

Session 4

Data clustering techniques to characterize representative buildings

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Politecnico di Torino



REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT,
CLIMATE AND ENERGY

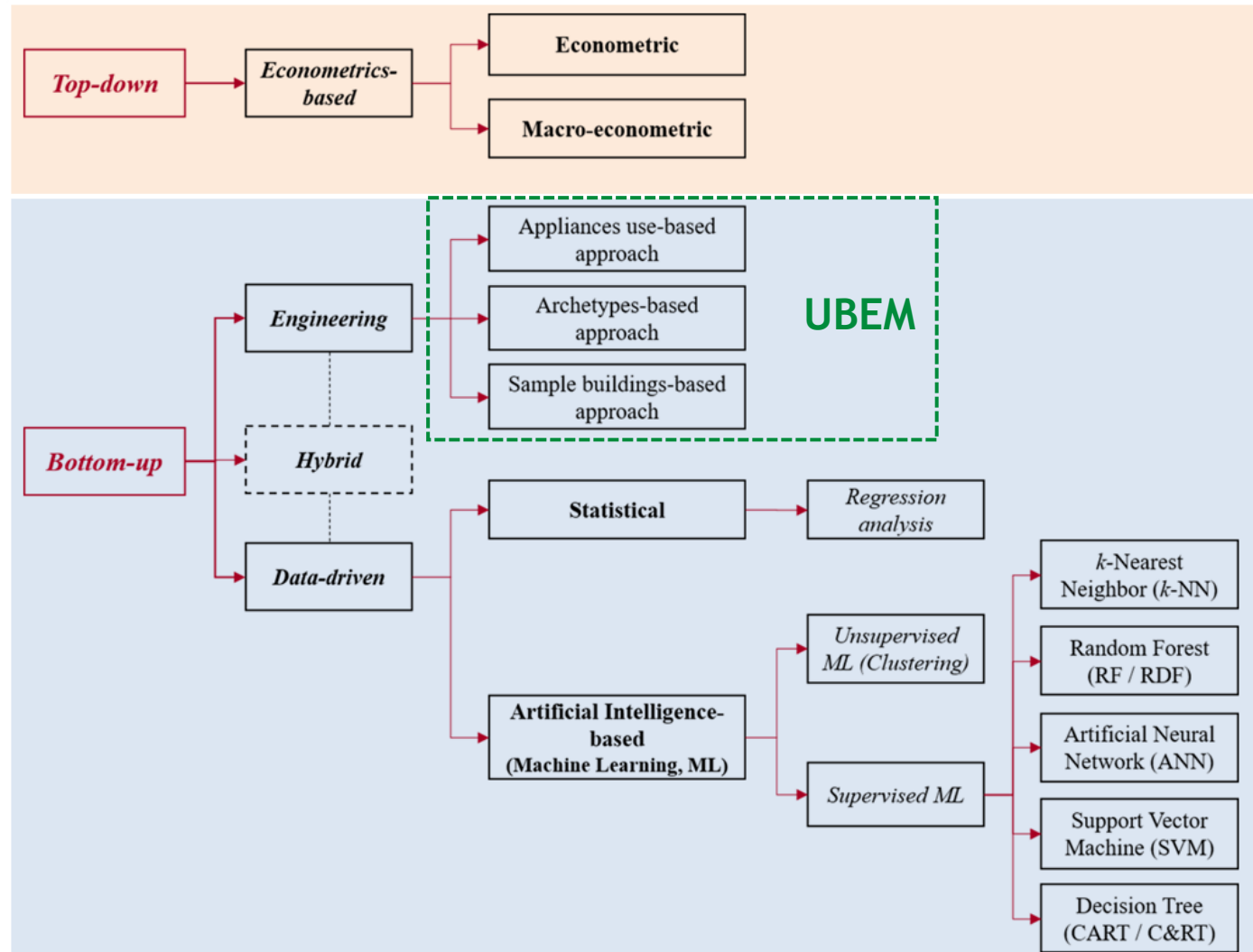
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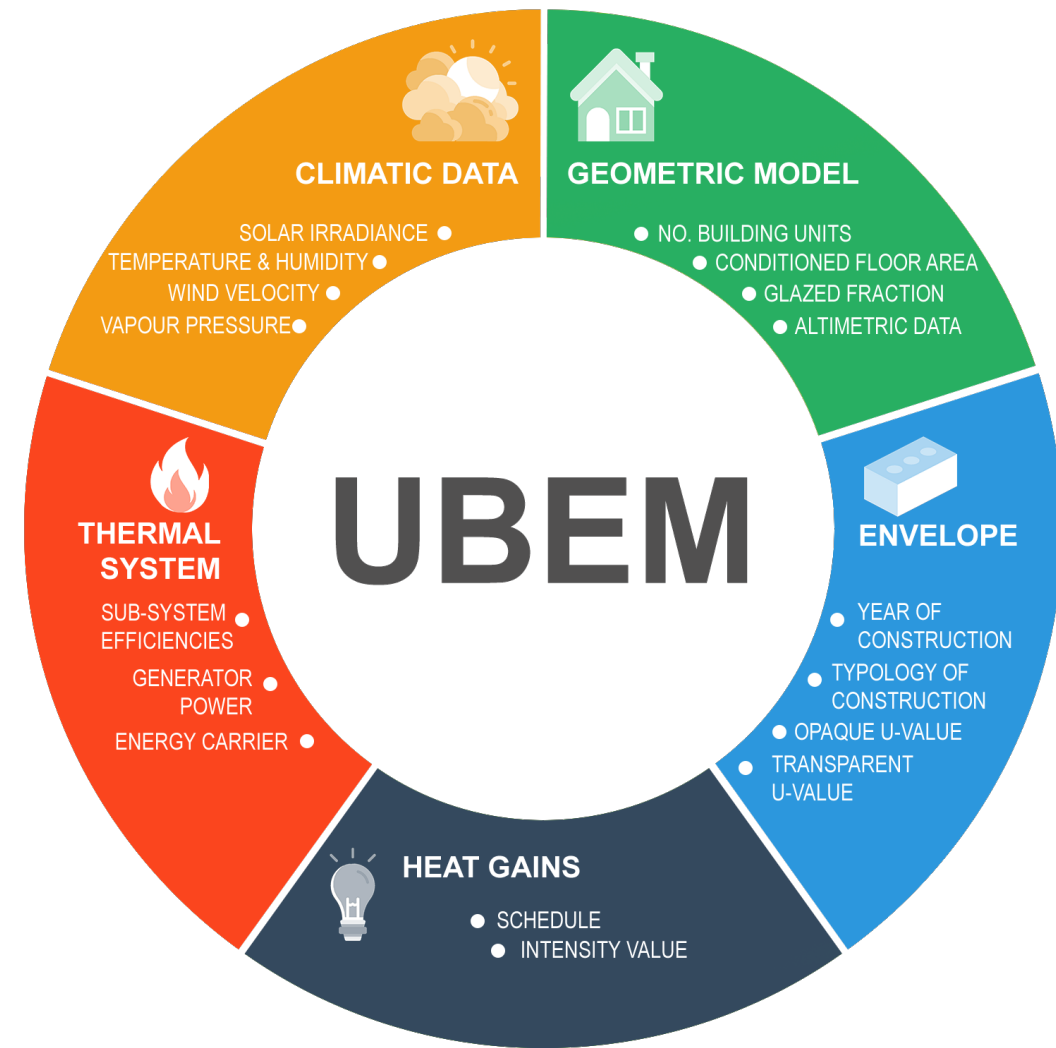
Classification of building stock energy models



