

# A place-based engineering model to map energy efficiency scenarios

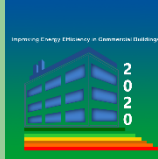
Guglielmina Mutani & Valeria Todeschi\*

*\*FULL, Energy Department, Polytechnic of Turin*

## TOPIC 10

*Energy consumption monitoring and  
benchmarking, energy modelling of  
building and district performances*

*urban energy atlas  
engineering energy models  
energy performance certificates  
energy savings  
retrofit interventions  
energy-efficiency scenarios*



# Background

- The **civil sector** is the most important **energy consumer in the EU**:
  - **97%** of the EU building stock is **not energy efficient**
  - only **0.2%** of residential buildings in the EU are undergoing **significant retrofit interventions**
- How to achieve **energy and climate targets**?

2020 Package	2030 Framework
GHG emission reduction: 20%	GHG emission reduction: 40%
Increase of RES use: 20%	Increase of RES use: 32%
Increase of EE: 20%	Increase of EE: 32.5%

The **Energy Performance Building Directive** introduced a tool to monitor and promote EP improvements in buildings:

- the **Energy Performance Certificate (EPC)** schemes

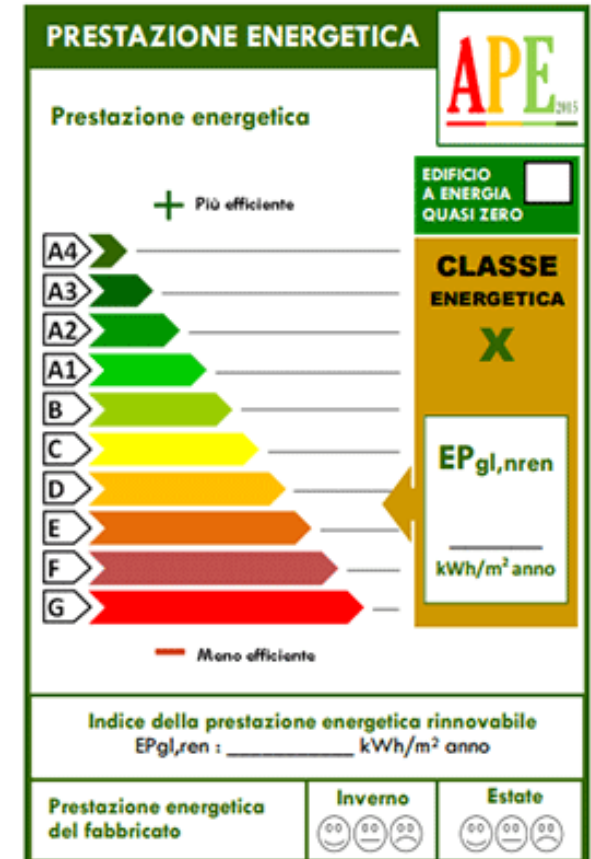




# EPBD implementation in Italy

- **National Decree 192/2005 relating to EP in buildings (ACE scheme):**
  - **Article 6** on 'Energy performance certificate, release and posting'
  - **8 energy classes (A+ - G)**
  - Introduction of **minimum requirements** and the **mandatory energy certification**
- **National Decree 63/2013 the new Italian EPC Regulations (APE scheme) :**
  - From **ACE** to **APE**
  - **10 energy classes (A4 - G)**
  - Mandatory to provide the **APE** when a home is put for sale or for rent
  - Establishing **new methodology** to calculate the EP of buildings
  - New target for all "new buildings to be nearly zero-energy"

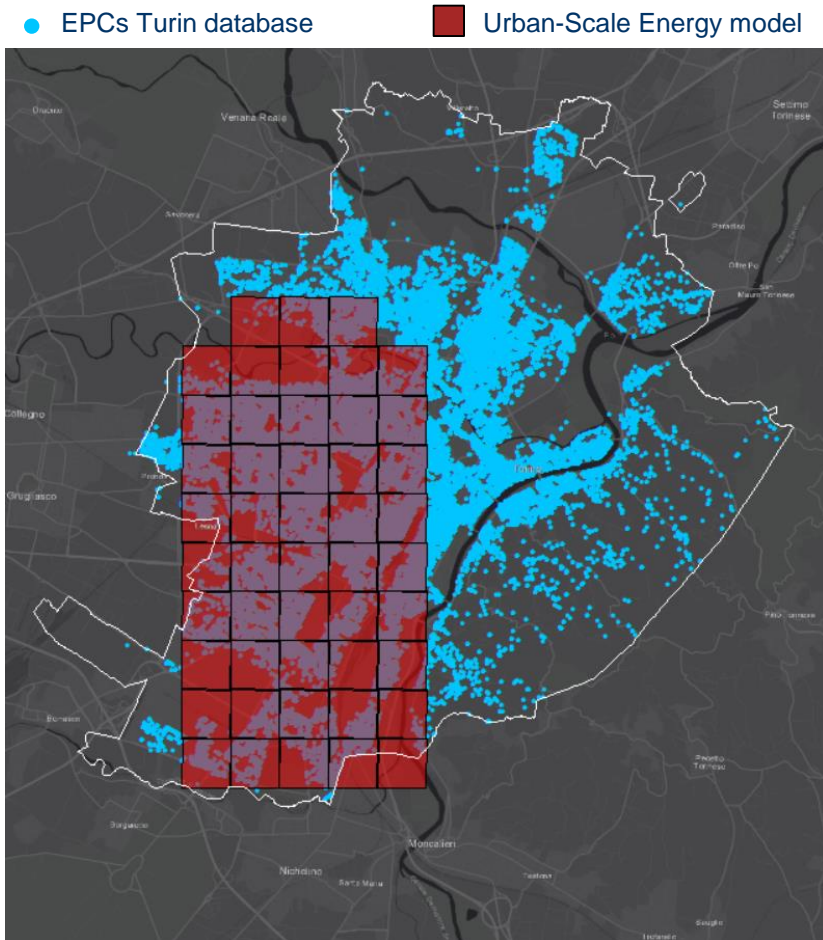
Plaque in commercial advertisements from Oct. 2015



# Objectives of the work

## EPCs database as a tool to support EE in buildings

1. Assessment of the **EP of buildings** in the city of Turin using the **EPCs database**
2. **Optimization of an engineering monthly model** using the EPCs database able to describe the real characteristics of the buildings
3. Identification of **energy efficiency scenarios** according to the energy performance of existing building stock
4. **Updating of an urban-energy atlas** designed for the city of Turin (Italy) giving information of the energy retrofit trend



