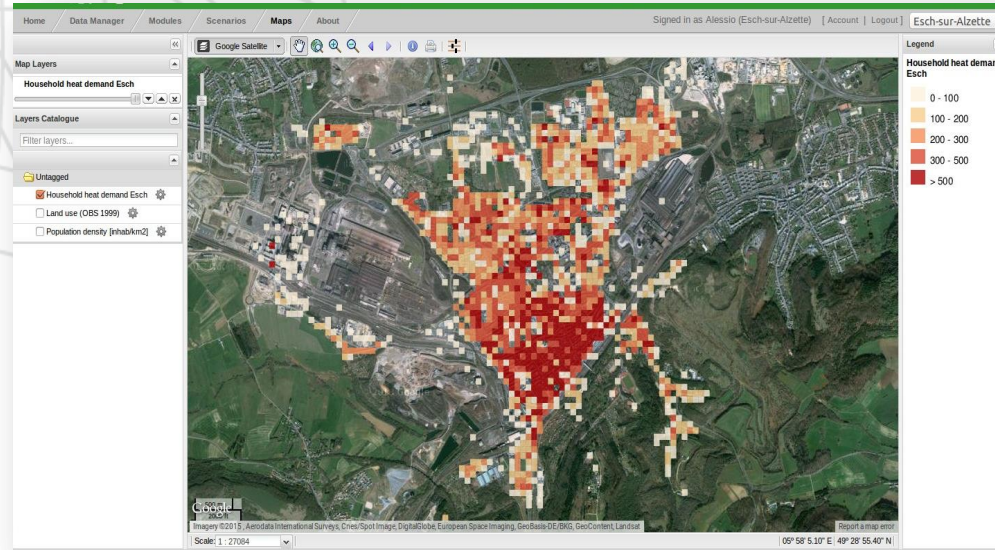


# Workshop

## Characterizing the built environment stocks: methods and case studies

Odense, Denmark, August 11-12, 2016



Geospatial characterization of building material stocks to support environmental LCA at the city scale

Antonino Marvuglia

# RATIONALE - OBJECTIVES

## Sustainable retrofitting of urban housing stocks

Partners:



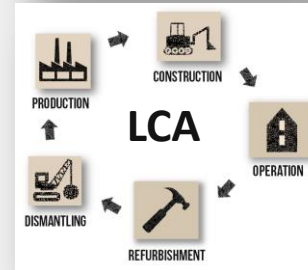
Financial support:



Fonds National de la  
Recherche Luxembourg

### Context

- **Building sector:**
  - 40% energy consumption
  - 36% carbon emissions and 33% of the total C&DW in Europe.
- **Local authorities need comprehensive tools** to assess the effect of building renovation at the city scale in order to **target sustainable policies.**



## DAEDALUS

Post Doc project  
Dr. Alessio Mastrucci



### Objective of the project

- **Evaluate the effect of retrofitting residential buildings** on energy savings and **environmental impact (including C&DW)** considering their **whole life cycle** for decision support in sustainable urban planning.

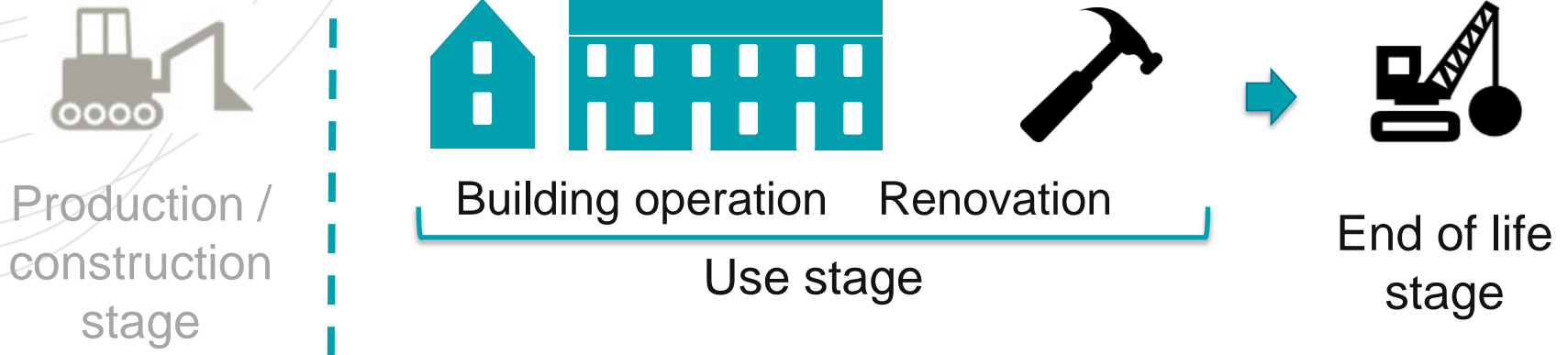
This presentation will focus only on:

- **Quantifying the materials' stock in residential buildings at the city scale**
- **Assessing the potential environmental impact for demolition waste treatment scenarios**



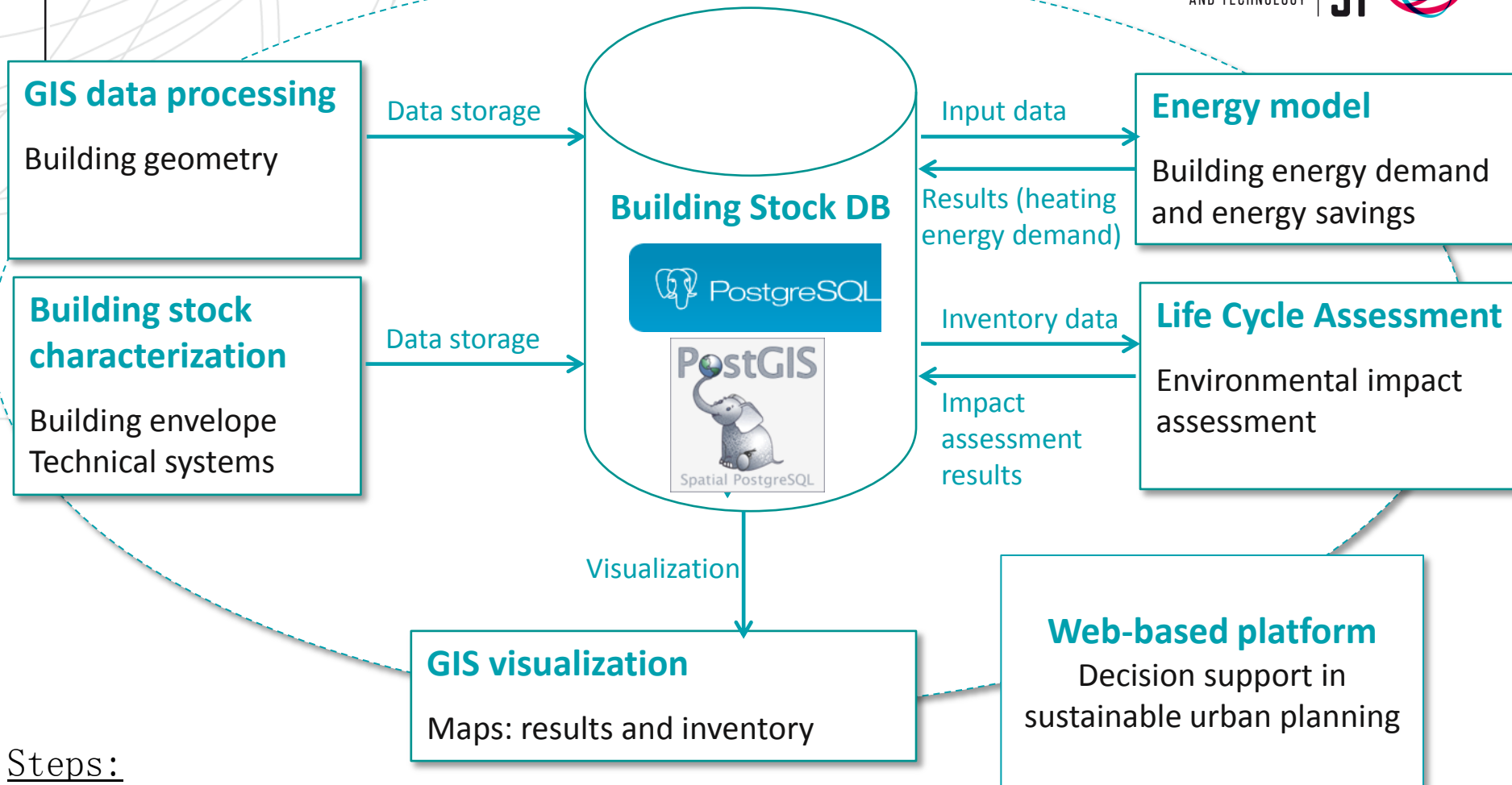
# WHY LCA AT URBAN SCALE?

