TIMEPAC Academy

Session 5

Bottom-up energy model using EPC data as a support tool to assess the energy performance of building stocks

Presenter: Ilaria Ballarini (Politecnico di Torino)

20 March 2024

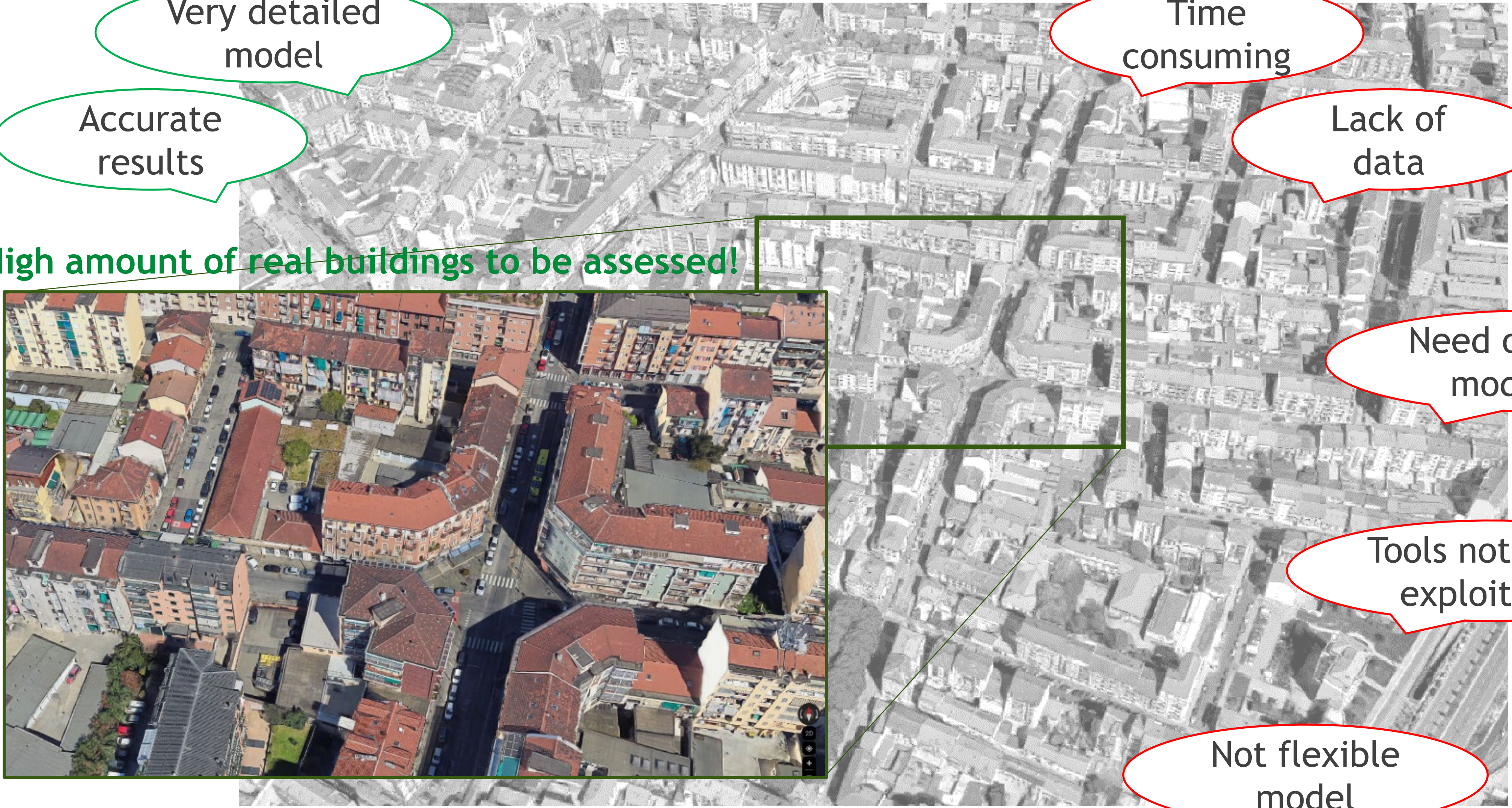
Politecnico di Torino
1859

REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT, CLIMATE AND ENERGY

laSalle
RAMON LLULL UNIVERSITY

SERA
Institute for Sustainable Energy and Resources Availability

How to develop a building stock energy model?



