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TIMEPAC

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Setting the scene: Building archetypes for developing municipal renovation plans

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Art. 3 – National building renovation plan

Each Member State shall establish a **national building renovation plan to ensure the renovation of the national stock of residential and non-residential buildings**, both public and private, into a highly energy efficient and decarbonised building stock by 2050, with the objective to transform existing buildings into zero-emission buildings.

Each building renovation plan shall comply with the energy efficiency first principle and shall encompass:

a. an **overview of the national building stock for different building types**, including their **share in the building stock** […], **construction periods** and **climatic zones** of each Member State, based, as appropriate, on **statistical sampling**, energy and life-cycle GWP **benchmarking** […];

b. an overview of implemented and planned policies […];

c. a roadmap with nationally established targets and **measurable progress indicators**, and **specific timelines** for all existing buildings to achieve higher energy performance classes by 2030, 2040 and 2050 […];

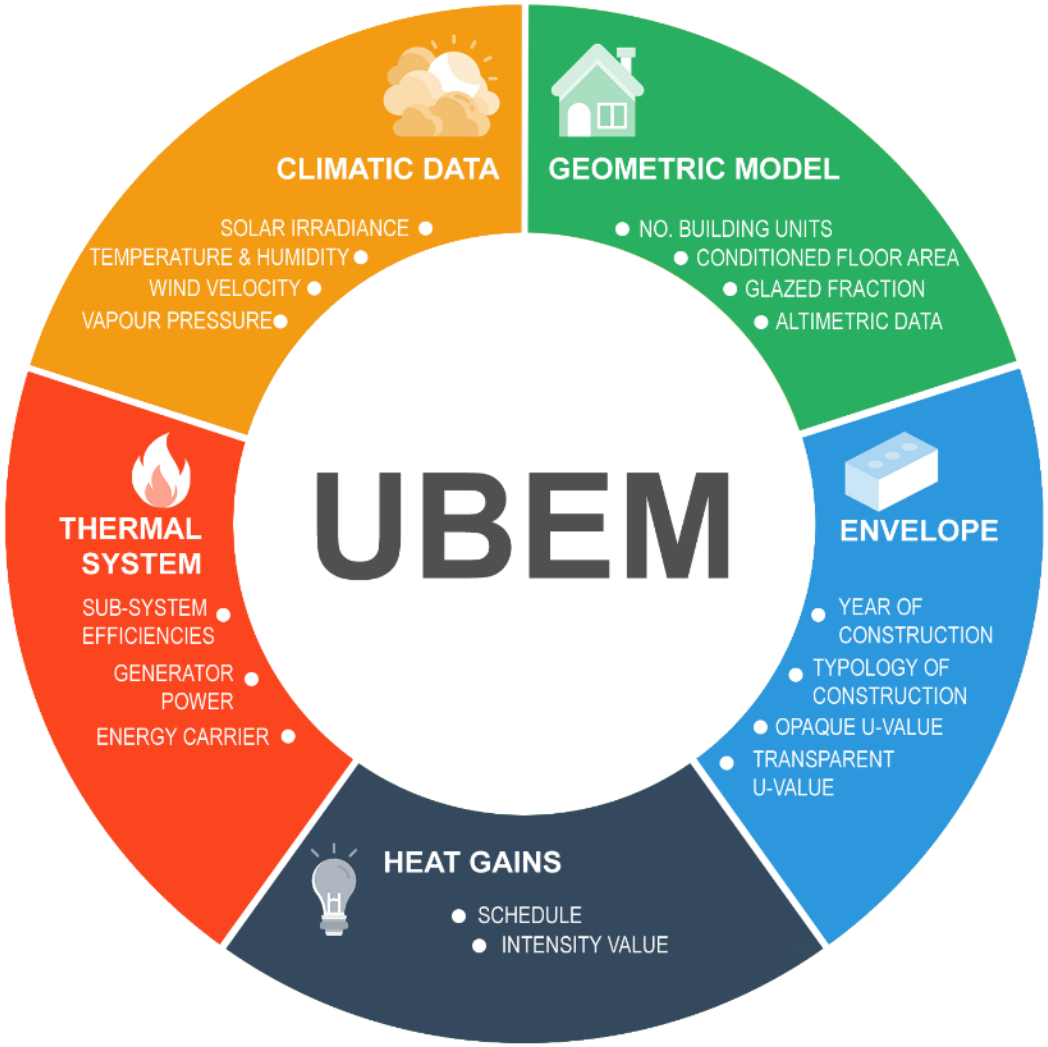
d. an overview of implemented and planned policies and measures including their duration in consistency […];

e. a detailed roadmap up to 2050 of the investment needs for the implementation of the building renovation plan […];

f. a roadmap on the reduction of **energy poverty and energy savings achieved** among vulnerable households and people living in social housing comprising of nationally established targets and an overview of implemented and planned policies and funding measures supporting the elimination of energy poverty. […]

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**.