## Existing building stocks



- 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

# METHODOLOGY OVERVIEW



## Steps:

1. Geospatial processing.
2. Material stock characterization.
3. Identification of the end-of-life scenarios.
4. Life Cycle Assessment of valorization



# GEOSPATIAL DATA - PROCESSING



**BUILDING  
FOOTPRINTS**



**DIGITAL ELEVATION  
AND TERRAIN  
MODELS**



## **Building geometry (building-by-building)**

- Height of buildings
- Building gross volume
- Heated floor surface
- Surface of outer walls
- Housing type (detached house, row house)

# HOUSING TYPES (ESCH-SUR-ALZETTE)

LUXEMBOURG  
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**Population (2014):** 32 600 inhabit.

**Housing stock (2014):**

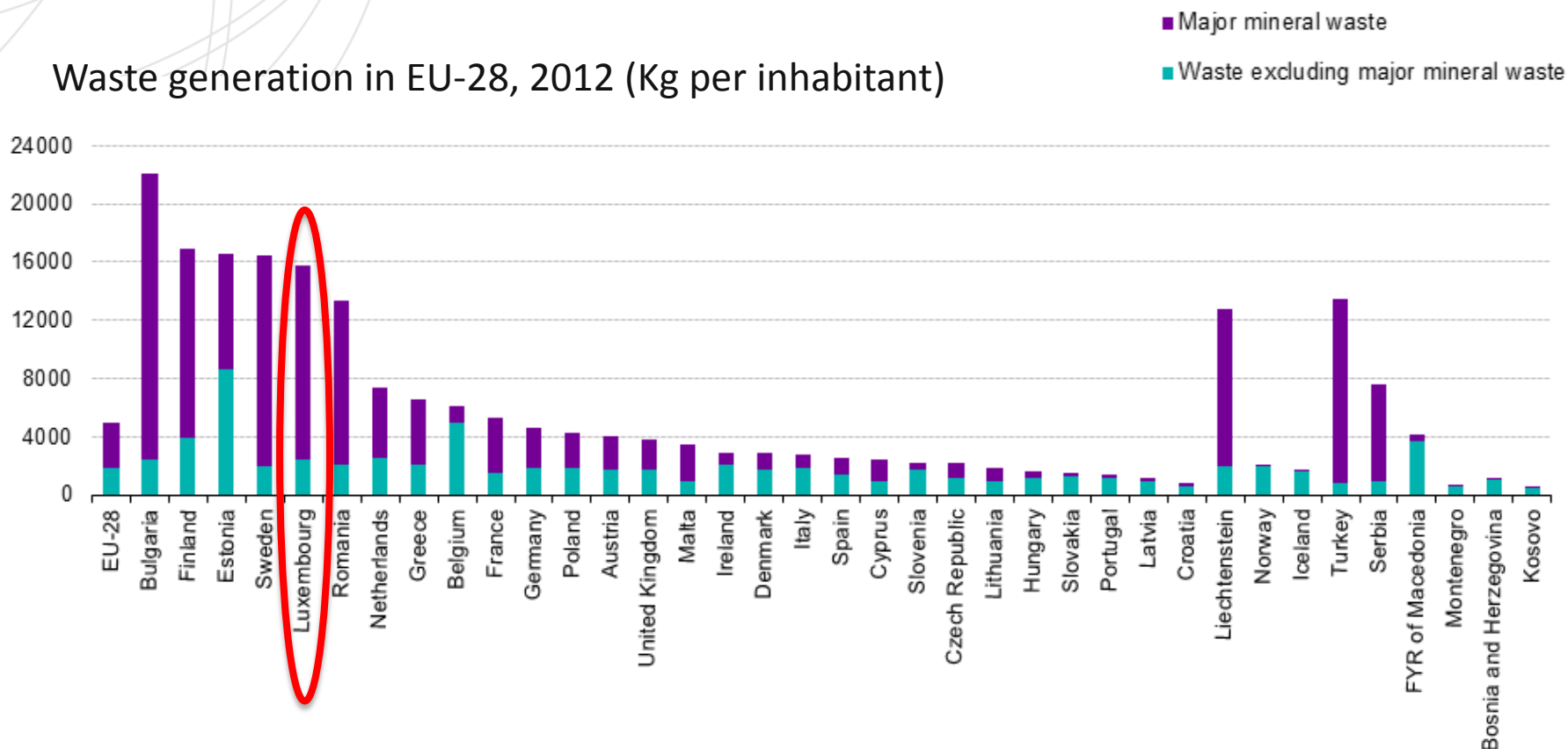
~6400 residential buildings

~13 000 dwellings

Housing types	< 1949	1949 - 1968	1969 - 1994	> 1994
<b>SFH</b> Single-Family House				
				
<b>MFH</b> Multi-Family House				

# WASTE GENERATION

Waste generation in EU-28, 2012 (Kg per inhabitant)