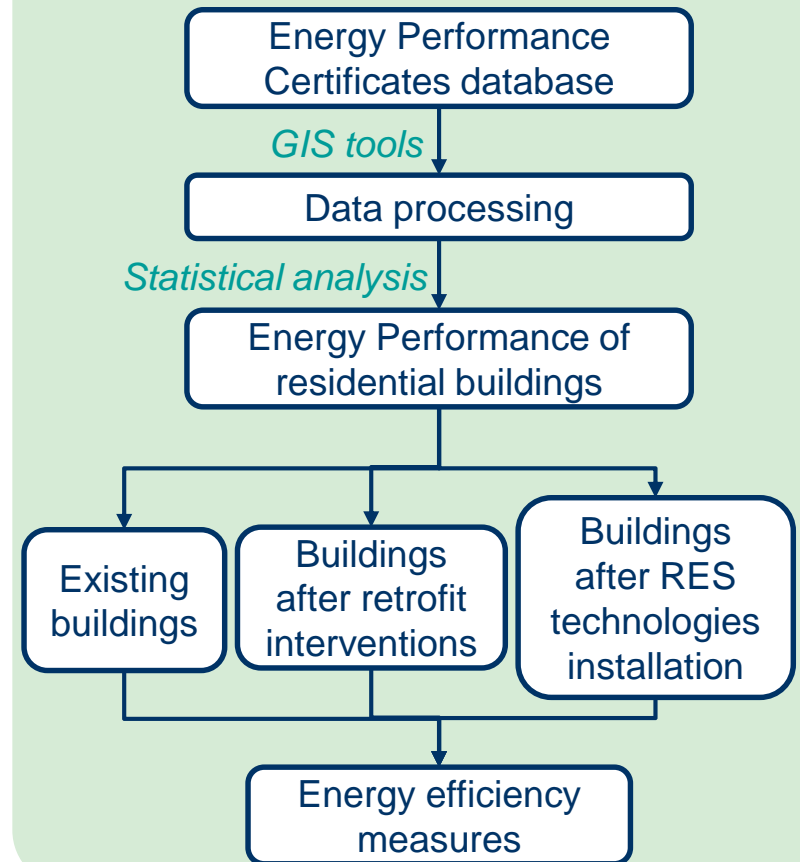


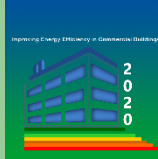
# Assessment of EPCs Database

## EPCs database as a tool to support EE in buildings

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## EPCs database





# Assessment of EPCs Database

- Acquisition and analysis of EPCs
- Classification on the **type of residential buildings**
- Classification on the **construction period**
- Classification on the **motivation for the EPCs' release**
- Analysis of consumptions

$$E_{\text{savings,retrofit}} = EP_{\text{gl,generic}} - EP_{\text{gl,retrofit}}$$

$$E_{\text{savings,RES}} = EP_{\text{gl,generic}} - EP_{\text{gl,RES}}$$

$$E_{\text{savings,int}} = EP_{\text{gl,int}} - EP_{\text{gl,reach,int}}$$

Number of EPCs in Turin and in the 33 meshes distinguishing the motivation release

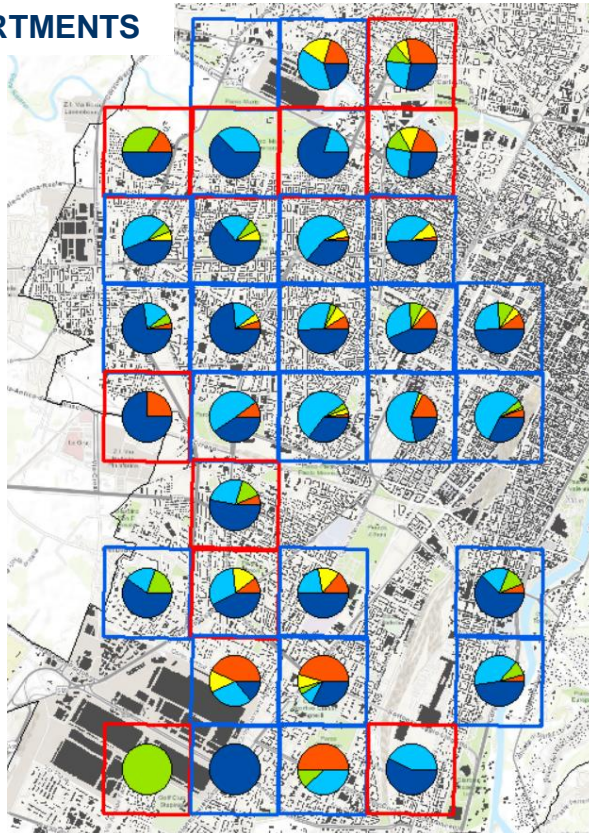
Number of EPCs	Area	Generic		Retrofit		RES	
		Apartments	Detached Houses	Apartments	Detached Houses	Apartments	Detached Houses
	Turin	167,899 (95%)	5,632 (83%)	5,786 (3%)	760 (11%)	4,030 (2%)	374 (6%)
	33 districts	53,174 (97%)	429 (81%)	992 (2%)	49 (9%)	581 (1%)	51 (10%)



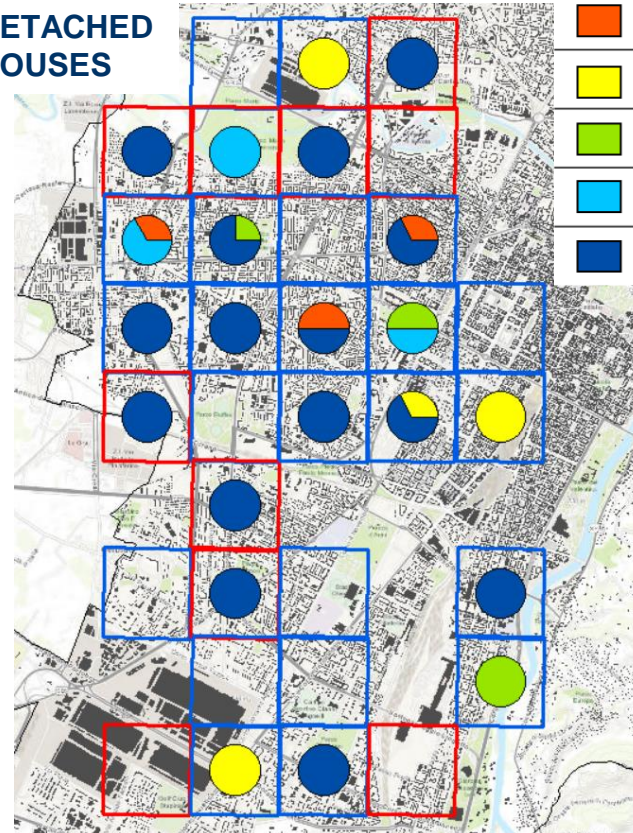
# Assessment of EPCs Database

Typologies of retrofit interventions in the 33 meshes connected to the DH network: apartments and detached houses (EPCs database up to September 2015)

## APARTMENTS



## DETACHED HOUSES



- Installation of thermostatic valves
- Thermal insulation of roof
- Thermal insulation of slab/floor
- Replacement of windows
- Thermal insulation of vertical walls & windows replacement