How to develop a UBEM?

Very detailed model

Accurate results

Time consuming

Lack of data

High amount of real buildings to be assessed!

Need of expert modellers

Tools not easily exploitable

Not flexible model

Source: Google Maps

Reference building approach

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

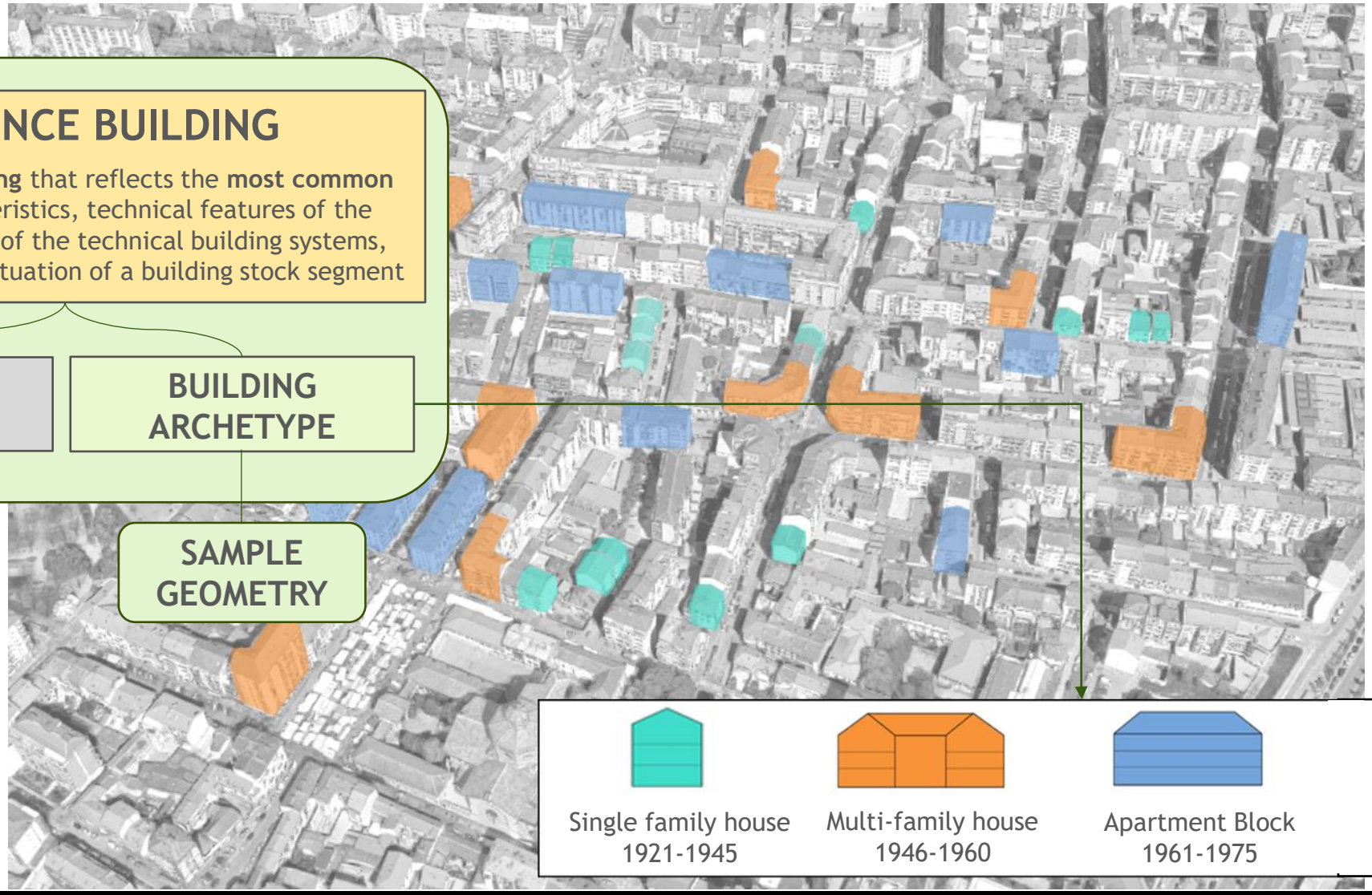
REAL BUILDING

REAL GEOMETRY

BUILDING ARCHETYPE