**Luxembourg**

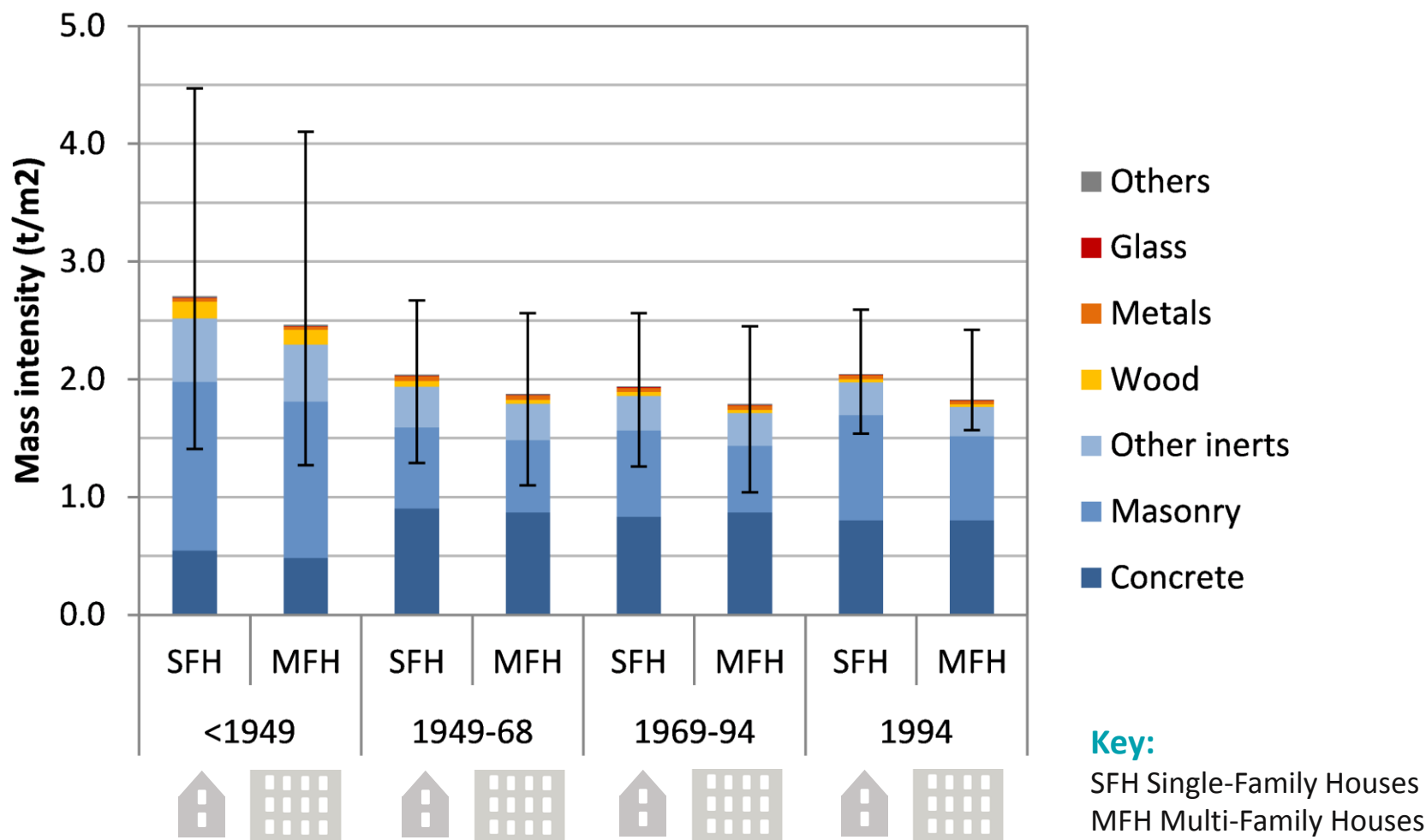
Mineral waste: **13 393** kg/inhab.

EU-28 average: **3156** kg/inhab.

Source: Eurostat – Waste statistics  
[http://ec.europa.eu/eurostat/statistics-explained/index.php/Waste\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics)