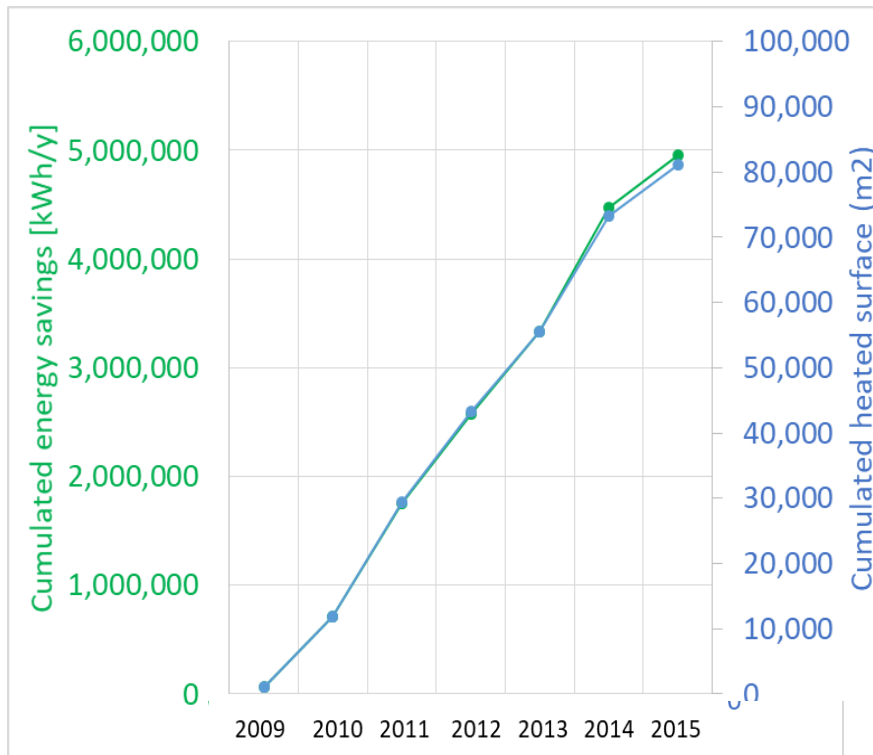
- H
- H+DHW



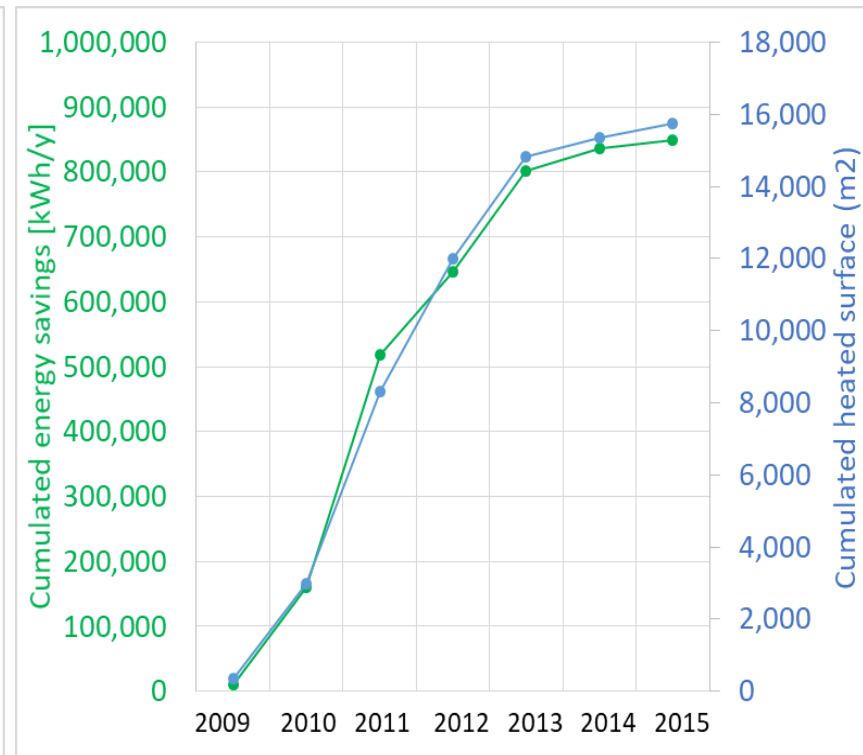
# Energy Efficiency trend

**Cumulative energy savings for apartments and for detached houses in the 33 districts (EPCs from 2009 to 2015)**

## APARTMENTS



## DETACHED HOUSES



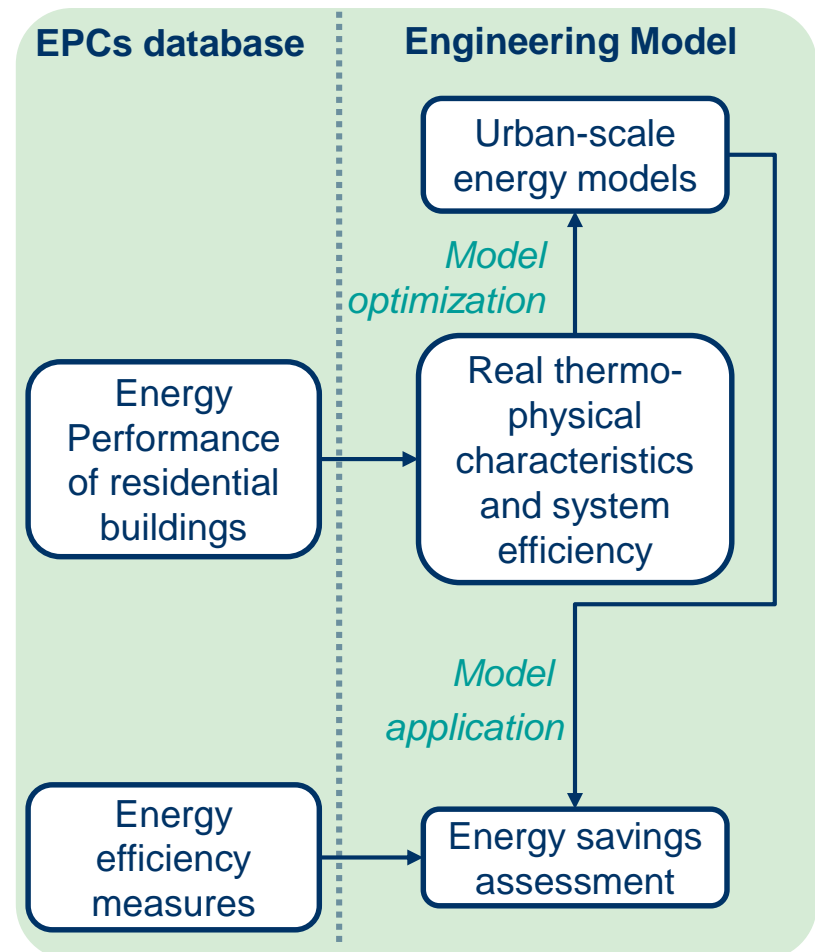


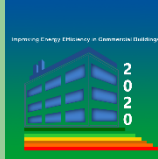


# Engineering Model optimization

## EPCs database as a tool to support EE in buildings

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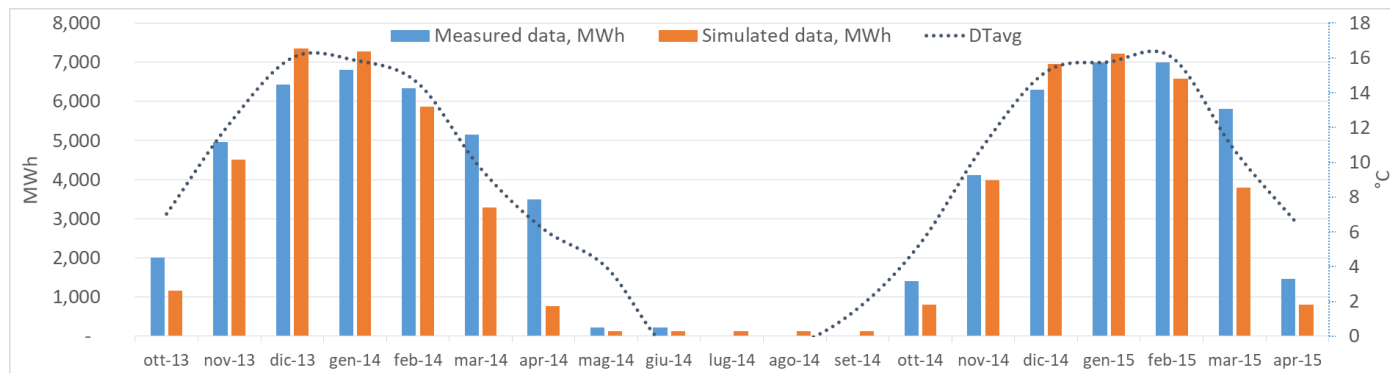