Source: Google Maps

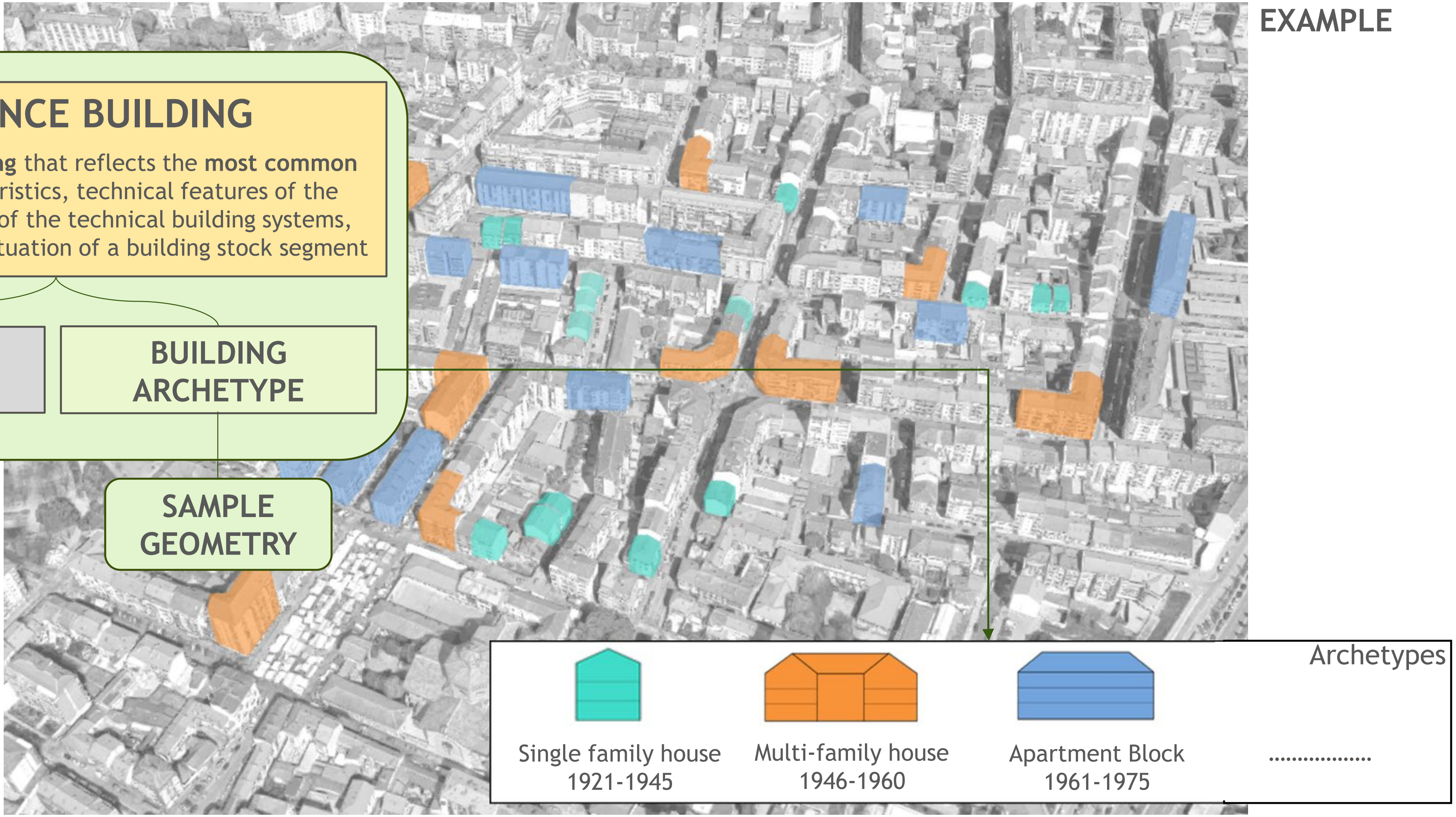
Reference building approach

EXAMPLE

REFERENCE BUILDING

Representative building that reflects the **most common** geometrical characteristics, technical features of the building envelope and of the technical building systems, providing the average situation of a building stock segment

