assessment of building stocks from urban to transnational scales: A review. Renewable & Sustainable Energy Reviews 74: 316–332

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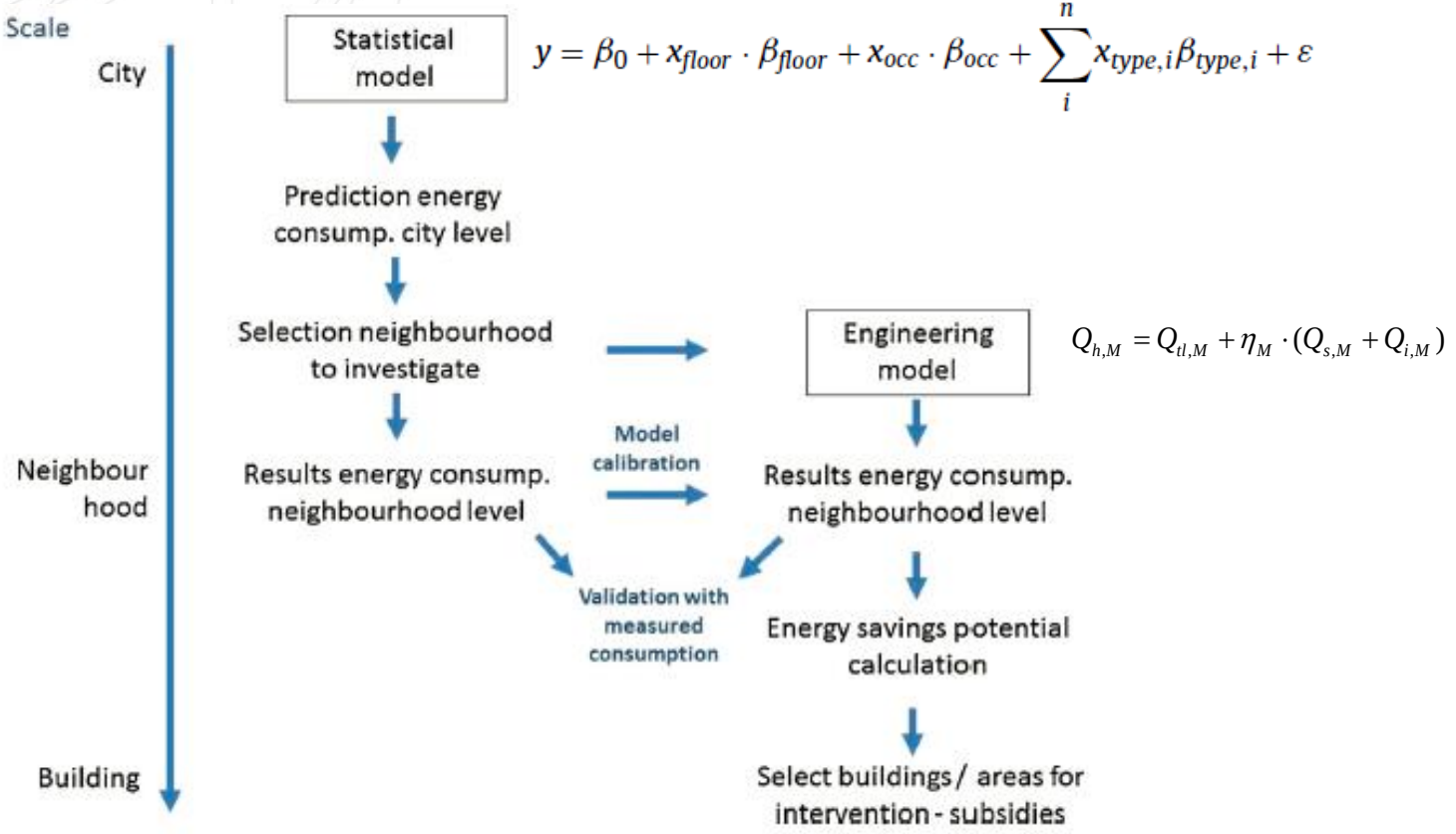
SUPPORTING SLIDES


Scale
City
Neighbour hood
Building
Statistical model
$y = \beta_0 + x_{floor} \cdot \beta_{floor} + x_{occ} \cdot \beta_{occ} + \sum_i^n x_{type,i}\beta_{type,i} + \varepsilon$
Prediction energy consump. city level
Selection neighbourhood to investigate
Engineering model
$Q_{h,M} = Q_{tl,M} + \eta_M \cdot (Q_{s,M} + Q_{i,M})$
Model calibration
Results energy consump. neighbourhood level
Results energy consump. neighbourhood level
Validation with measured consumption
Energy savings potential calculation
Select buildings / areas for intervention - subsidies

SPATIO-TEMPORAL DATABASE

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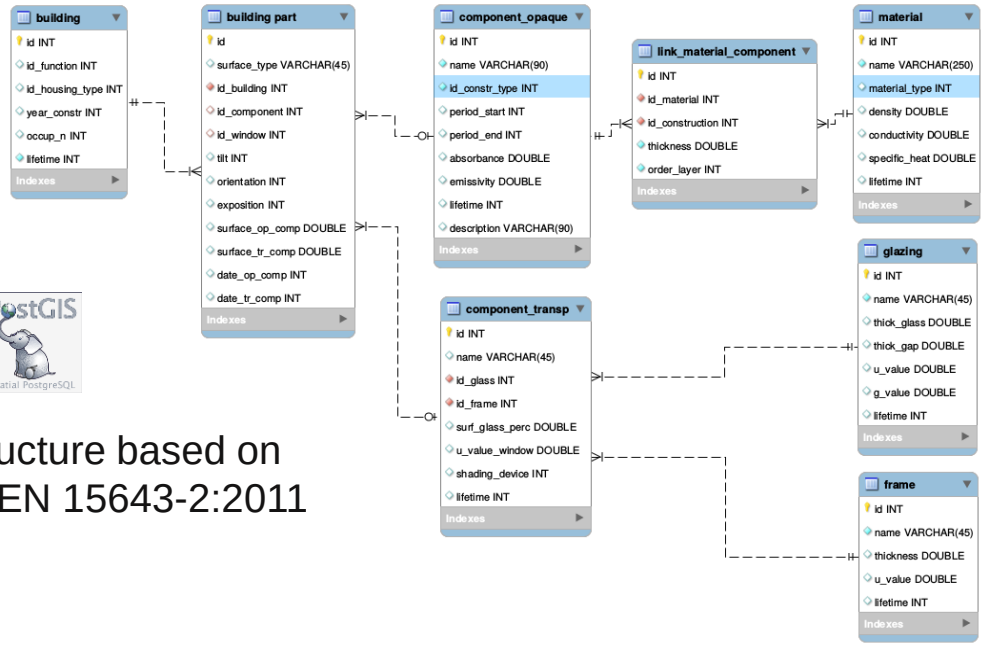
Relational database in PostgreSQL – PostGIS used to automatically associate elements to real buildings and aggregate results to several scales.

Level: **Buildin g** | **Building part** | **Element/Componen t** | **Product**



Data structure based on the std. EN 15643-2:2011