# THE WEIGHT OF THE CITY

## Material stock of residential buildings in Esch-sur-Alzette

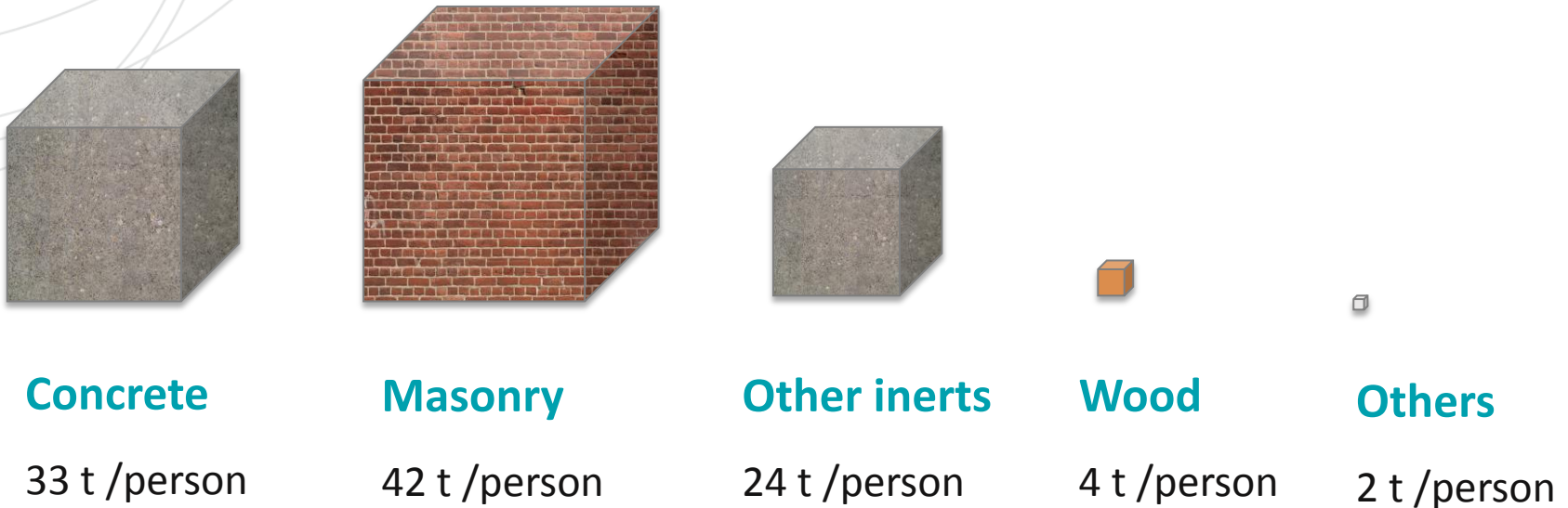




# THE WEIGHT OF THE CITY

## Material stock of residential buildings in Esch-sur-Alzette

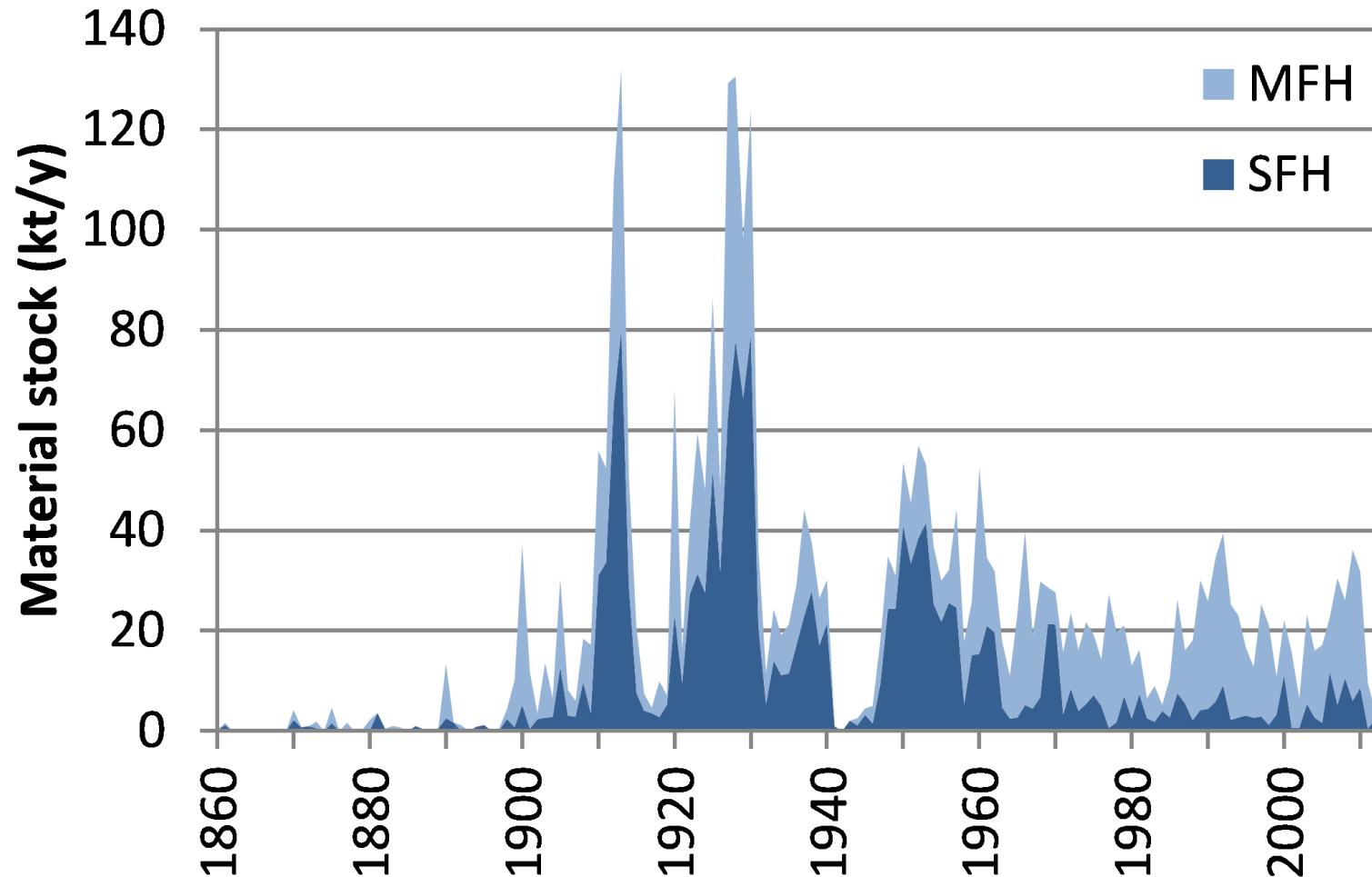
- How much material per person?



**~ 105 tonnes per person!**

# THE WEIGHT OF THE CITY

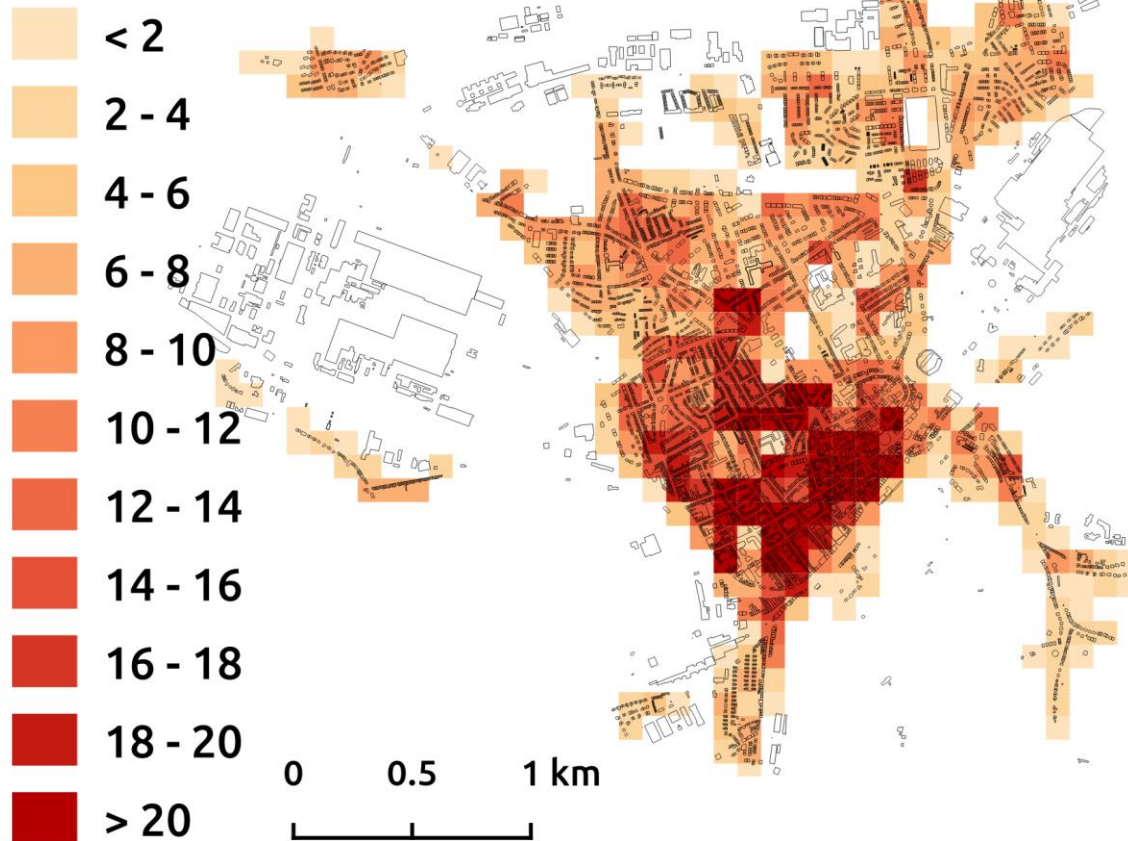
## Material stock of residential buildings in Esch-sur-Alzette



# THE WEIGHT OF THE CITY

## Material stock of residential buildings in Esch-sur-Alzette

Current material stock  
(kilotonnes / ha)