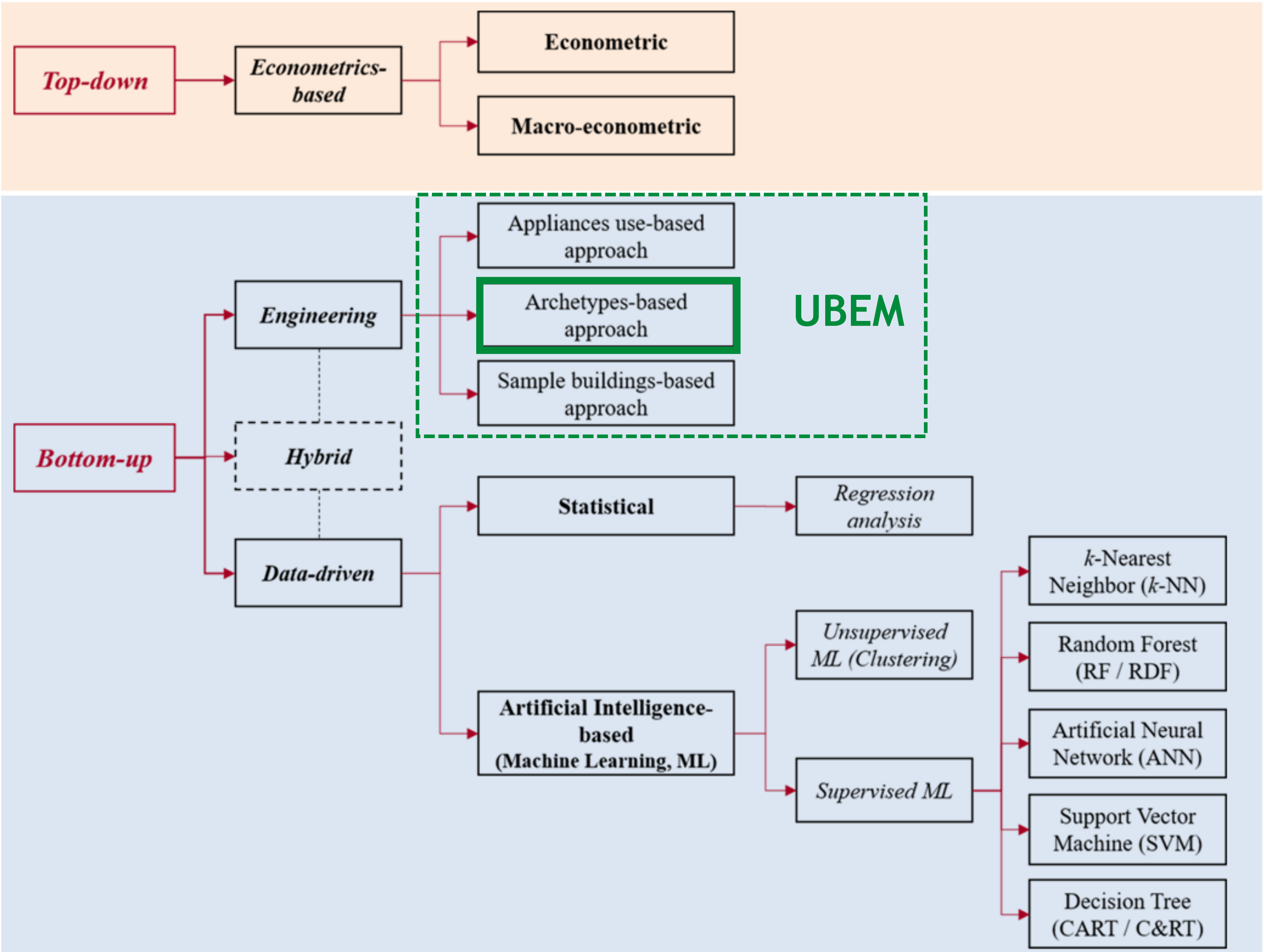
REAL BUILDING	BUILDING ARCHETYPE
REAL GEOMETRY	SAMPLE GEOMETRY



Building archetype

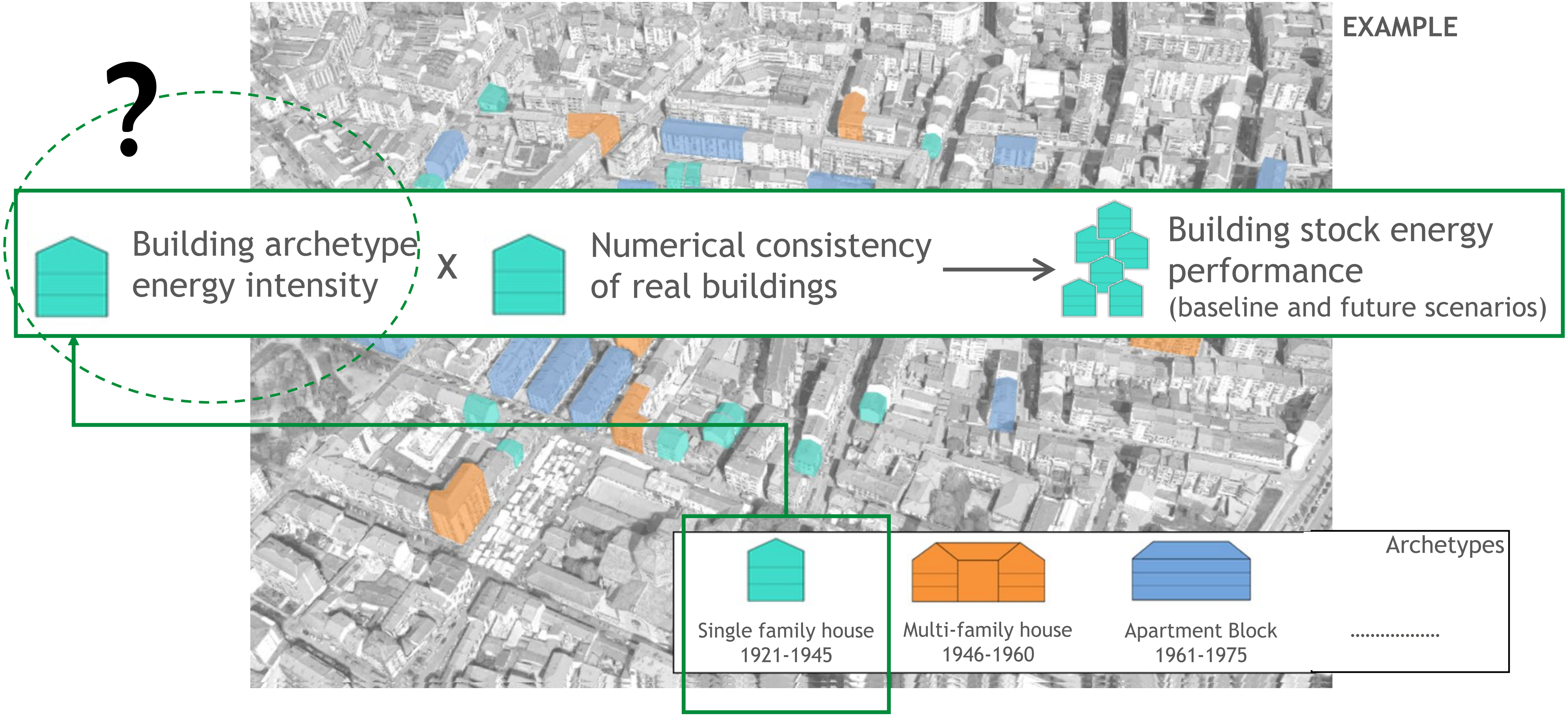
The **building archetype** is a ***statistical composite*** *of the features* found within a category of buildings in the stock (IEA-ECBCS, Annex 31, 2004).

*The archetype is not a real building, it is a **"virtual" building** characterized by a set of properties statistically detected in a building category (Sartori et al., Energy Policy 37, 2009; Caputo et al., Energy Policy 55, 2013; Ballarini et al., Energy Policy 68, 2014).*