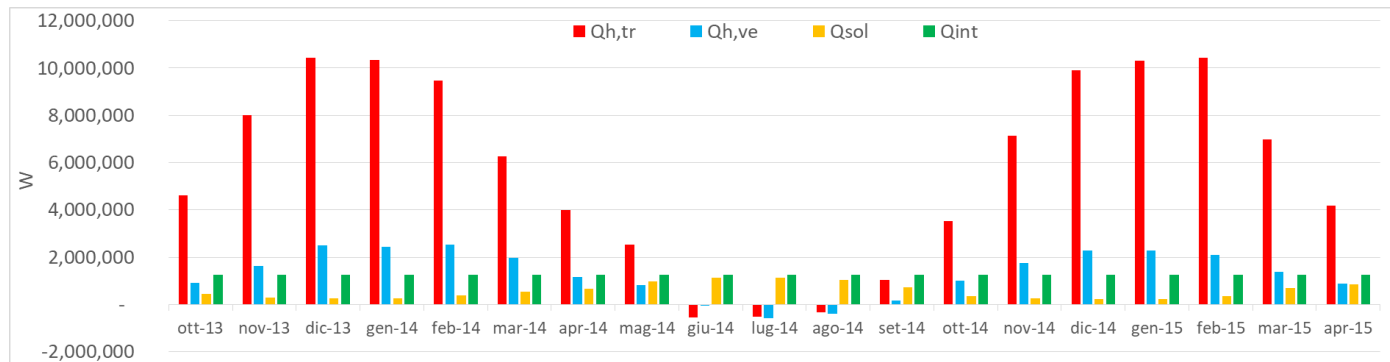


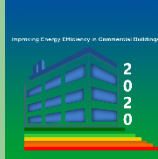


# Urban-Scale Engineering Model

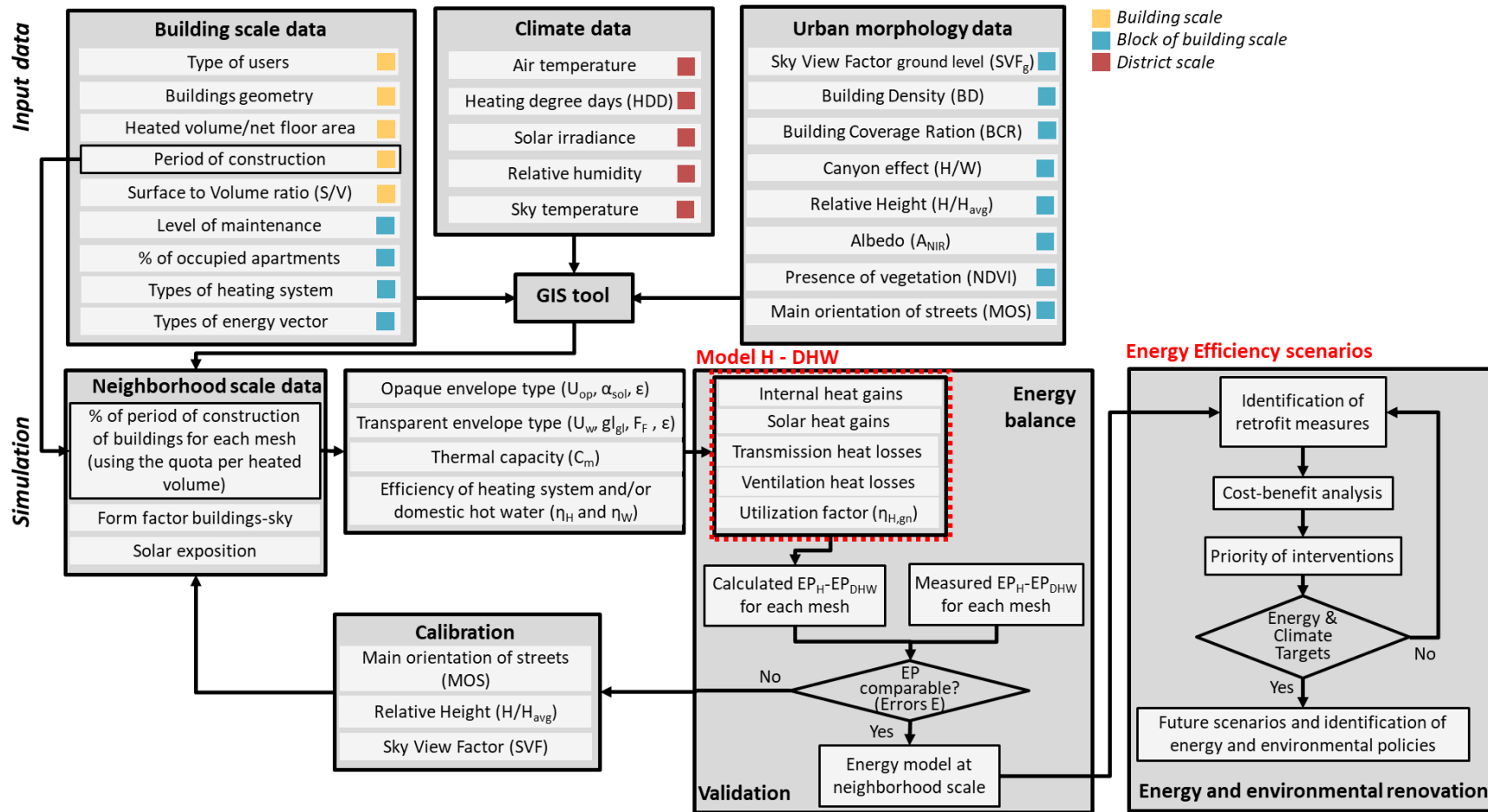
Building energy balance at urban scale during the heating season

$$Q_{H,nd} = \sum Q_{H,ht} - \eta_{H,g_n} \cdot \sum Q_{g_n} = \left( \sum Q_{H,tr} + \sum Q_{H,ve} \right) - \eta_{H,g_n} \cdot \left( \sum Q_{int} + \sum Q_{sol} \right)$$