SAMPLE GEOMETRY

EXAMPLE



Archetypes

Single family house
1921-1945

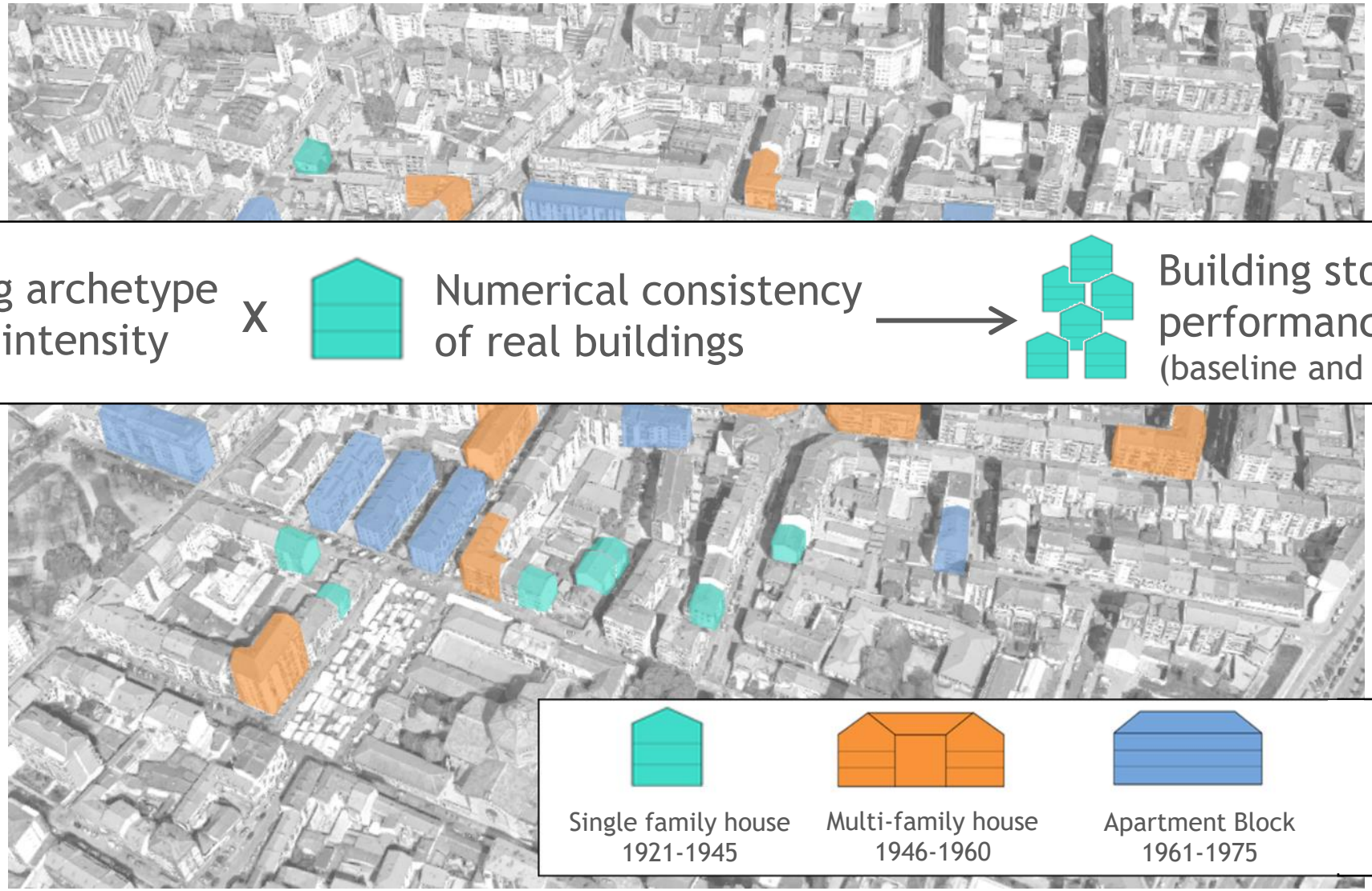
Multi-family house
1946-1960

Apartment Block
1961-1975

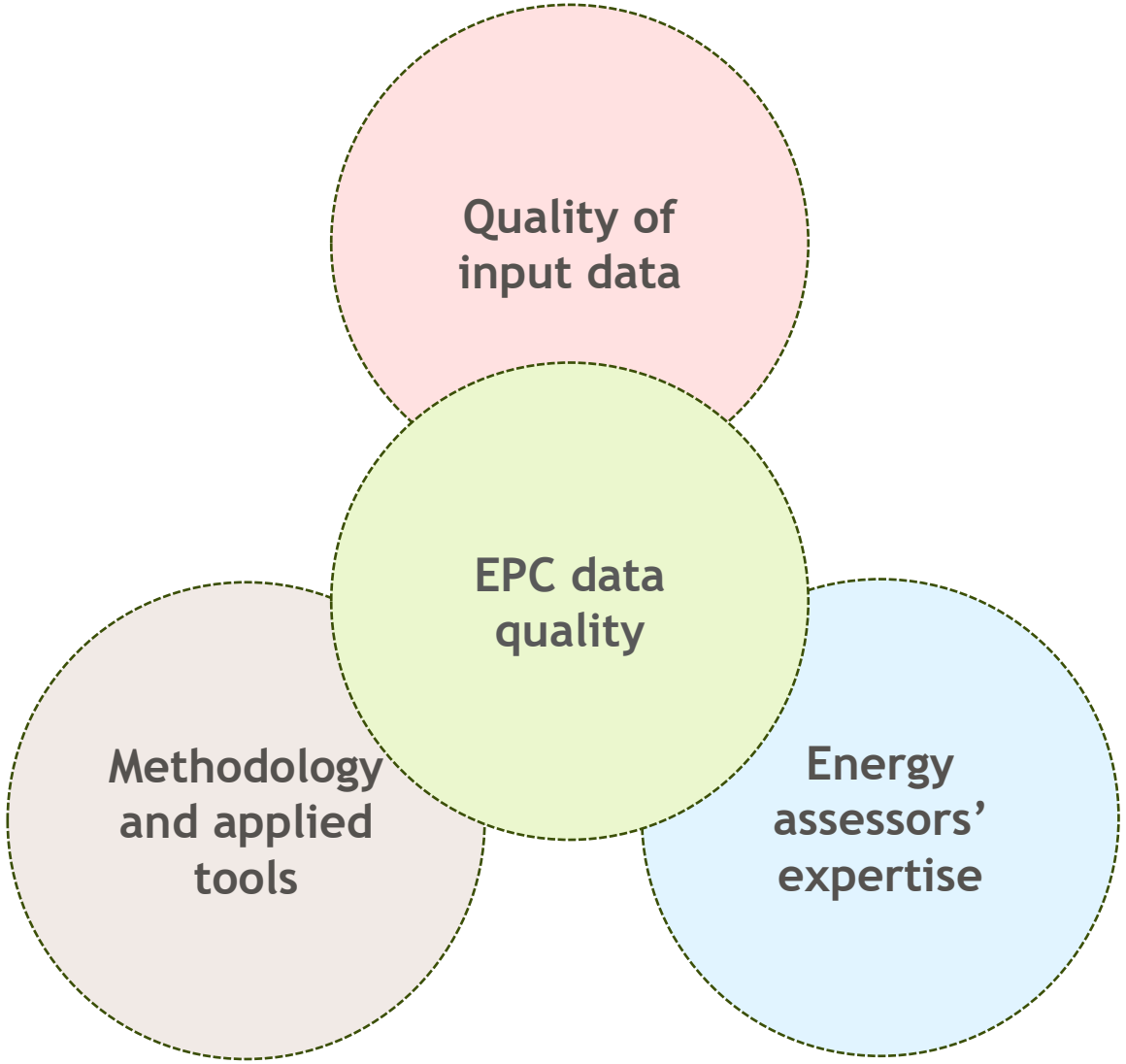
.....