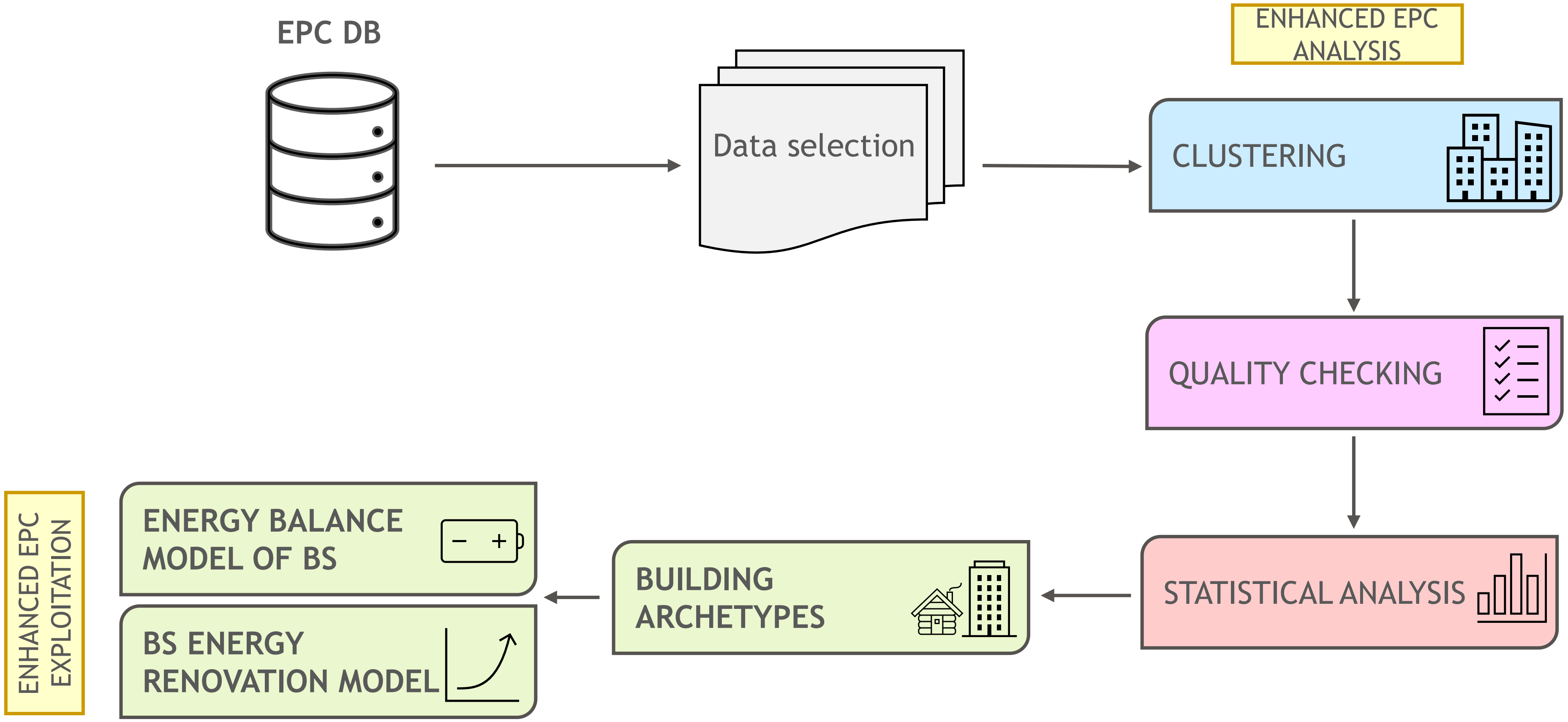


Source: Ballarini, I., Corrado, V., & Piro, M. (2021). Building Stock Energy Models and ICT Solutions for Urban Energy Systems. In M. Del Giudice, A. Osello (Eds.), Handbook of Research on Developing Smart Cities Based on Digital Twins (pp. 490-514). IGI Global.