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.

Urban Building Energy Modelling (UBEM)

- **UBEM** for the **large-scale energy and environmental performance assessment**.
- UBEM as a **support tool** for **public administrations**, energy agencies, and urban planners **to encourage** the development of **national building renovation plans**.



Reference building approach

EXAMPLE

REFERENCE BUILDING

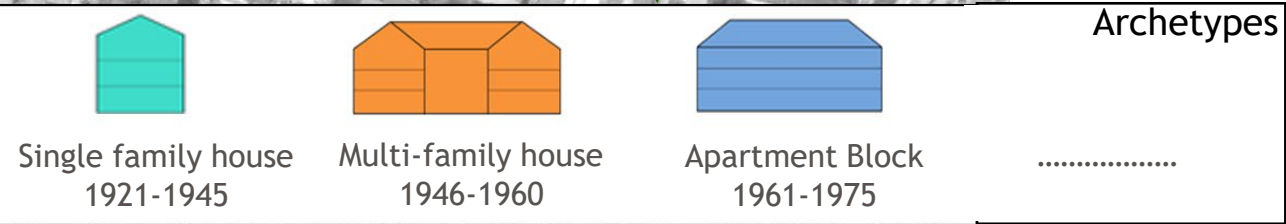
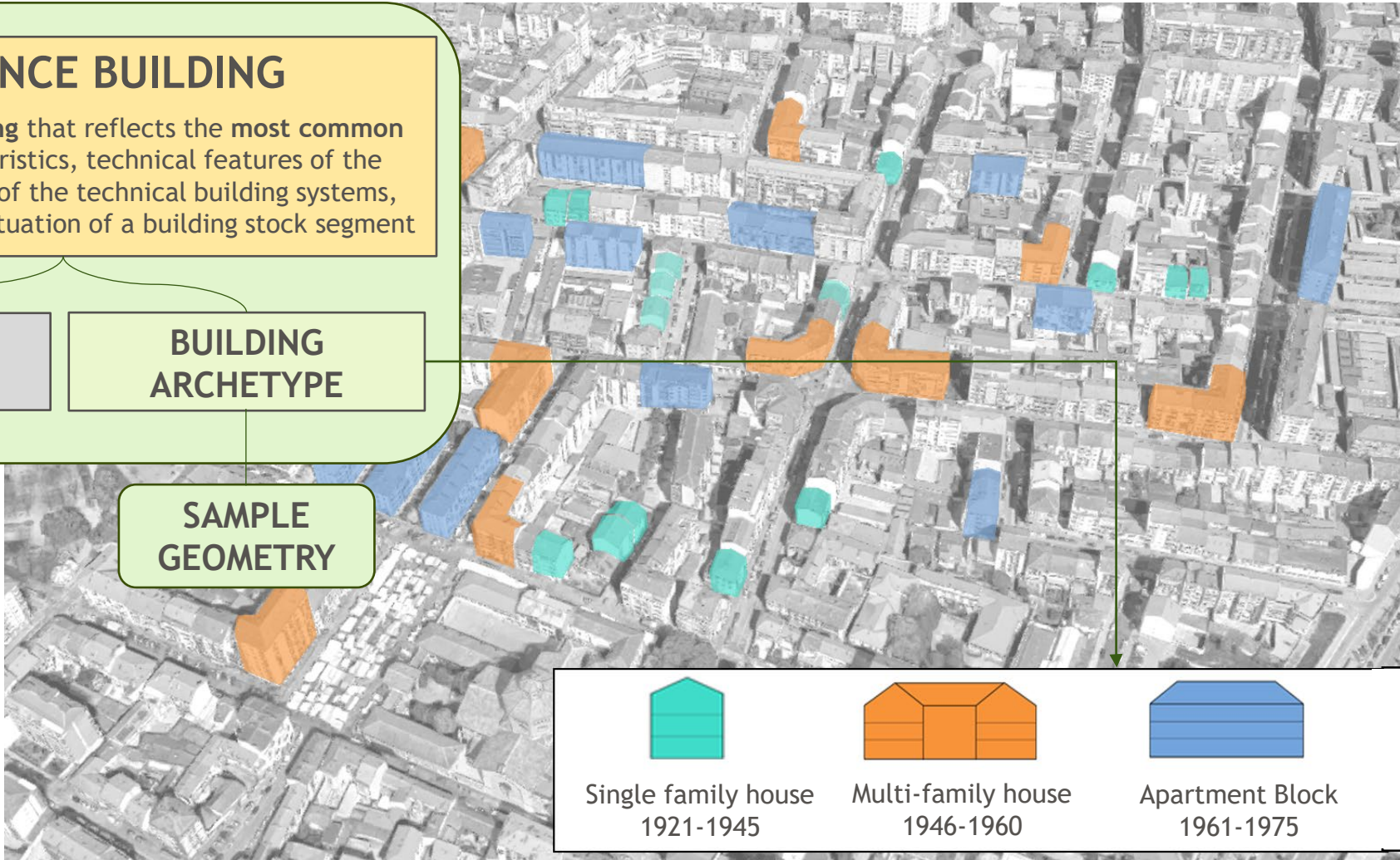
Representative building that reflects the most common geometrical characteristics, technical features of the building envelope and of the technical building systems, providing the average situation of a building stock segment