Bottom-up UBEM using archetypes

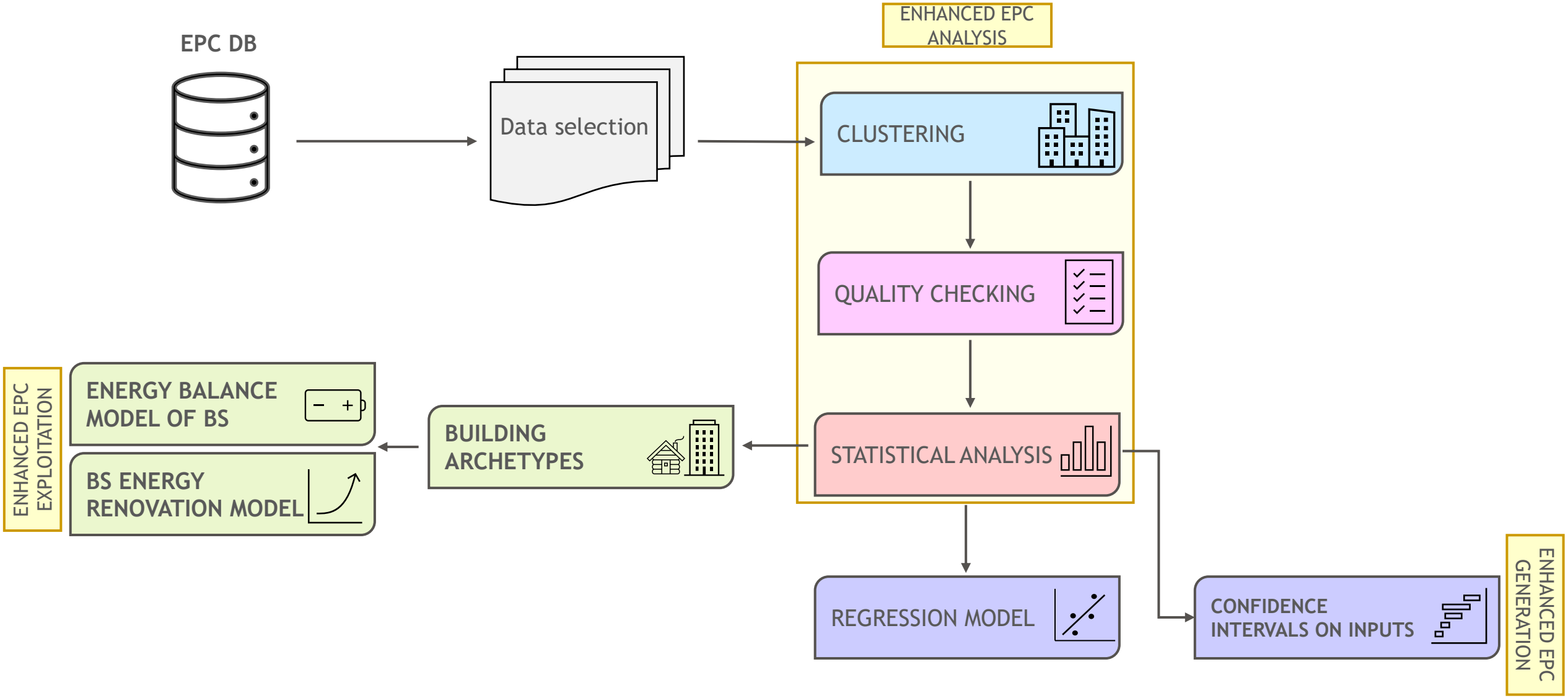
EXAMPLE



Energy Performance Certificate (EPC) as a data source

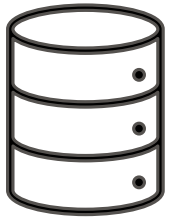


Work-flow from EPCs to archetypes in TIMEPAC

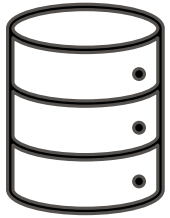


EPC data selection

"reduced" XML

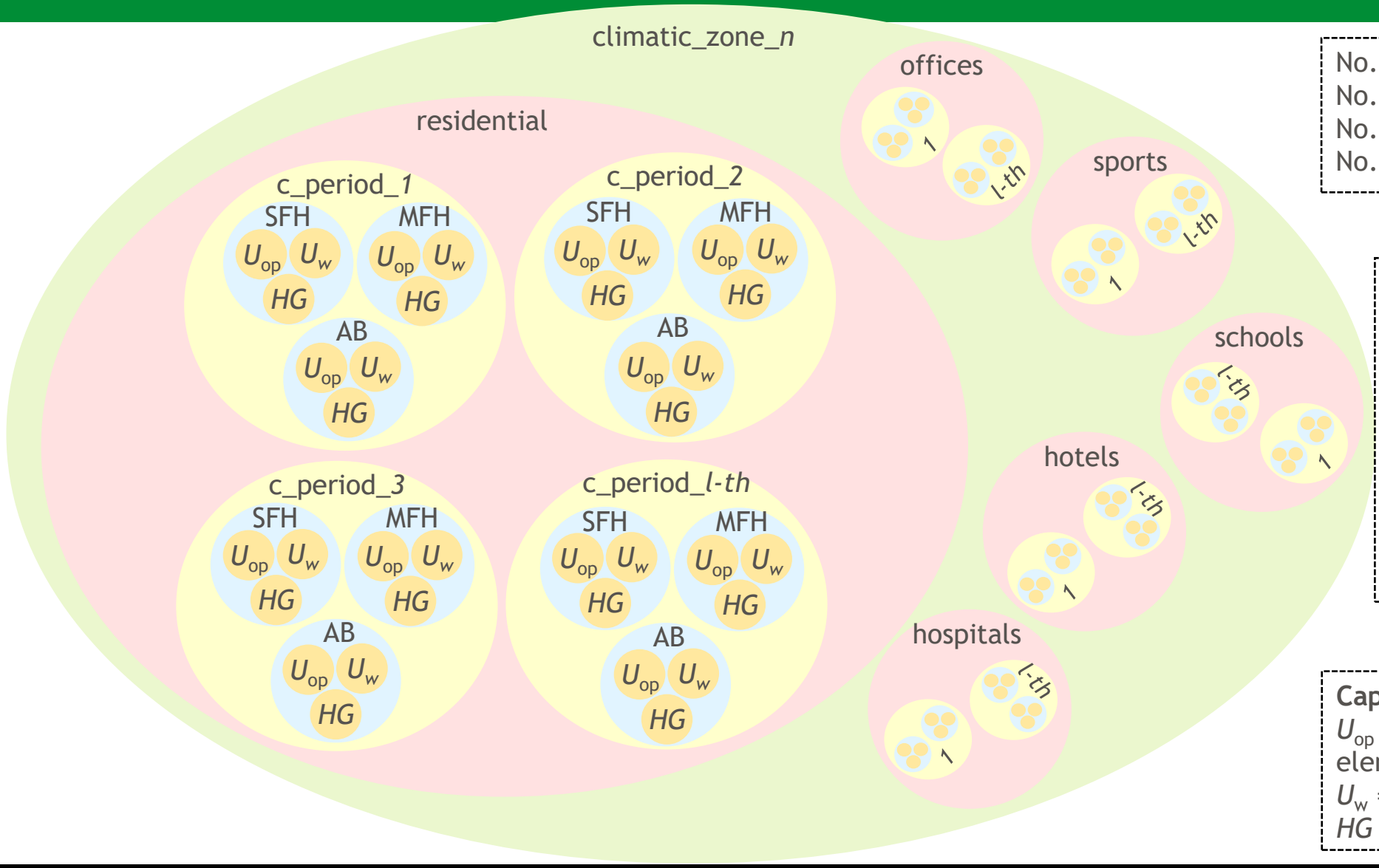


"extended" XML



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)

EPC data clustering



No. of climatic zones: n = *(1, …, 6)*