Bottom-up UBEM using archetypes

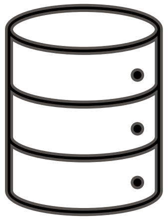


EPC as a data source for UBEM: the TIMEPAC approach

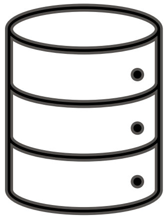


EPC data selection

"reduced" XML

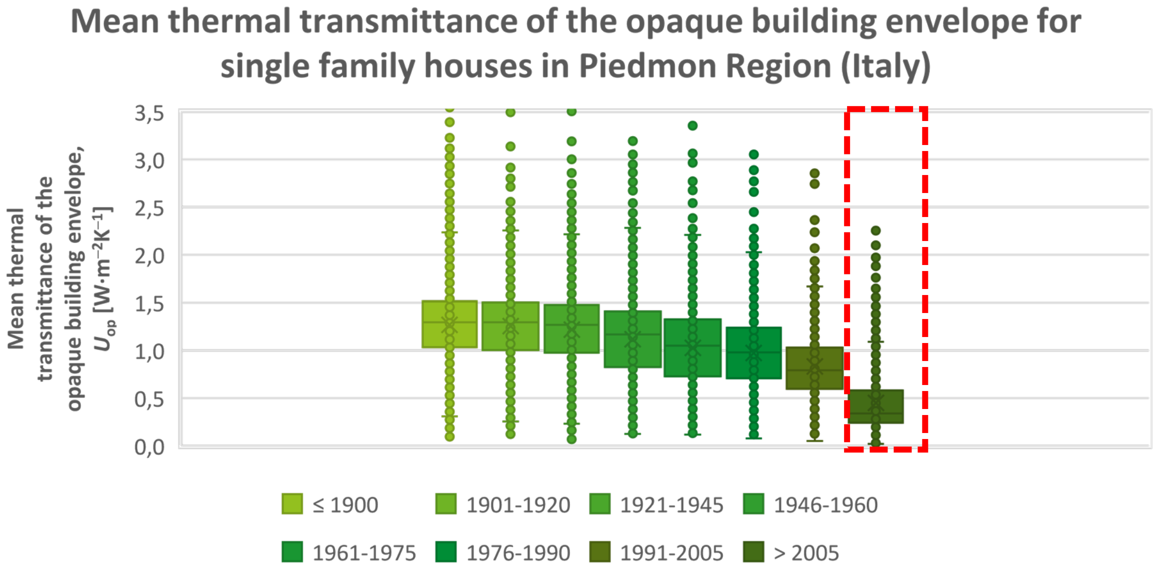


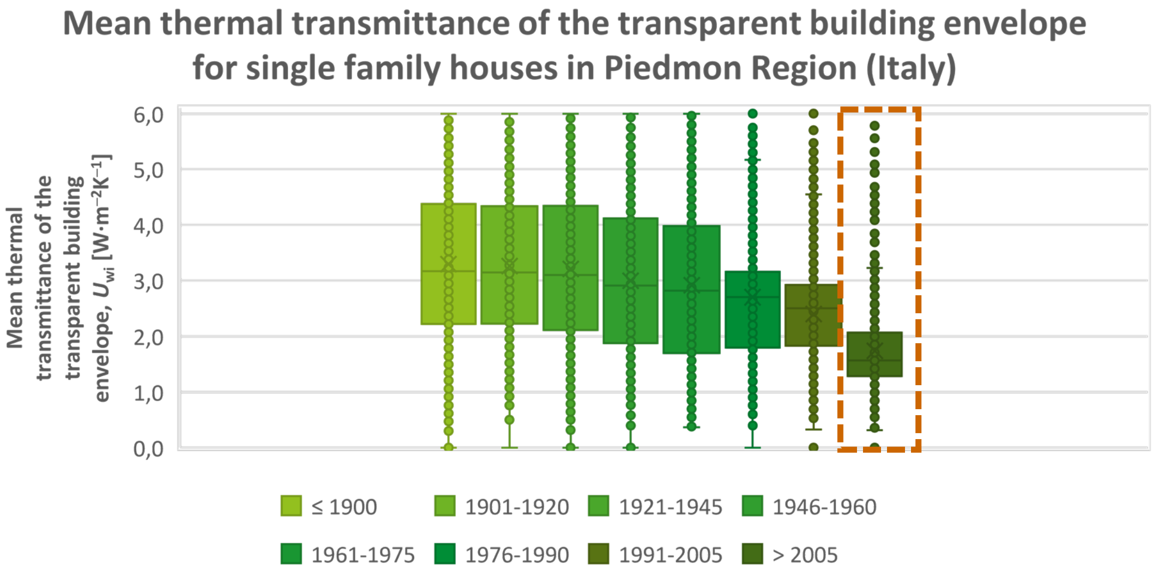
"extended" XML



Assessed object	Application type	EPC ID code	Building city
Building category	No. of building units	Building typology	Building constructive typology
Year of construction	Year of last renovation	No. of floor	Climatic region
Heating degree days	Compactness ratio	Thermally conditioned floor area	Thermally conditioned gross volume
Thermal envelope area	Mean overall heat transfer coefficient by thermal transmission	Opaque thermal envelope area	Transparent thermal envelope area
Mean *U*-value of the total building envelope	Mean *U*-value of opaque building envelope	Mean *U*-value of transparent building envelope	Energy services
TBS type of generator per energy service	TBS energy carrier per energy service	TBS mean global seasonal efficiency per energy service	TBS subsystems efficiency per heating system
$EP_{H,nd}$	$EP_{C,nd}$	$EP_{W,nd}$	$EP_{H,nren}$
$EP_{C,nren}$	$EP_{W,nren}$	$EP_{gl,nren}$	$EP_{gl,ren}$
$EP_{gl,nren}$ per energy service	Delivered energy per energy carrier	Recommended EEM(s)	$EP_{gl,nren}$ of recommended EEM(s)

Statistical analysis of EPC data





EXAMPLE

PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP8						
	Data	Symbol	Unit of measure	Median	$(Q_3 - Q_2)$	$(Q_2 - Q_1)$
Geometry	Compactness ratio	CR	m^{-1}	0,788	0,111	0,102
	Thermally heated gross volume	$V_{H;g}$	m^3	534	179	117
	Thermally heated floor area	$A_{H;use;ztc}$	m^2	130	43	28
	Transparent thermal envelope area on thermal envelope area	A_{wi}/A_{env}	%	5%	1%	1%
Envelope	Mean thermal transmittance of opaque building envelope	U_{op}	W/(m^2·K)	0,338	0,244	0,097
	Mean thermal transmittance of transparent building envelope	U_{wi}	W/(m^2·K)	1,570	0,498	0,280
Technical building system	Energy carrier per space heating	Natural gas = 78%; solid biomass = 7%; others = 15% (of the analysed sample)				
	Energy carrier per space cooling	Electricity = 100% (of the analysed sample)				
	Energy carrier per domestic hot water	Natural gas = 72%; electricity = 17%; others = 11% (of the analysed sample)				
	Mean seasonal efficiency of the heating generation sub-system (natural gas)	$\eta_{H;gn}$	–	0,917	0,093	0,127
	Mean seasonal efficiency of the heating generation sub-system (solid biomass)	$\eta_{H;gn}$	–	0,750	0,186	0,290
	Utilisation energy efficiency	$\eta_{H;u}$	–	0,875	0,048	0,065