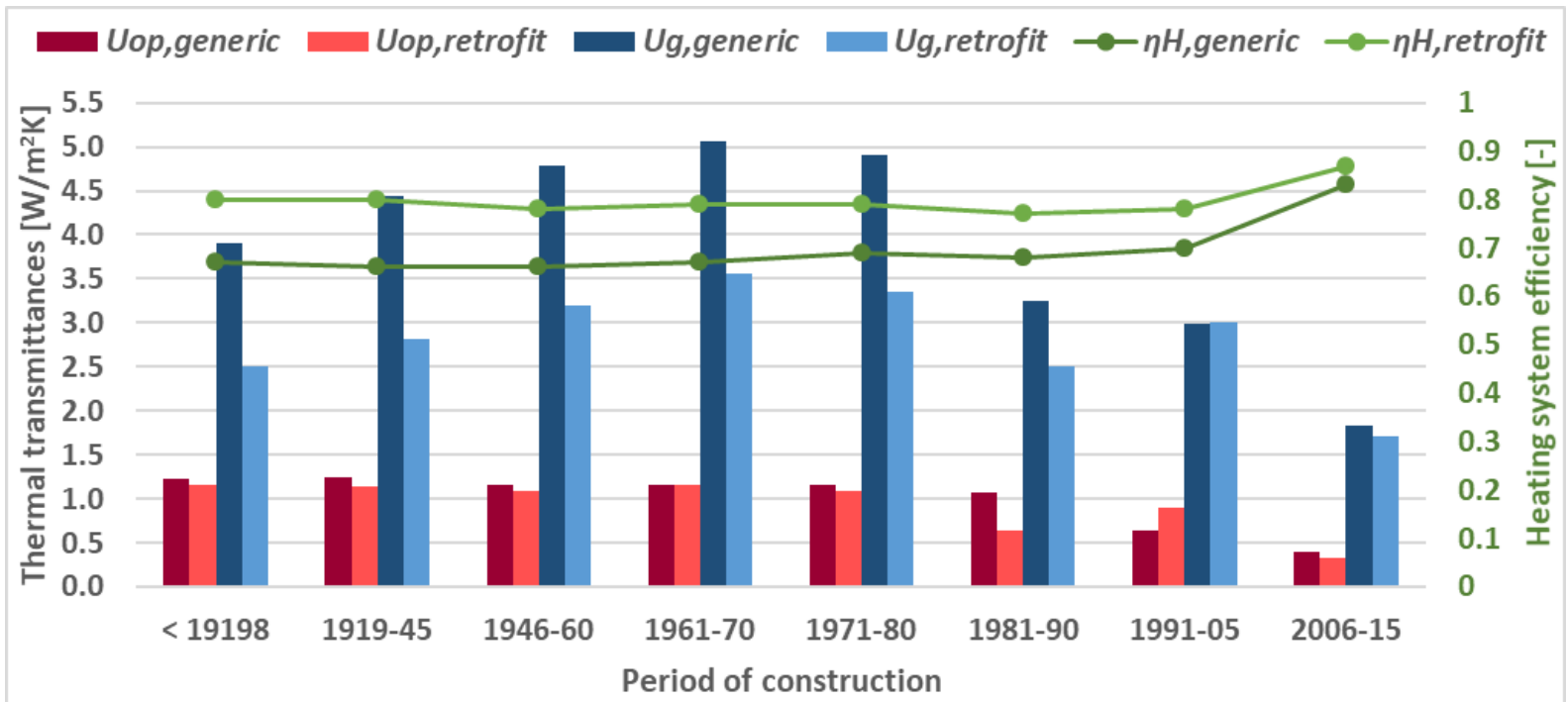
# Urban-Scale Engineering Model





# Engineering Model optimization

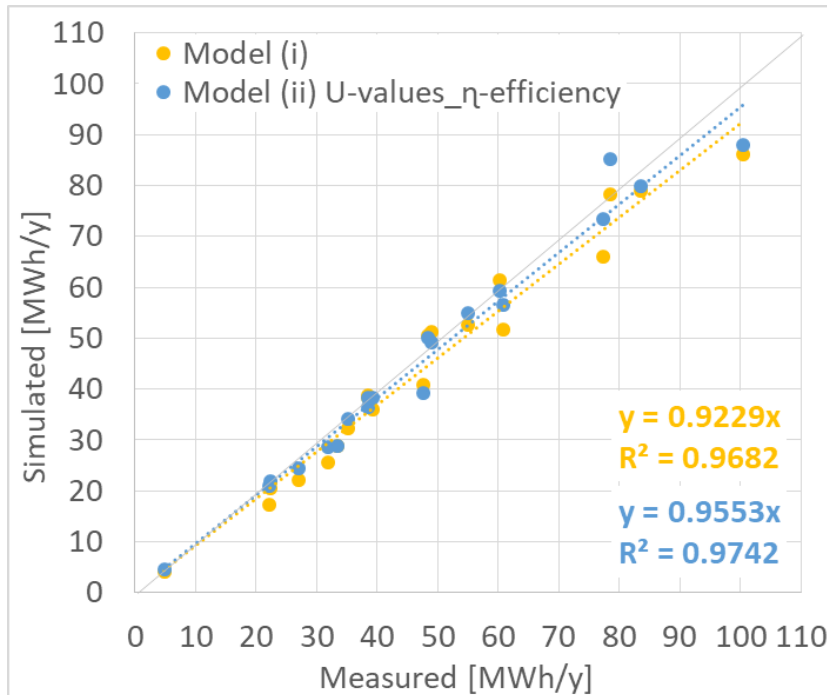
Thermal transmittances and system efficiencies values elaborated from EPCs database distinguishing generic and retrofit motivation (EPCs from 2009 to 2015)



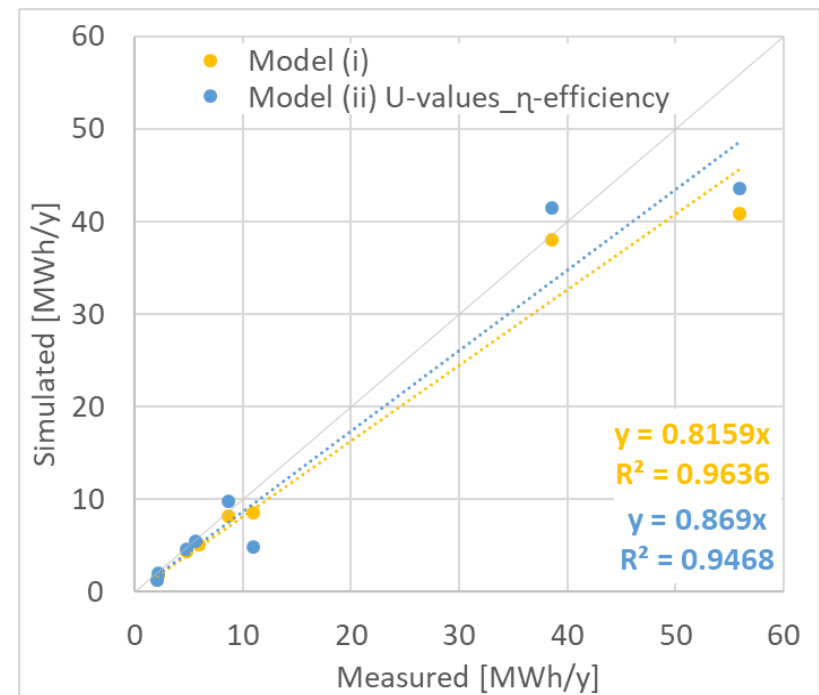
# Model Application

Comparison of **measured and simulated energy consumptions** between old (i) and new (ii) engineering model