No. of intended uses: m = *(1, …, 6)*
No. of constr. periods: l = *(1, …, L)*
No. of bldg size: o = *(1, …, 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 quality

- The **EPC data quality checking** procedure provides the **score attribution** to parameters and values contained in the energy certificates. For each of the EPC data, a **validity rule** has been associated.

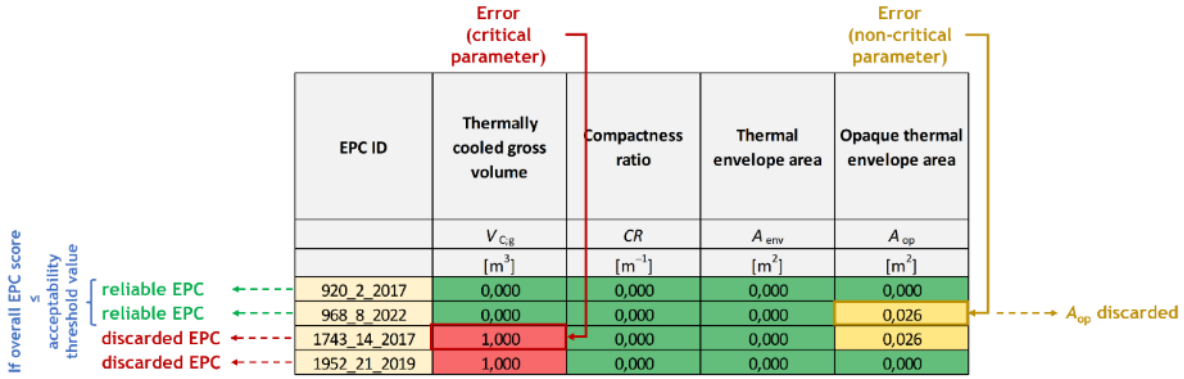
X-tendo

(*) This procedure draws inspiration from the X-tendo project (x-tendo.eu).