Library of building archetypes developed in TIMEPAC

In TIMEPAC, more than 150 BAs were developed:

- 21 BAs for Spain (Catalonia)
- 48 BAs for Slovenia
- 32 BAs for Italy (Piemonte)
- 8 BAs for Austria (Salzburg)
- 42 BAs for Croatia
- 3 BAs for Cyprus

EXAMPLE for Piemonte region (Italy)

Climatic zone E	Residential bldgs	
	SFH	BU(AB)
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)_CP1
CP2	E_RES_SINGLE_CP2	E_RES_BU(AB)_CP2
CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)_CP3
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)_CP4
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)_CP5
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)_CP6
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)_CP7
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)_CP8

PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP1

	Data	Symbol	Unit of measure	Median	$(Q_3 - Q_2)$	$(Q_2 - Q_1)$
Geometry	Compactness ratio	CR	m^{-1}	0,754	0,128	0,114
Geometry	Thermally heated gross volume	$V_{H;g}$	m^3	457	+196	145
Geometry	Thermally heated floor area	$A_{H;use;ztc}$	m^2	110	47	35
Geometry	Transparent thermal envelope area on thermal envelope area	A_{wi}/A_{env}	%	5%	2%	1%
Envelope	Mean thermal transmittance of opaque building envelope	U_{op}	$W/(m^2 \cdot K)$	1,295	0,221	0,262
Envelope	Mean thermal transmittance of transparent building envelope	U_{wi}	$W/(m^2 \cdot K)$	3,166	1,211	0,940
Technical building system	Energy carrier per space heating	Natural gas = 78%; solid biomass = 7%; others = 15% (of the analysed sample)				
Technical building system	Energy carrier per space cooling	Electricity = 100% (of the analysed sample)				
Technical building system	Energy carrier per domestic hot water	Natural gas = 72%; electricity = 17%; others = 11% (of the analysed sample)				
Technical building system	Mean seasonal efficiency of the heating generation sub-system (natural gas)	$\eta_{H;gn}$	–	0,917	0,093	0,127
Technical building system	Mean seasonal efficiency of the heating generation sub-system (solid biomass)	$\eta_{H;gn}$	–	0,750	0,186	0,290
Technical building system	Utilisation energy efficiency	$\eta_{H;u}$	–	0,875	0,048	0,065
Energy indicators	Energy need for space heating	$EP_{H;nd;ztc}$	kWh/m^2	193,7	65,6	56,6
Energy indicators	Energy need for space cooling	$EP_{C;nd;ztc}$	kWh/m^2	7,3	6,7	4,4
Energy indicators	Energy need for domestic hot water	$EP_{W;nd;ztc}$	kWh/m^2	17,0	2,0	1,4
Energy indicators	Seasonal space heating energy efficiency	$\eta_{s;H}$	–	0,730	0,040	0,050
Energy indicators	Seasonal space cooling energy efficiency	$\eta_{s;C}$	–	1,190	1,440	0,470
Energy indicators	Seasonal domestic hot water energy efficiency	$\eta_{s;W}$	–	0,580	0,170	0,080
Energy indicators	Non-renewable energy performance per space heating	$EP_{H;nren}$	kWh/m^2	241,5	102,0	94,3
Energy indicators	Non-renewable energy performance per space cooling	$EP_{C;nren}$	kWh/m^2	6,6	8,5	4,1
Energy indicators	Non-renewable energy performance per domestic hot water	$EP_{W;nren}$	kWh/m^2	26,7	8,8	7,0
Energy indicators	Overall non-renewable energy performance	$EP_{gl;nren}$	kWh/m^2	270,8	105,7	98,0
Energy indicators	Overall renewable energy performance	$EP_{gl;ren}$	kWh/m^2	1,8	12,7	1,3
Energy indicators	Renewable Energy Ratio	RER	%	1%	5%	1%

TIMEPAC Guidelines to create archetypes from EPCs

Annex A - Guidelines to create archetypes of the building stock from EPC data

https://timepac.eu/reports/procedures-and-services-to-undertake-large-scale-statistical-analysis-of-epcs-databases/