# THE WEIGHT OF THE CITY

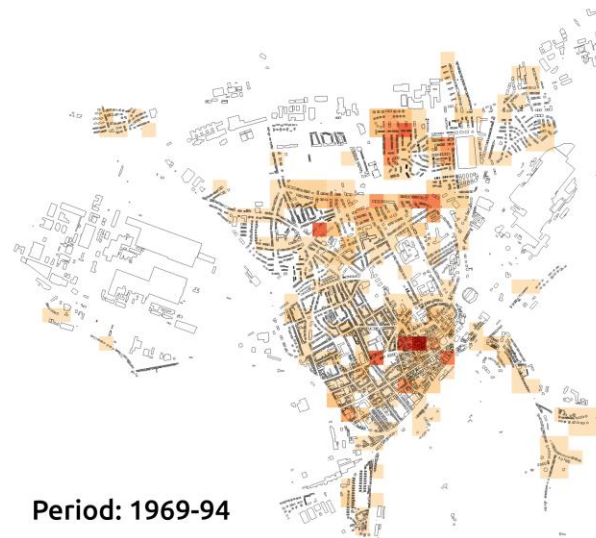
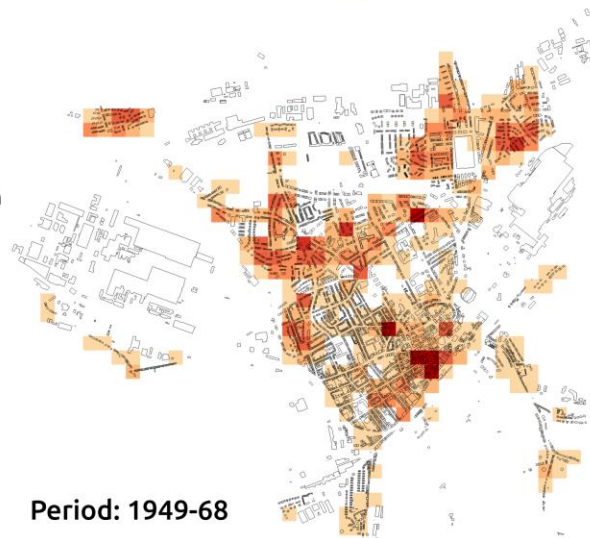
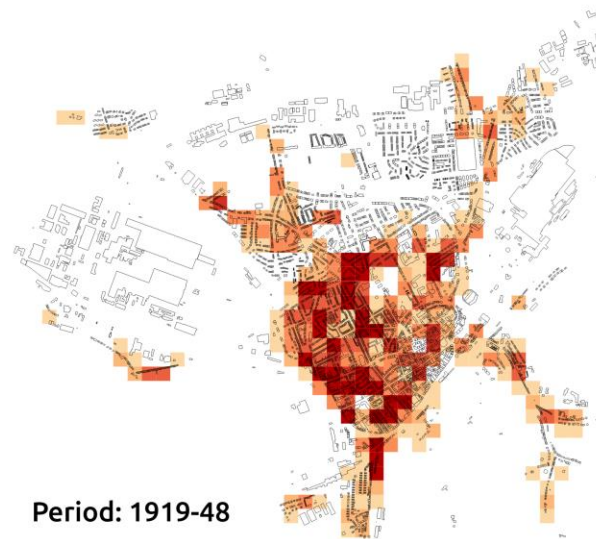
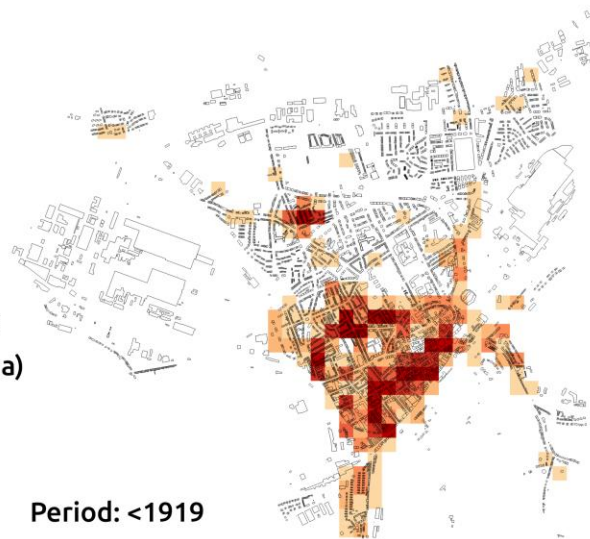
## Material stock of residential buildings in Esch-sur-Alzette

Material stock  
(kilotonnes / ha)



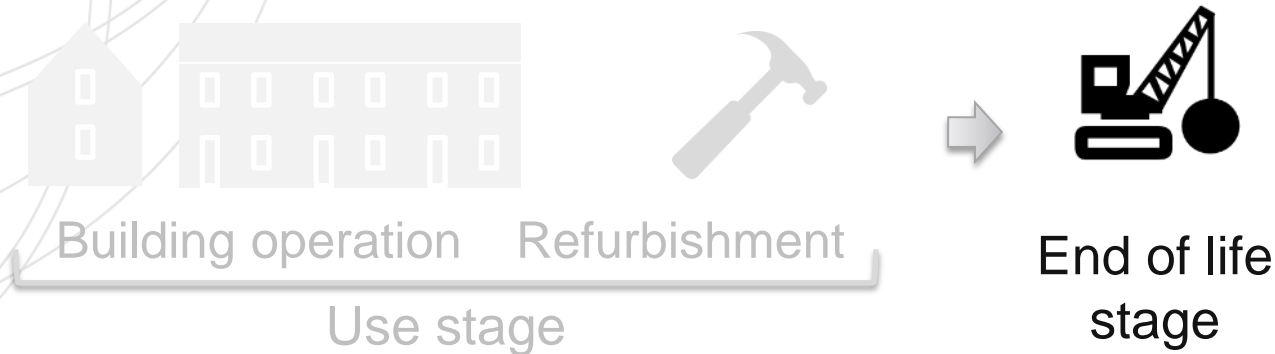
0 0.5 1 km

A horizontal scale bar with markings for 0, 0.5, and 1 km.





# LIFE CYCLE ASSESSMENT



- **LCA** of end-of-life according to EN 15643-2.  
Database Ecoinvent 2.2. Method CML 2-baseline 2000.
- **Stages included:**  
Demolition, transportation, waste treatment, recycling/downcycling.
- **Main input data:**  
Plan general de gestion des dechets (Luxembourg), STATEC data, previous work.