EPC data rules and scores

Data name (Critical parameter*)	Typology of rules	Rule	Respected rule (score)	Unrespected rule (score)
Assessed object	D	string not null	0,000	$1/(n-m)$
Application type	D	string not null	0,000	$1/(n-m)$
EPC ID code*	D	string not null	0,000	1,000
Building city	D	string not null	0,000	$1/(n-m)$
Number of building units	D	string not null *or* integer ≥ 0	0,000	$1/(n-m)$
Building typology	D	string not null	0,000	$1/(n-m)$
Building construction typology	D	string not null	0,000	$1/(n-m)$
Building category	D	string not null	0,000	1,000
Year of construction	D, P	integer > 0	0,000	1,000

EPC data scoring



Building Archetypes (BAs)

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)

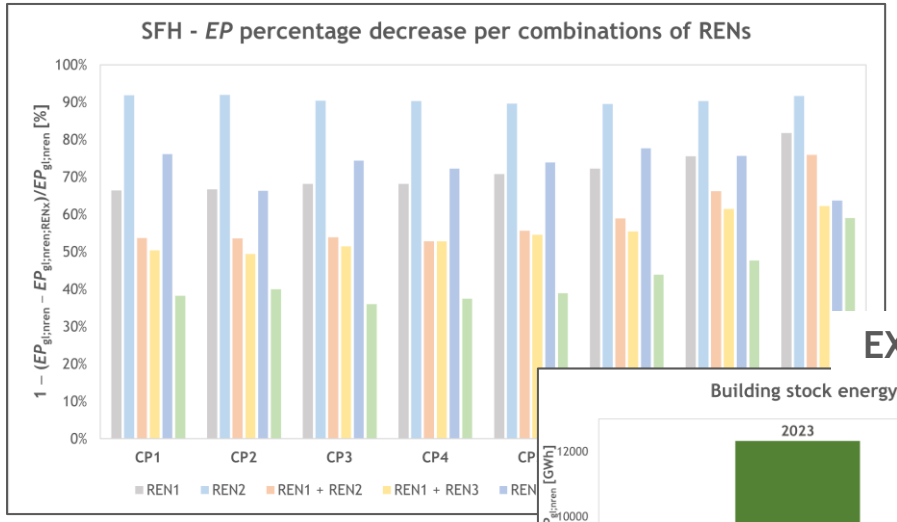
Climatic zone E	Residential bldgs	
	SFH	BU(AB)
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)_CP1
CP2	E_RES_SINGLE_CP2	E_RES_BU(AB)_CP2
CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)_CP3
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)_CP4
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)_CP5
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)_CP6
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)_CP7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

PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP1

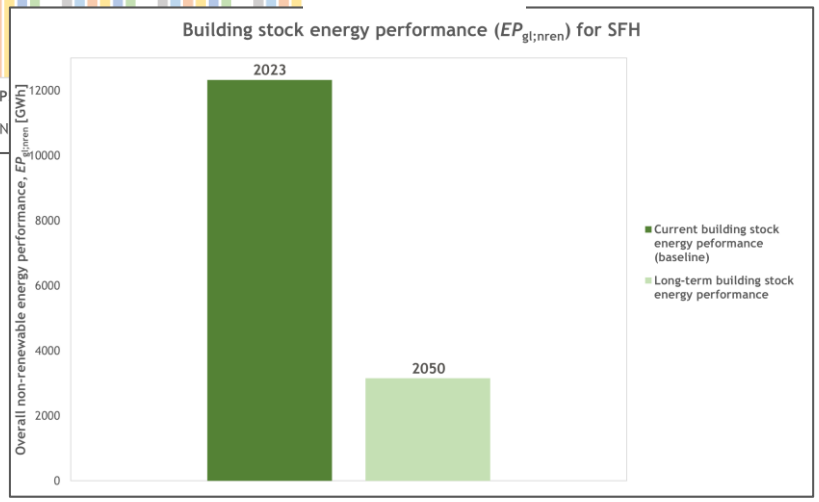
	Data	Symbol	Unit of measure	Median	$(Q_3 - Q_2)$	$(Q_2 - Q_1)$
Geometry	Compactness ratio	CR	m^{-1}	0,754	0,128	0,114
	Thermally heated gross volume	$V_{H;g}$	m^3	457	+196	145
	Thermally heated floor area	$A_{H;use;ztc}$	m^2	110	47	35
	Transparent thermal envelope area on thermal envelope area	A_{wi}/A_{env}	%	5%	2%	1%
Envelope	Mean thermal transmittance of opaque building envelope	U_{op}	$W/(m^2 \cdot K)$	1,295	0,221	0,262
	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)				
	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
Energy indicators	Energy need for space heating	$EP_{H;nd;ztc}$	kWh/m^2	193,7	65,6	56,6
	Energy need for space cooling	$EP_{C;nd;ztc}$	kWh/m^2	7,3	6,7	4,4
	Energy need for domestic hot water	$EP_{W;nd;ztc}$	kWh/m^2	17,0	2,0	1,4
	Seasonal space heating energy efficiency	$\eta_{s;H}$	–	0,730	0,040	0,050
	Seasonal space cooling energy efficiency	$\eta_{s;C}$	–	1,190	1,440	0,470
	Seasonal domestic hot water energy efficiency	$\eta_{s;W}$	–	0,580	0,170	0,080
	Non-renewable energy performance per space heating	$EP_{H;nren}$	kWh/m^2	241,5	102,0	94,3
	Non-renewable energy performance per space cooling	$EP_{C;nren}$	kWh/m^2	6,6	8,5	4,1
	Non-renewable energy performance per domestic hot water	$EP_{W;nren}$	kWh/m^2	26,7	8,8	7,0
	Overall non-renewable energy performance	$EP_{gl;nren}$	kWh/m^2	270,8	105,7	98,0
	Overall renewable energy performance	$EP_{gl;ren}$	kWh/m^2	1,8	12,7	1,3
	Renewable Energy Ratio	RER	%	1%	5%	1%