REAL BUILDING

BUILDING ARCHETYPE

REAL GEOMETRY

SAMPLE GEOMETRY

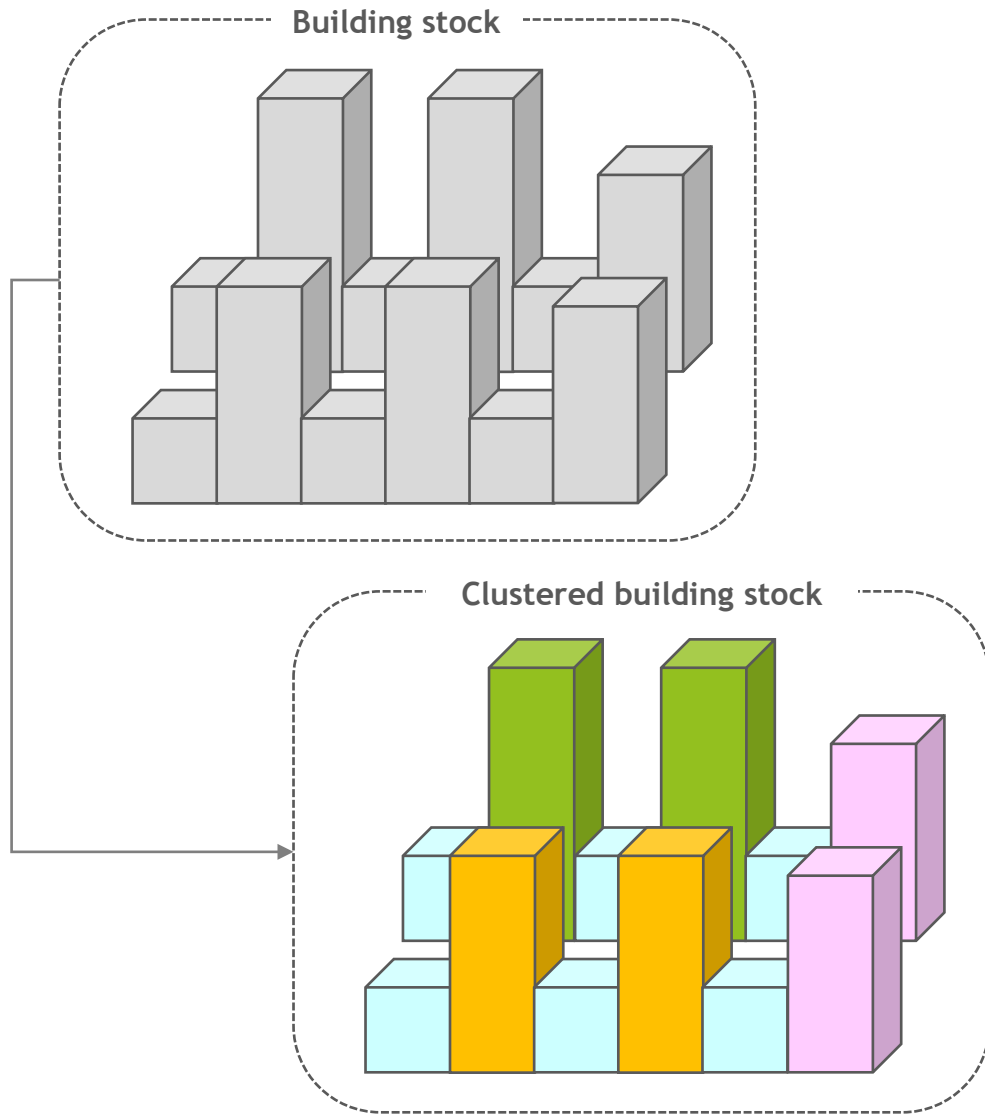


Archotyping

Archotyping is generally composed of two steps, following described:

- ➔ the **clustering** (or **segmentation**) phase refers to the taxonomy of similar buildings based on different criteria, such as climatic zone, building use category, construction periods, etc., and
 - the **characterisation** corresponds to the definition of the representative relevant parameters that generalise the building stock performance. This aspect influences the structure of the building archetype dataset since they may include deterministic or probabilistic parameters.