# END-OF-LIFE SCENARIOS

Landfill

Incineration

Recycling /  
Downcycling

Concrete  
Brick, Other inerts



Plaster  
Float glass



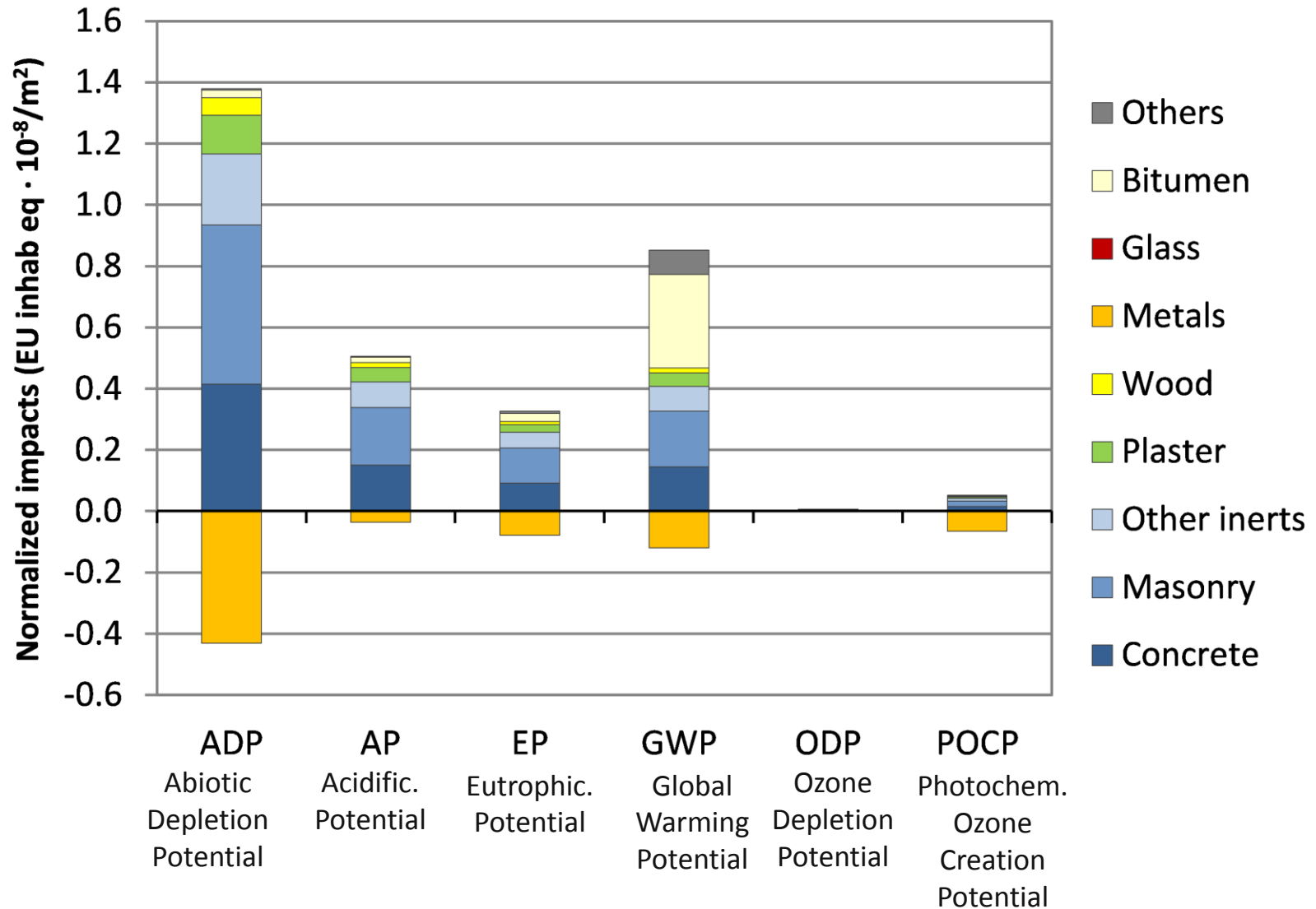
Insulating materials  
Bitumen  
Wood



Metals

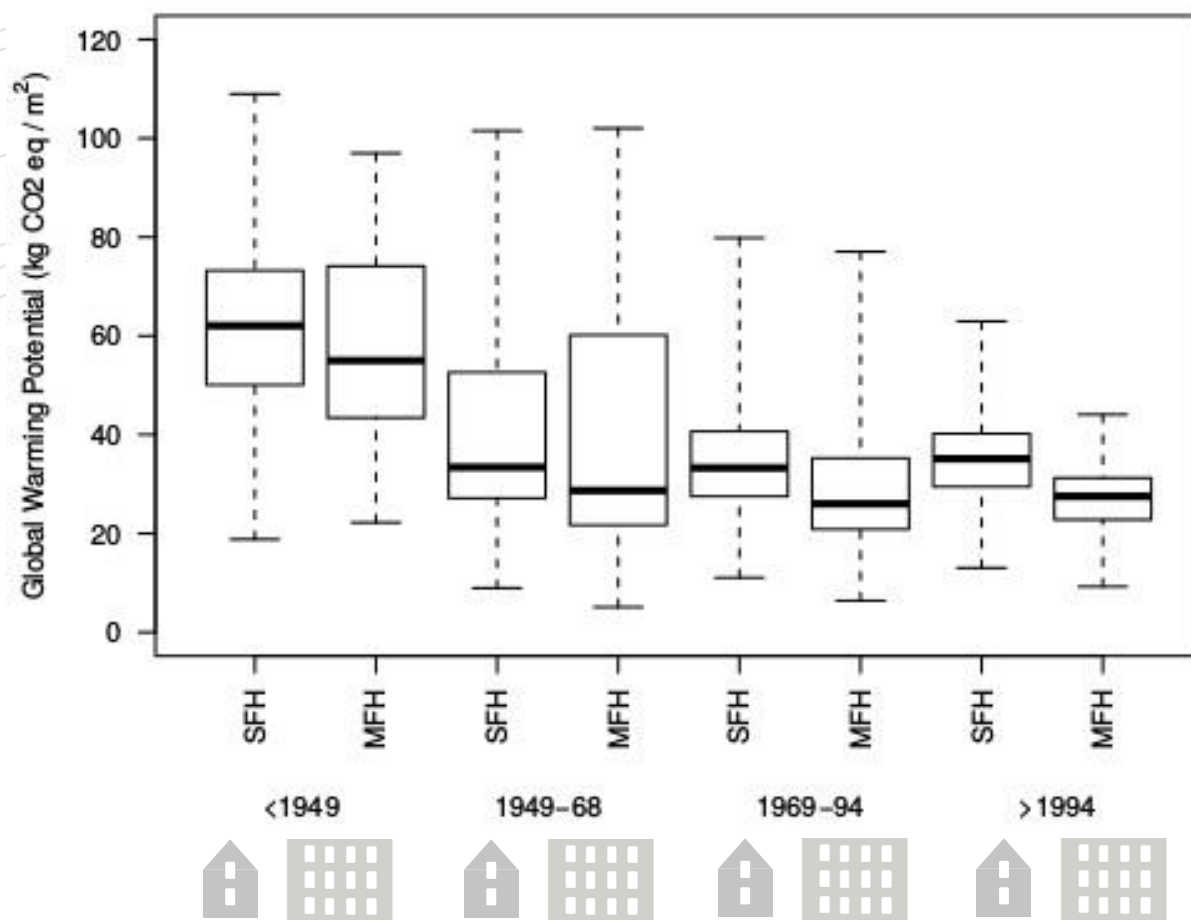


# END-OF-LIFE IMPACT



# END-OF-LIFE IMPACT

## Global Warming Potential (GWP) of the end-of-life stage



### Key:

SFH Single-Family Houses

MFH Multi-Family Houses



# END-OF-LIFE SCENARIOS

## Inert materials

**Scenario 1:** Business as usual

**50%** Landfill, **50%** Downcycling

**Scenario 2:** Increased downcycling

**30%** Landfill, **70%** Downcycling

**Demolition**



**to Landfill**



**to Sorting plant**



**to Landfill**

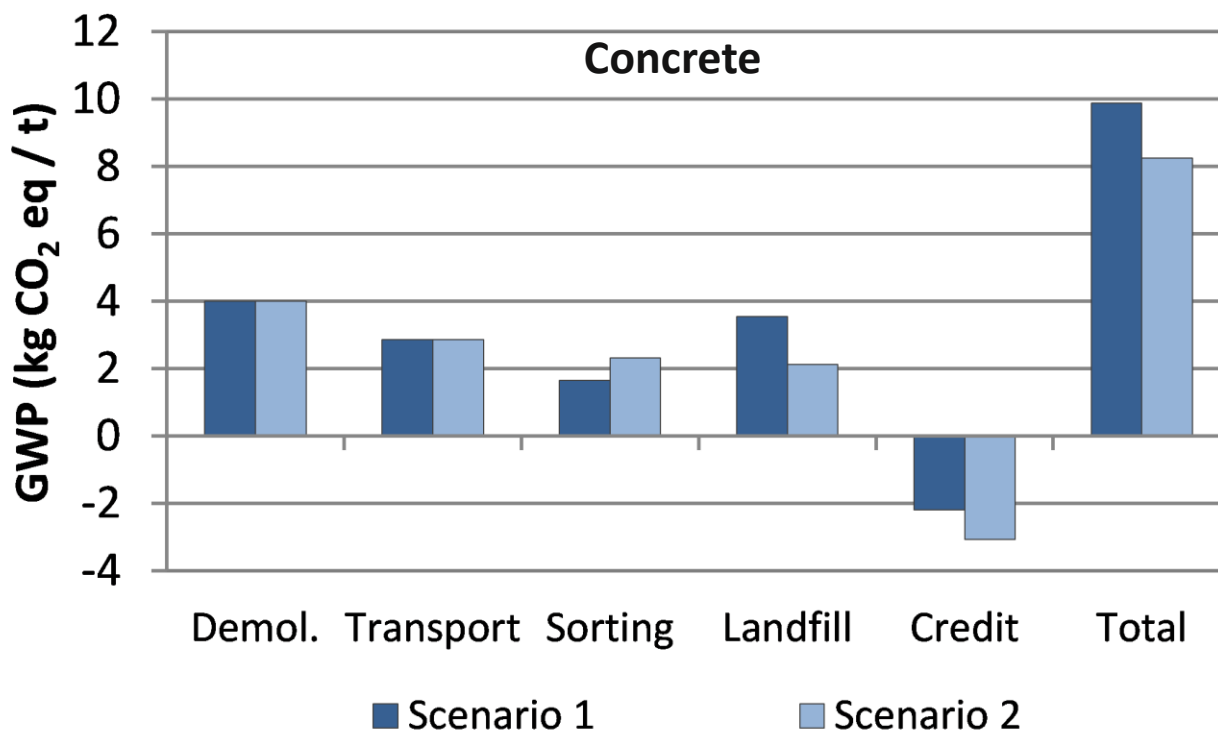


**to Downcycling**



# RESULTS

## Environmental Impact of the end-of-life

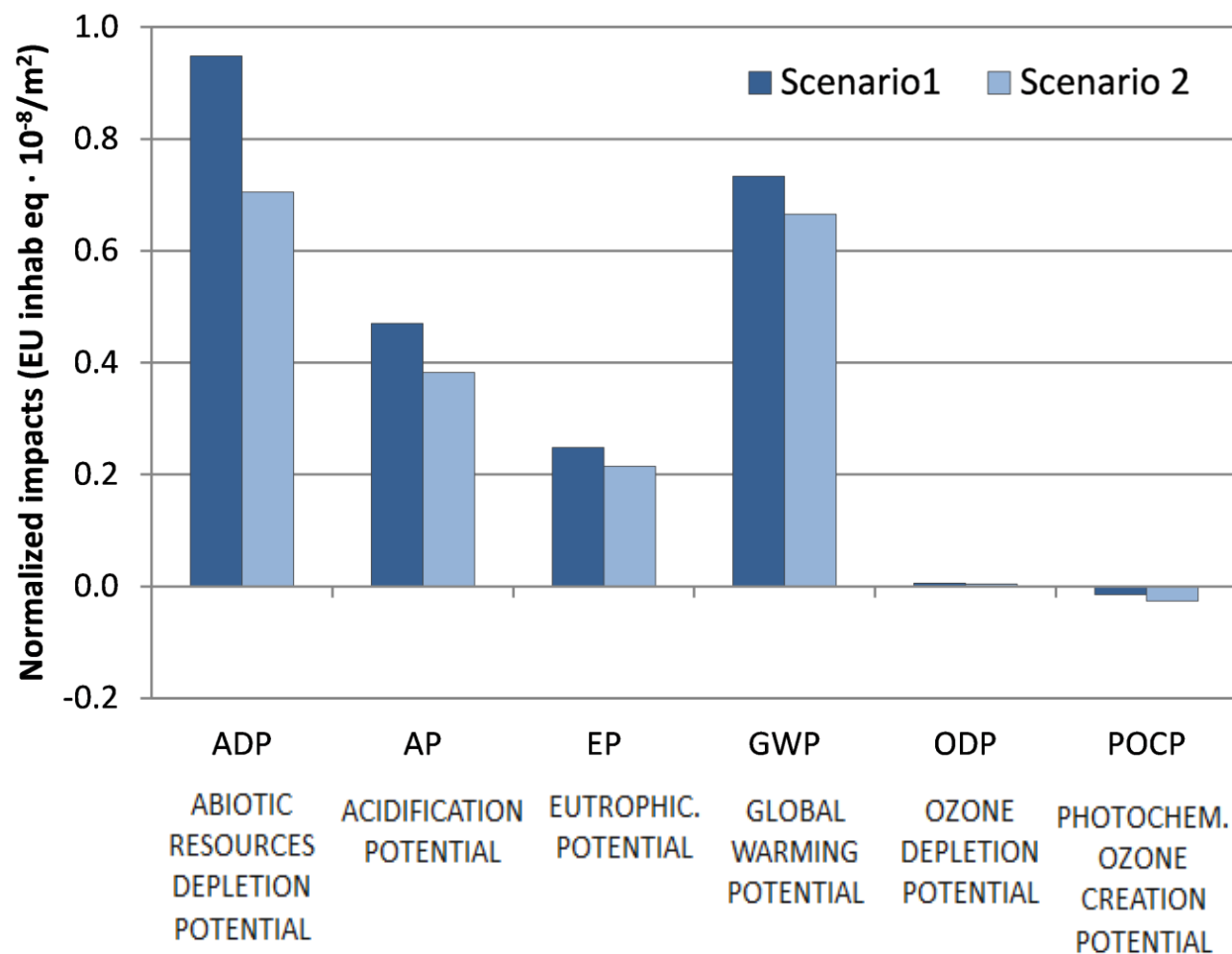


Impact reduction potential for different inert materials and impact categories between the two scenarios.

Material	Impact reduction potential (%)					
	ADP	AP	EP	GWP	ODP	POCP
Concrete	20.7	20.6	12.8	16.4	24.8	26.9
Limestone	21.0	21.0	13.1	16.7	25.0	27.3
Brick	21.6	22.2	13.5	17.3	25.7	28.8

# RESULTS

## Average environmental impact end-of-life



**Reduction potential:**

26% ADP

9% GWP

# CONCLUSIONS AND FUTURE WORK

## Material stock and end-of-life scenarios

- Buildings before 1949 embed over 54% of the material mass in the city, mostly composed of inert materials.
- The amount of mineral waste per inhabitant is higher in Luxembourg (13'393 kg/inhab in 2012) than the European average (3156 kg/inhab in EU28)
- Pushing downcycling of inert materials to 70%: potential reduction -25.6% on Abiotic Depletion Potential, -9.2% on Global Warming Potential.