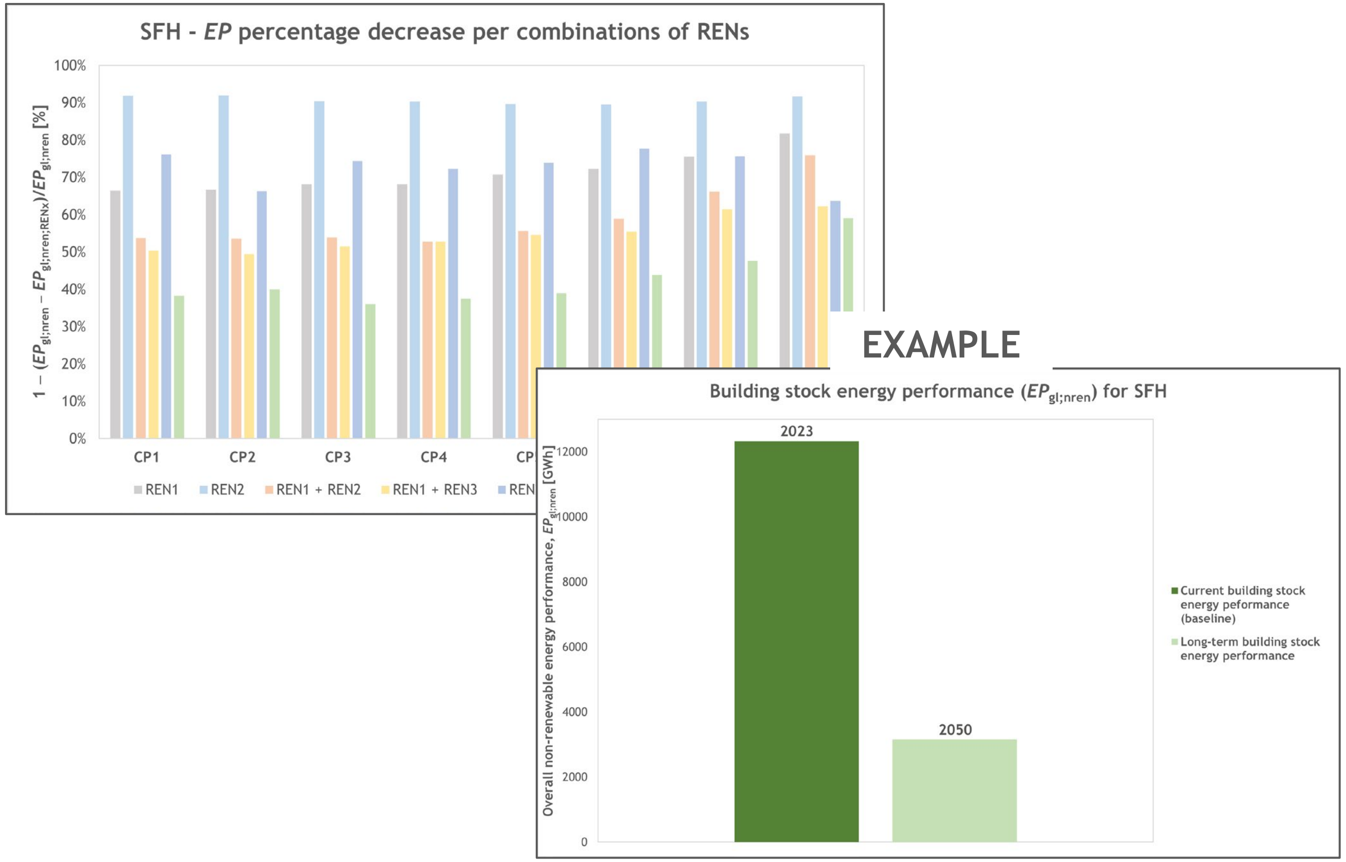
TIMEPAC D2.5 - Annex A - Guidelines to create archetypes of the building stock from EPC data

Table of Annex A contents

Bottom-up energy model

Building archetype energy intensity X Numerical consistency of real buildings → Building stock energy performance (baseline and future scenarios)

- **Building archetypes** used to perform **large-scale balances (energy and CO_2)** and to carry out **energy refurbishment scenarios**.
- The building stock energy model has been implemented in an **MS Excel spreadsheet**, upgradable with additional functionalities.
- The developed model is not intended to replace detailed UBEM simulation programs, but to **exploit effectively the archetypes with a plain and transparent approach.**



Conclusion

- The Building Archetype approach is an effective support for **building stock benchmarking** and **tracking the implementation of renovation measures**.
- **Data clustering** and **quality evaluation** of the EPC database enable the **creation of BAs** for **building stock renovation plans (*bottom-up models*)**.
- **Limitations** have to be overcome by the enhanced EPC: data quality increase, dataset enrichment with new indicators and data sources.
- To be more effective in practice, these procedures need **training activities**, **reliable databases**, and **simplified** but **accurate assessment models**.

TIMEPAC The new EPC for Europe

If you would like more information, please visit www.timepac.eu or contact us at

ilaria.ballarini@polito.it

Thanks for your attention!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033819