Clustering for building archetypes



- Classification the **heterogeneity** of building stock in several layer of categories
- To group buildings with similar **thermo-physical properties** and comparable **technical building systems characteristics**
- **To profile** different building stock energy performance segments

Clustering criteria



Climatic zone

- Significant impact on building's energy needs and performance



Building use category

- Building functional requirements
- Building Codes and Regulations
- Occupant needs and expectations



Construction period

- Architectural styles and construction techniques
- Cultural and socioeconomic factors



Building size and shape

- Technical building system differentiation
- Building uses

... additional clusters to deepen the analysis

Socio-economic indicators

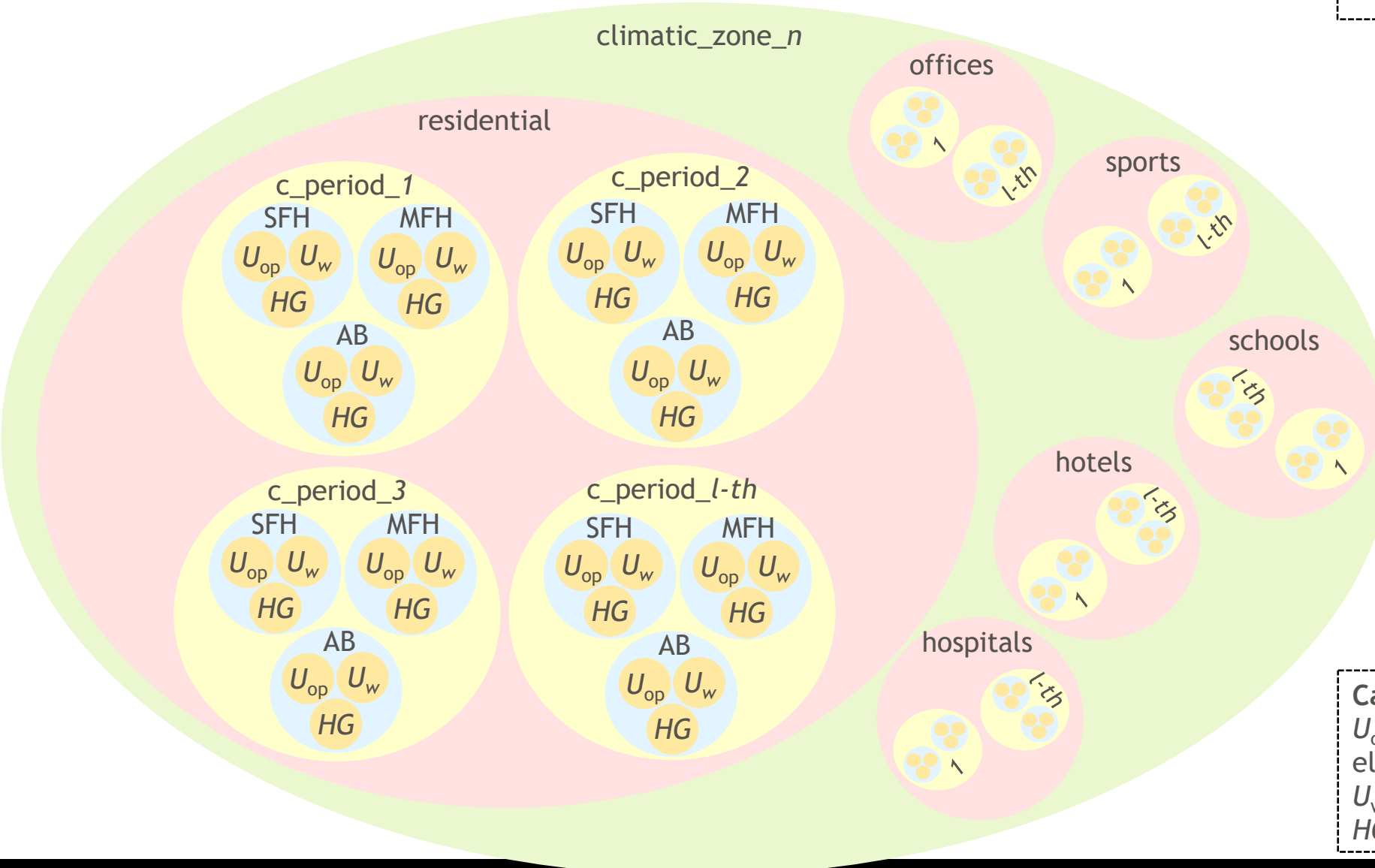
- Income level

Passive or active bldg. performance






- Building fabric
- Technical building systems
- Energy use intensity

TIMEPAC data clustering methodology

No. of climatic zones: $n = (1, \dots, 6)$
 No. of intended uses: $m = (1, \dots, 6)$
 No. of constr. periods: $l = (1, \dots, L)$
 No. of bldg size: $o = (1, \dots, 3)$