### Heating and Domestic Hot Water Model



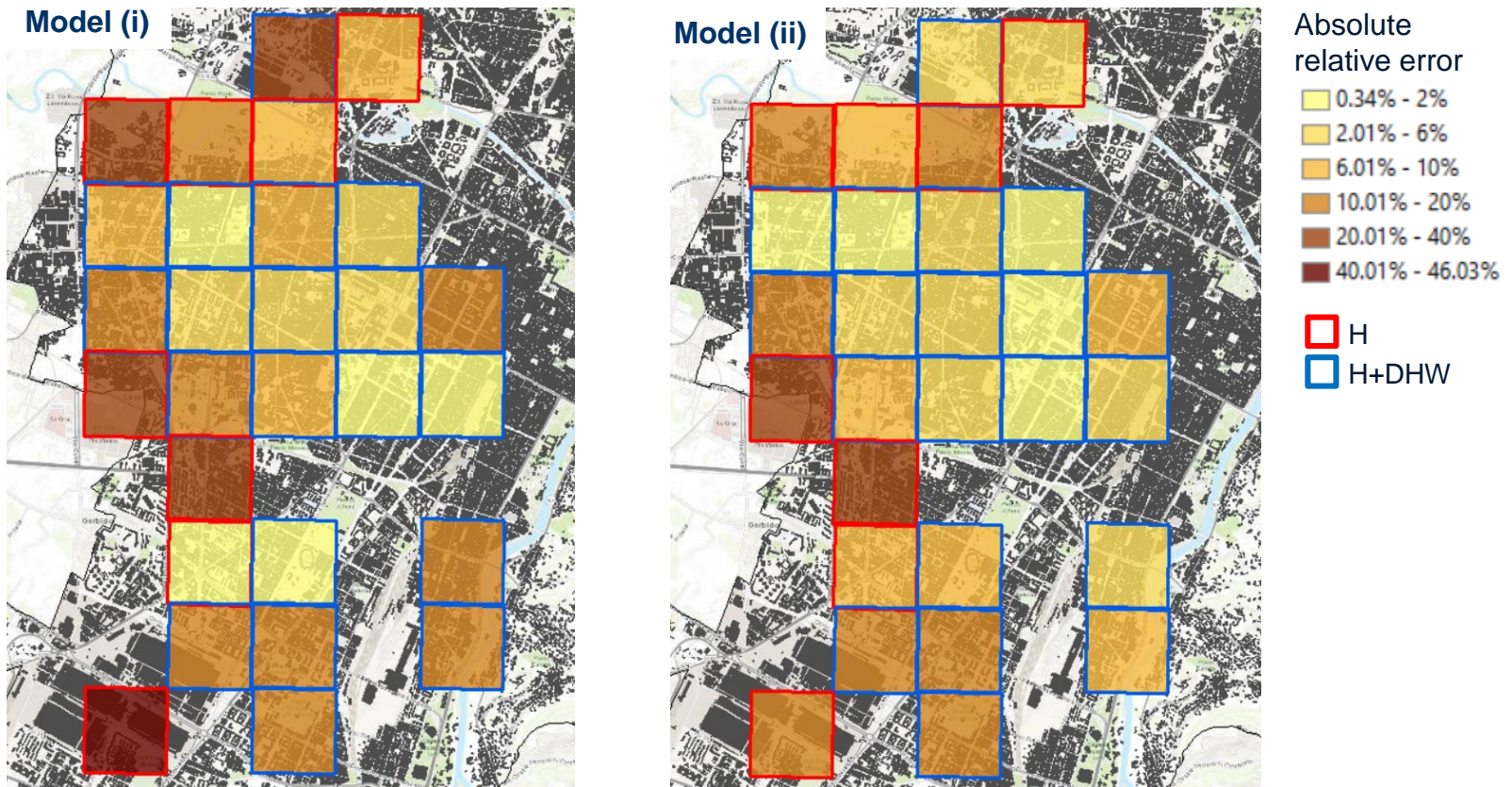
### Heating Model





# Model Application

Comparison of **absolute relative error** between old (i) and new (ii) monthly models

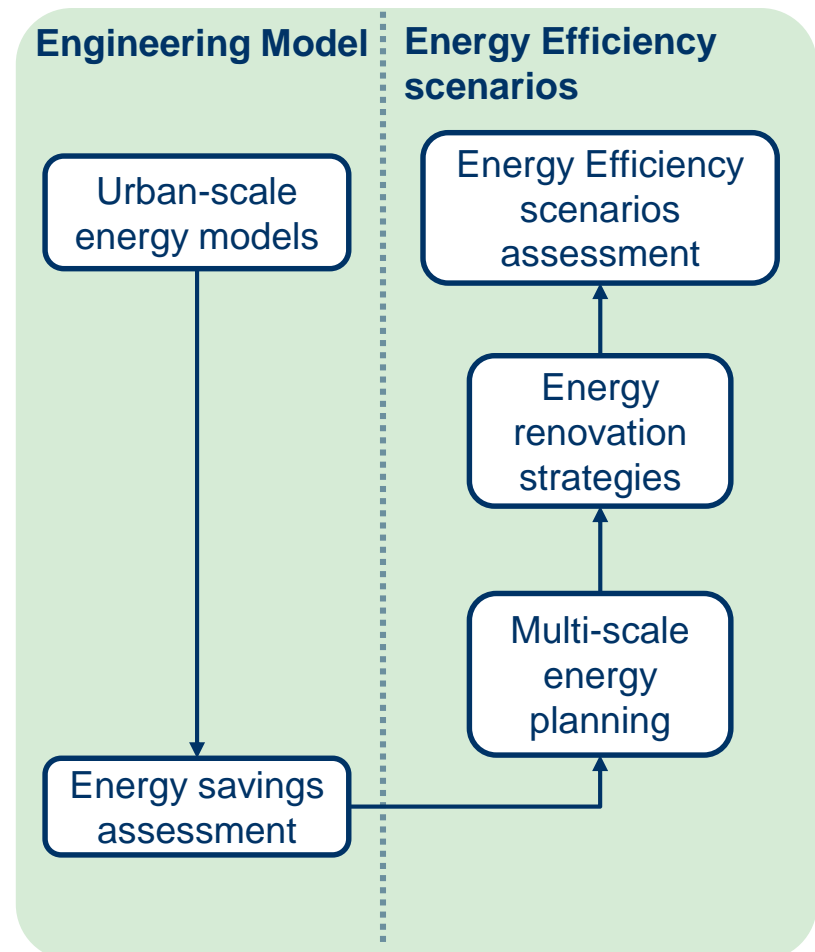




# Energy Efficiency scenarios

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# Energy Efficiency scenarios