Building stock energy model

- The **building stock energy model** adopts the **BAs** to perform **large-scale balances** (energy and CO_2) and to evaluate the effectiveness of the **energy refurbishment scenarios**.
- The building stock energy model has been implemented in an **MS Excel spreadsheet**, and it can be upgraded 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**.



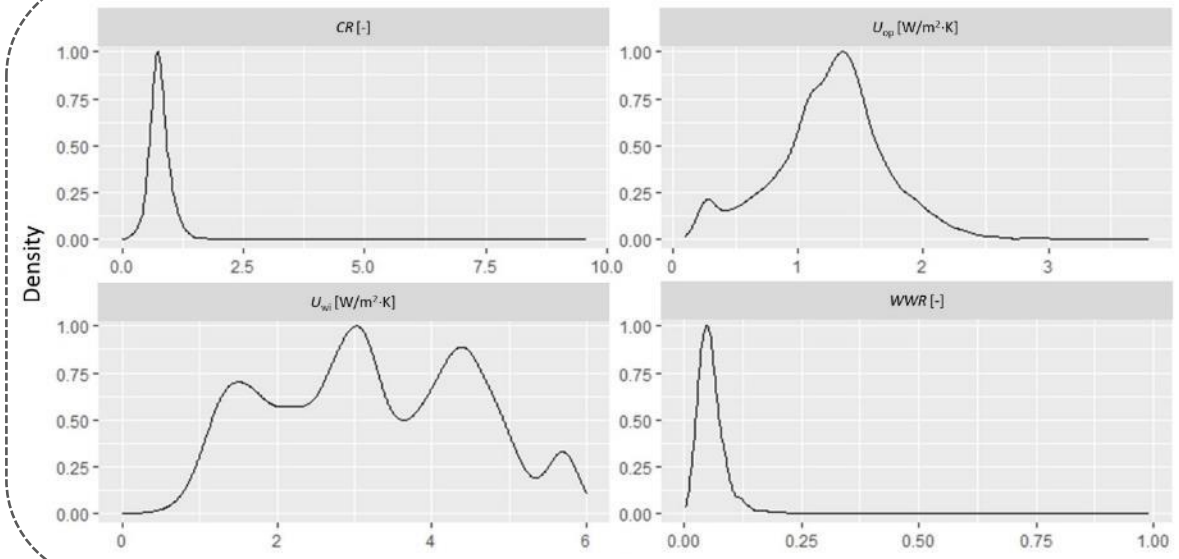
EXAMPLE



Confidence intervals to increase EPC quality in the future

- **Plausible values** for the main input data from the regional EPC databases that **affect the energy performance of buildings**.
- Set of controls on EPC input data to increase **reliability** and **representativeness**.

SFH	U_{op} [W/(m²·K)]			U_{wi} [W/(m²·K)]		
	Mean ± SD	95% CI		Mean ± SD	95% CI	
		LL	UL		LL	UL
CP1	1,259 ± 0,45	1,250	1,268	3,234 ± 1,30	3,209	3,260
CP2	1,243 ± 0,45	1,225	1,261	3,209 ± 1,25	3,159	3,258
CP3	1,216 ± 0,44	1,205	1,227	3,170 ± 1,30	3,138	3,203
CP4	1,114 ± 0,45	1,104	1,125	2,960 ± 1,29	2,929	2,991
CP5	1,019 ± 0,42	1,009	1,030	2,872 ± 1,32	2,840	2,905
CP6	0,970 ± 0,38	0,959	0,981	2,678 ± 1,14	2,645	2,712
CP7	0,830 ± 0,33	0,820	0,840	2,390 ± 0,81	2,366	2,415
CP8	0,447 ± 0,30	0,439	0,456	1,749 ± 0,68	1,730	1,769



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 contact us at

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Thanks for your attention!