Colour caption

	Climatic zone		Building use
	Construction period		Building size and shape
	Other parameters		

Caption
 U_{op} = Thermal trasmittance of the opaque element
 U_w = Thermal trasmittance of window
 HG = Space heating generator type

EPC data clustering

According to Italian legislation

No. of climatic zones: $n = (1)$
No. of bldg. use categories: $m = (1, 3)$
No. of constr. periods: $l = (1, 8)$
No. of bldg size: $o = (1, 2)$

climatic_zone **E**

residential

≤ 1900

SFH

BU(AB)

1901-1920

SFH

BU(AB)

1921-1945

SFH

BU(AB)

1946-1960

SFH

BU(AB)

1961-1975

SFH

BU(AB)

1976-1990

SFH

BU(AB)

1991-2005

SFH

BU(AB)

> 2005

SFH

BU(AB)

offices

CP1

CP8

...

schools

CP8

CP1

...

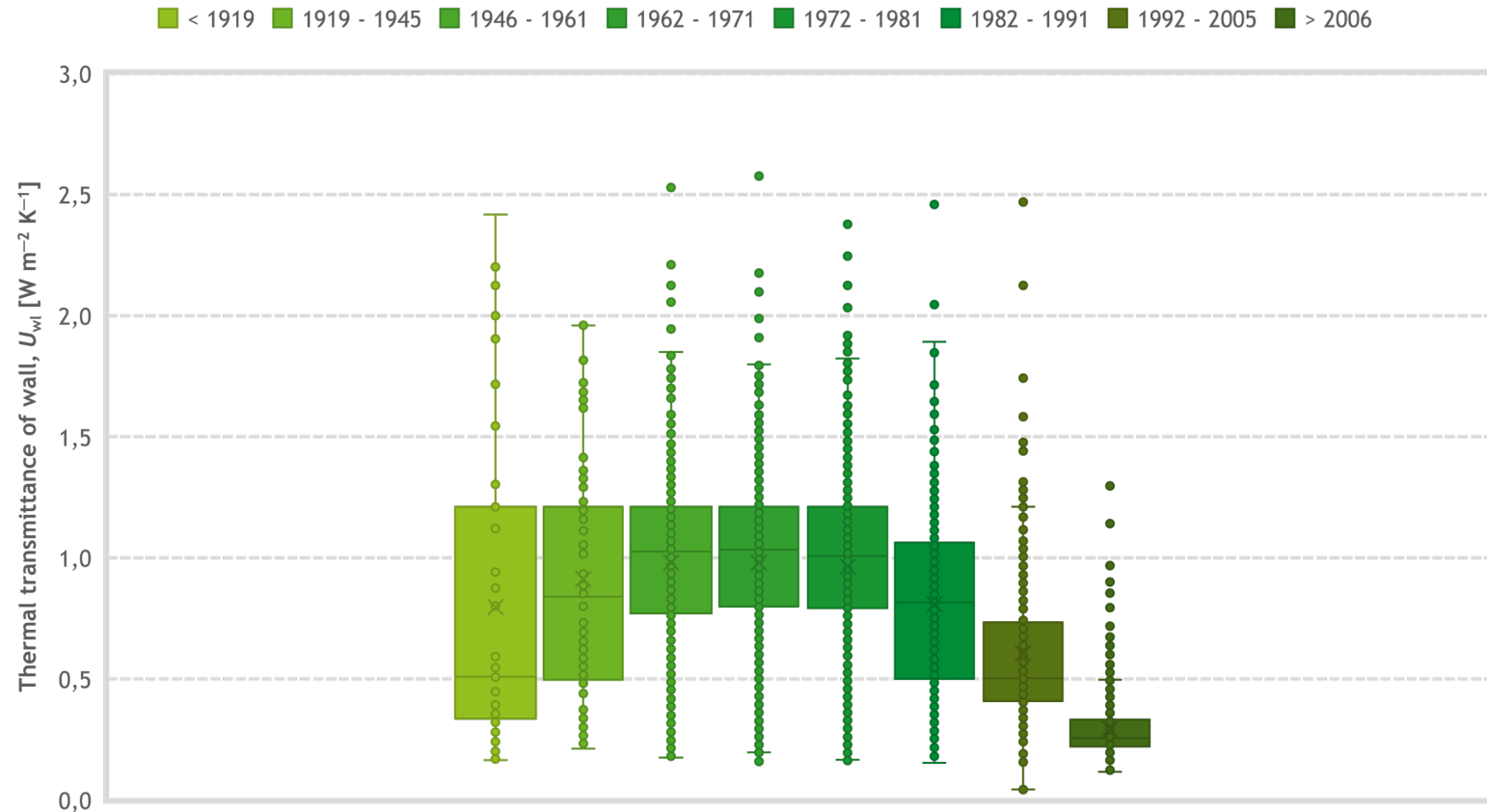
Colour caption

- Climatic zone
- Building use
- Construction period
- Building size and shape

The proposed example refers to the segmentation process applied to the **Piedmont Region** (Italy) **EPC database**

Why data clustering is important?

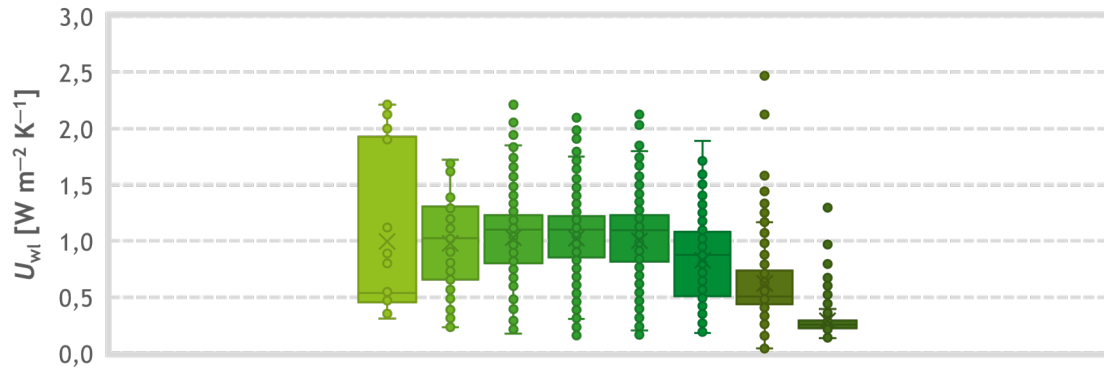
Reinforced concrete structure with brick masonry (climatic zone E and F, northern Italy)