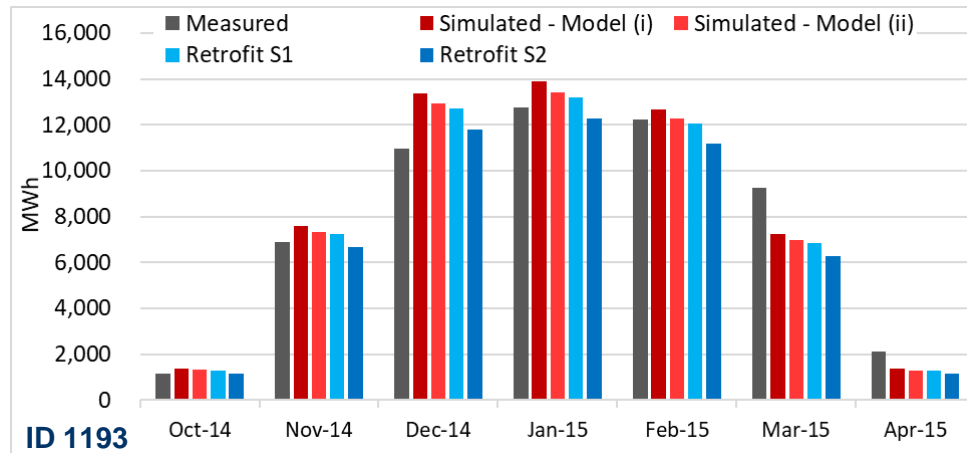
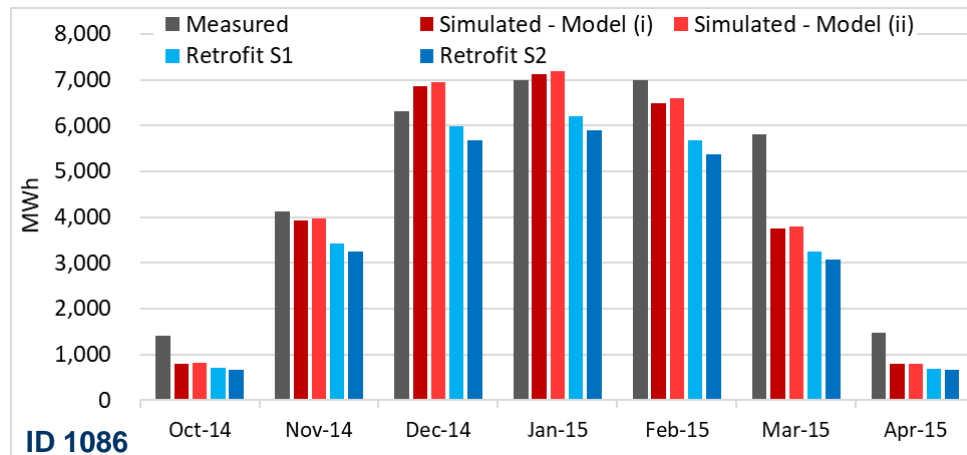
- **Monthly space heating consumption** of two meshes for the heating season 2014-2015:

- **measured data** (in gray)
- **simulated data** (in red) for the old (i) and the optimized (ii) models

- **Two retrofit scenarios** have been investigated (in blue):

- **thermal insulation** of the opaque envelope (**S1**)
- **thermal insulation** of the opaque envelope and **windows replacement** (**S2**)

## Results of two meshes

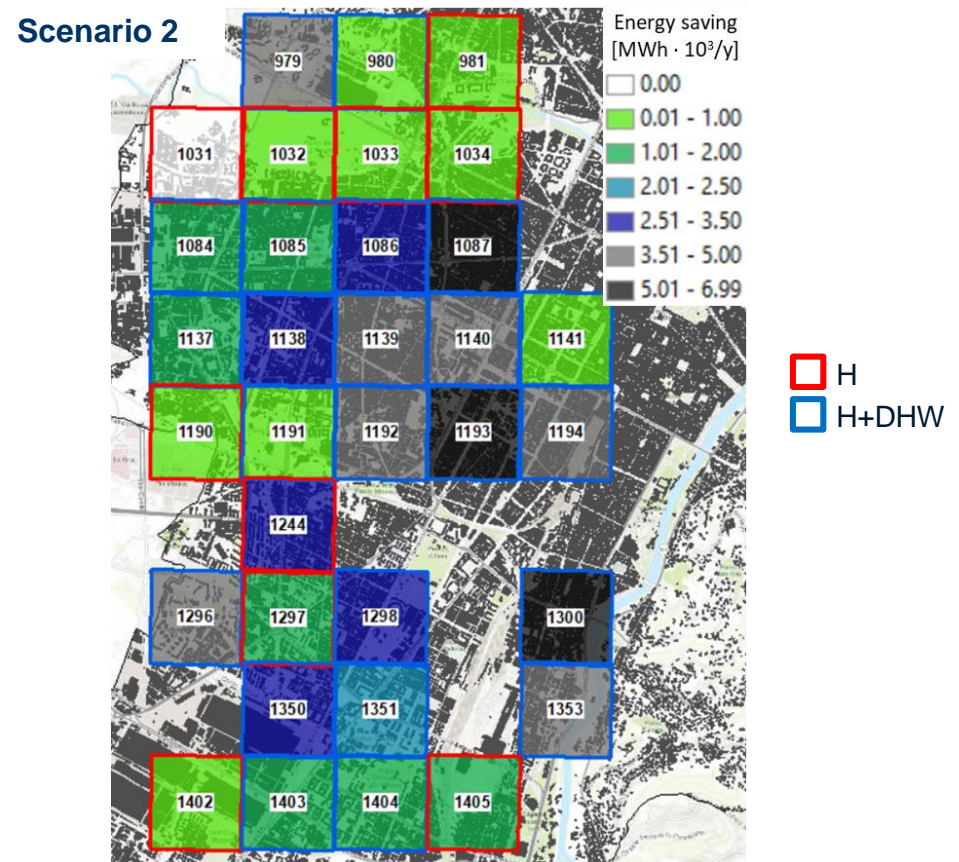
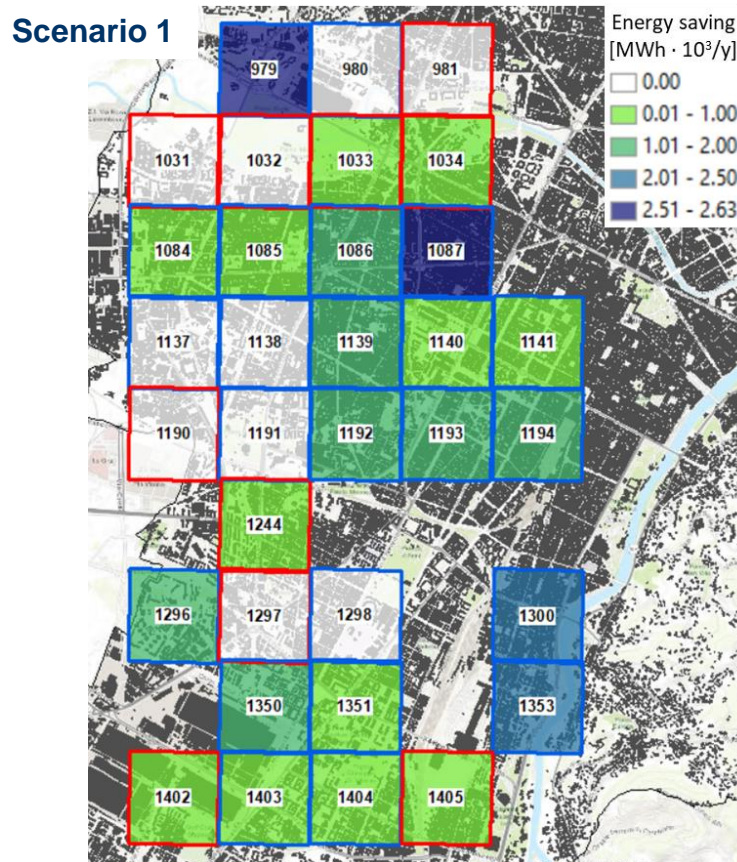