## Future work:


- Evaluating the impact of the different scenarios on land use
- Upgrading our current model at the city scale using the 3D city models (using the CityGML standard)

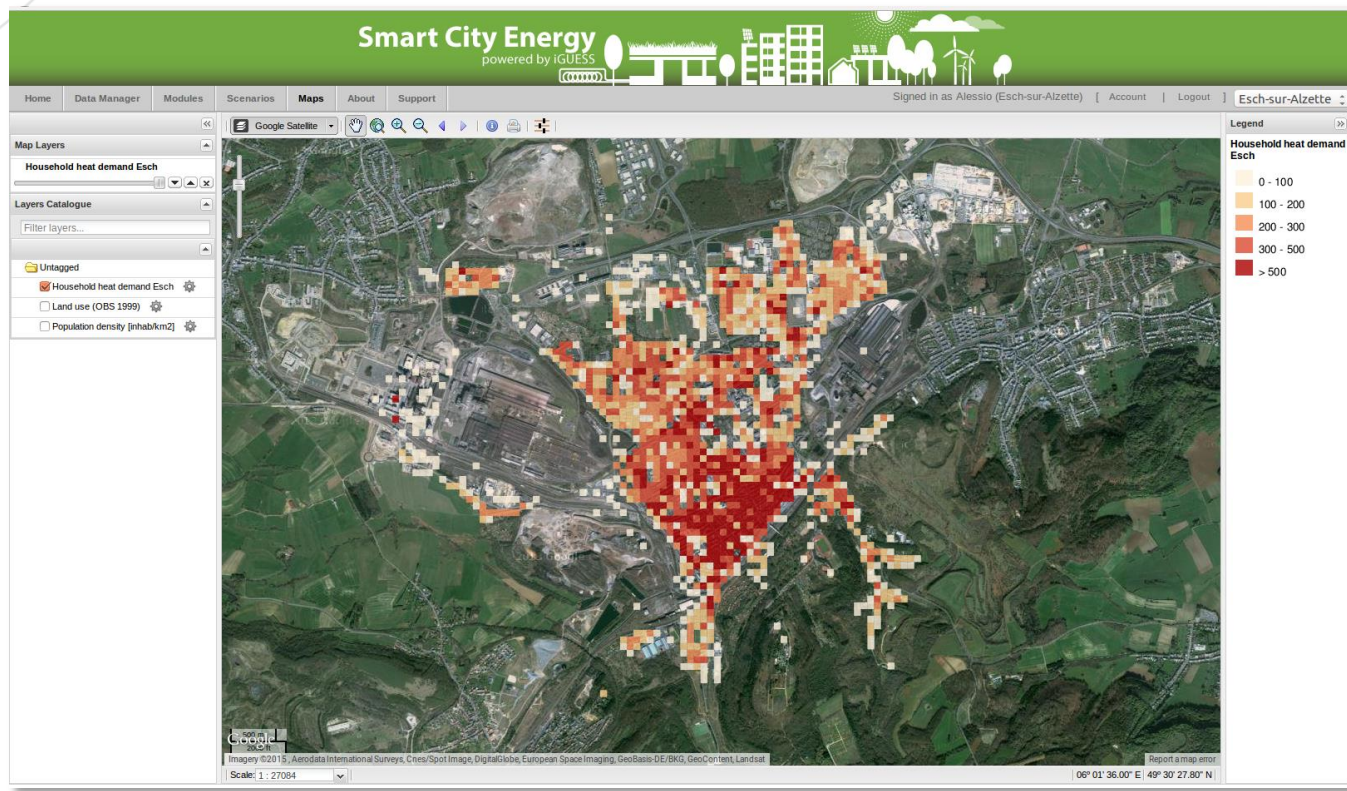
## Reference published work:





- Implementation in the Smart City and Region Energy web-platform

Powered by iGUESS 2.0  **iGUESS**



URL: <http://smartcity-energy.list.lu>

# LCM 2017 – Luxembourg 3-6 September

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**See you in  
Luxembourg!**

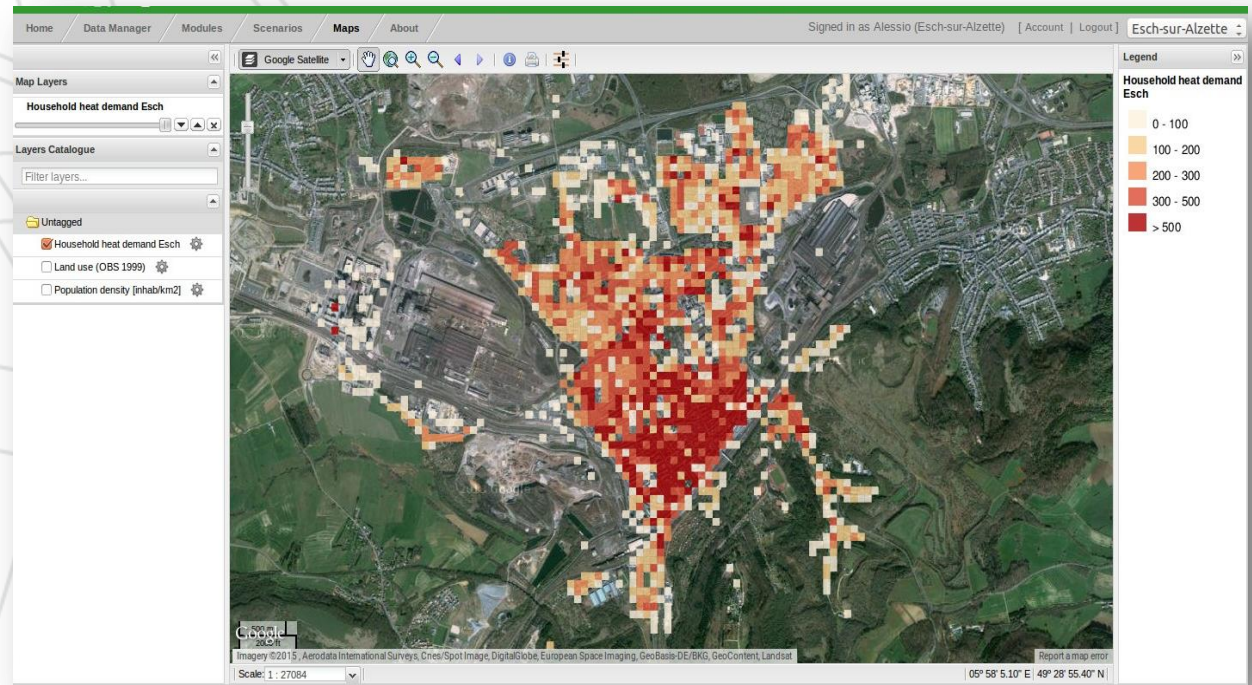
Abstracts submission: **15-12-2016**



**LCM  
2017**

3 - 6 September 2017  
Luxembourg, Luxembourg





Thank you for your attention

Antonino Marvuglia

Environmental Research & Innovation Department (ERIN)

Life Cycle Sustainability & Risk Assessment (LiSRA) Unit

E-mail: [antonino.marvuglia@list.lu](mailto:antonino.marvuglia@list.lu)

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