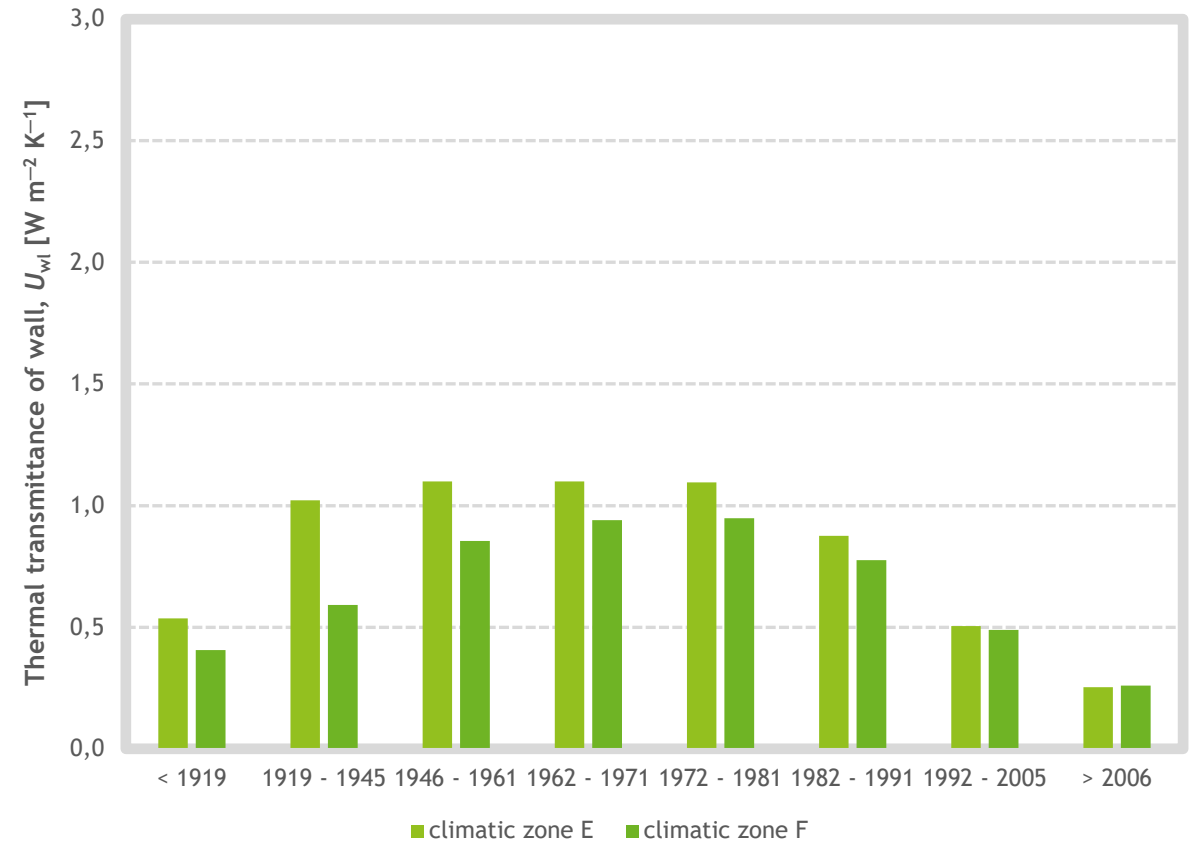
Why data clustering is important?

Reinforced concrete structure with brick masonry (climatic zone E)

- < 1919
- 1919 - 1945
- 1946 - 1961
- 1962 - 1971
- 1972 - 1981
- 1982 - 1991
- 1992 - 2005
- > 2006

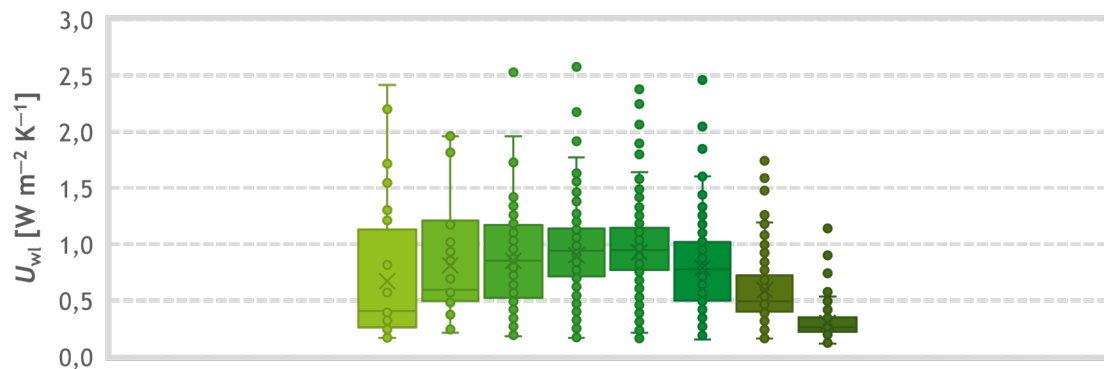


Reinforced concrete structure with brick masonry (medians)



Reinforced concrete structure with brick masonry (climatic zone F)

- < 1919
- 1919 - 1945
- 1946 - 1961
- 1962 - 1971
- 1972 - 1981
- 1982 - 1991
- 1992 - 2005
- > 2006



Conclusion

- Archetype-based model is the most **common approach** for assessing the energy and environmental performance of building stocks (blocks, districts, or entire cities).
- The building archetype approach is a **trade-off to reduce complexity** and **enhance the model's accuracy** in energy analysis.
- The segmentation process plays a **significant role** in building archetype generation.
- The segmentation phase allows to consider the **heterogeneity aspects** of the building stock.

**If you would like more information,
please visit www.timepac.eu or contact us at
matteo.piro@polito.it**

Thanks for your attention!