# Energy Efficiency scenarios

## Annual energy savings at district scale after energy renovation strategies



H  
 H+DHW

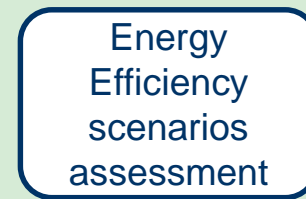


# Urban-Energy Atlas updating

## EPCs database as a tool to support EE in buildings

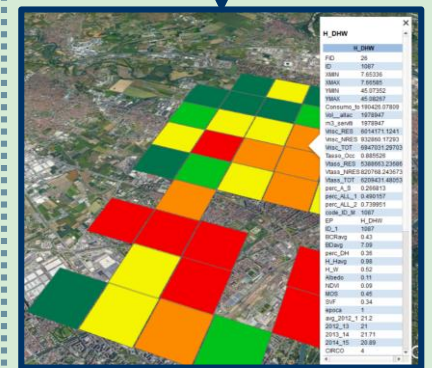
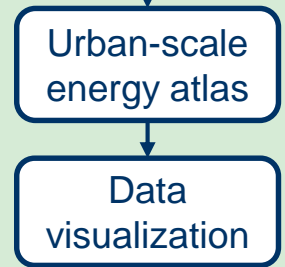
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## Energy Efficiency scenarios



## Urban-Energy Atlas

*Web-platform implementation*

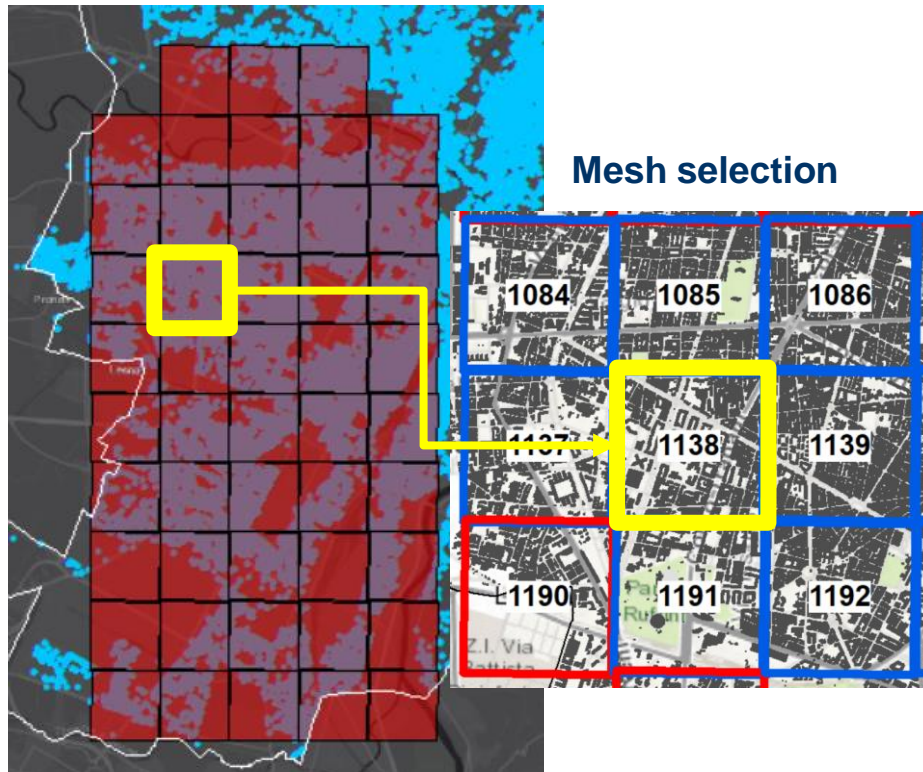




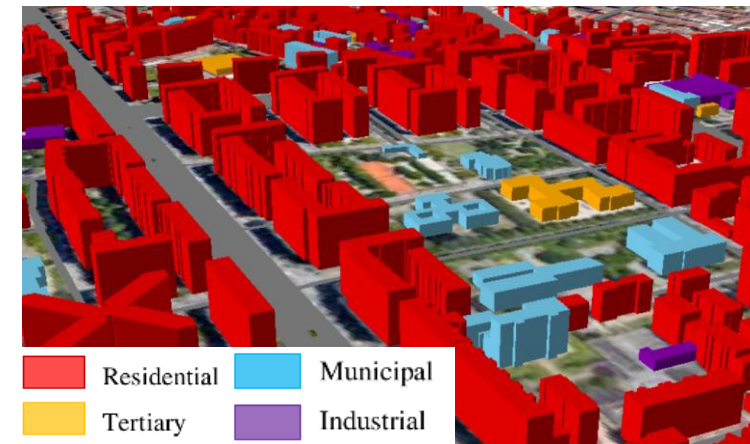


# Urban-Energy Atlas updating

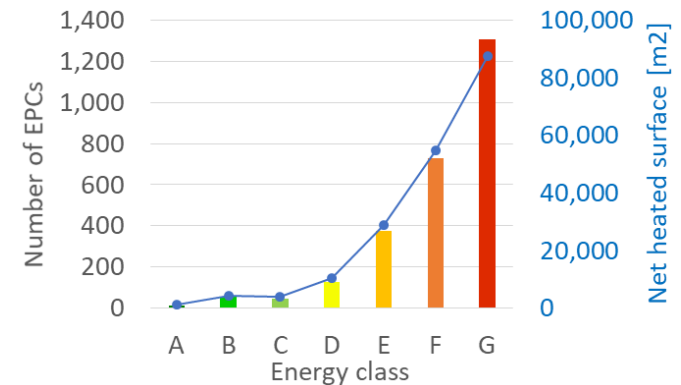
District heating area

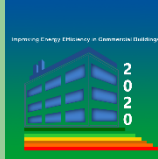


Buildings classification by type of users



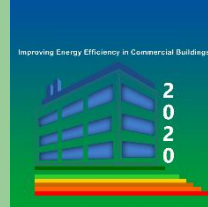
EPCs data of residential sector





# Conclusions

- This work presents an **optimization of an urban-scale energy model** and an **updating of the energy atlas for the city of Turin**, through the use of **EPCs database of Piedmont Region**
- The presented **urban-energy atlas may be used to:**
  - **explore energy consumption, GHG emissions and thermal comfort conditions** in urban spaces
  - quantitatively **assess energy retrofit strategies and their impacts** on the territory
  - **promote smart green solutions** (e.g. green roofs) with the use of financial mechanisms and incentives
  - **identify effective energy policies**, considering the real characteristics of the buildings, of the population and of the urban morphology
- This assessment can play a significant role in **the planning smart energy solution for a sustainable development at city level**
- In addition, the use of a GIS tool through the implementation of an urban platform facilitates **access to the data** and the **spatial representation of the results**



**Thank you for your attention!**

Guglielmina Mutani & Valeria Todeschi\*

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