

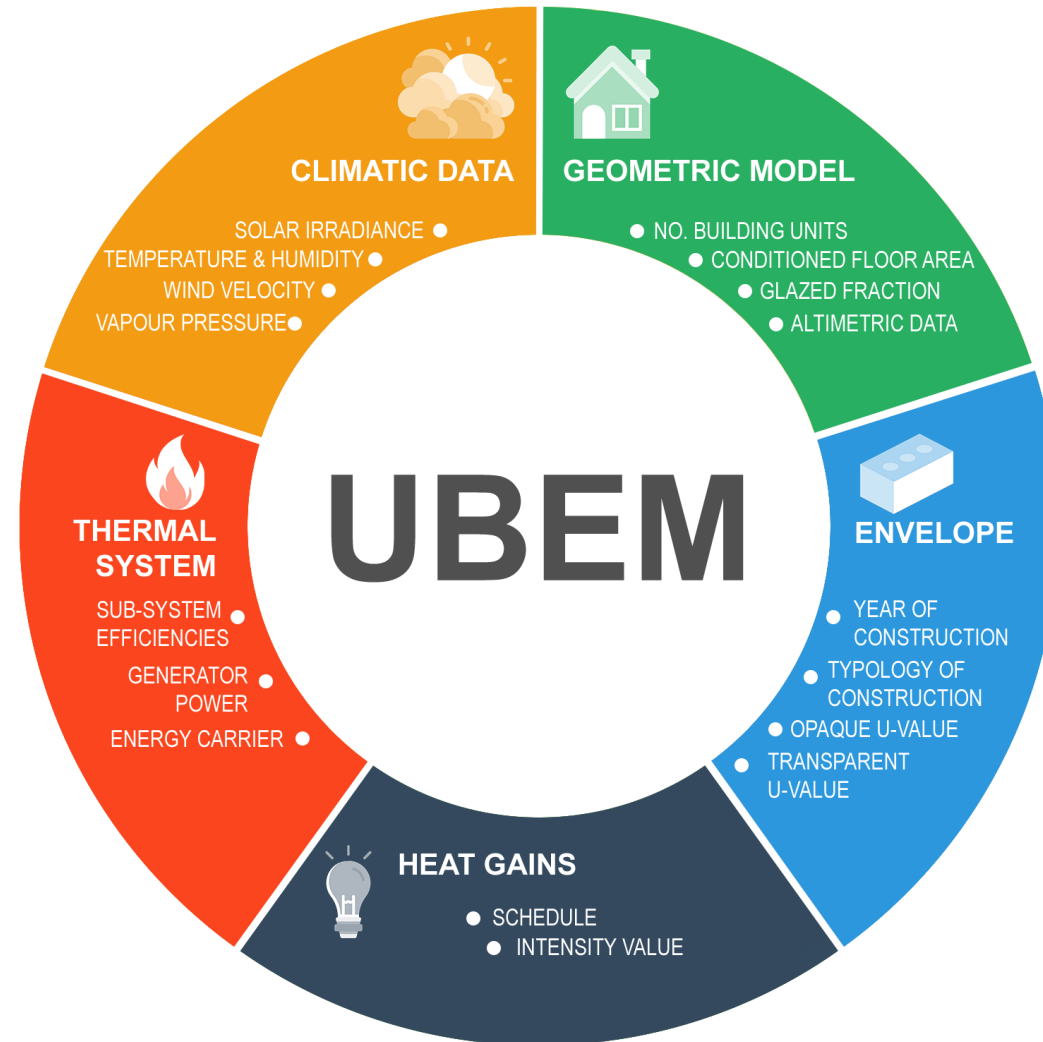
Results and discussion

Ing. Matteo Piro

Prof.ssa Ilaria Ballarini

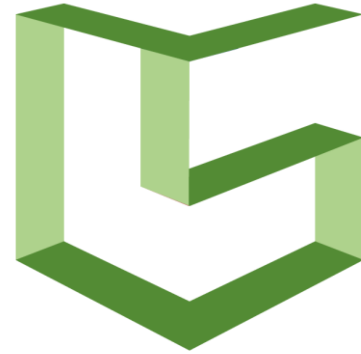
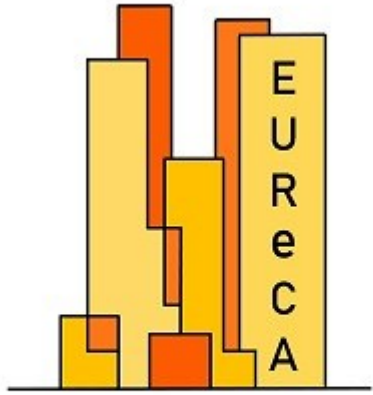
Dott.ssa Mamak P.Tootkaboni

Politecnico di Torino



UBEM tools

UBEM.IO



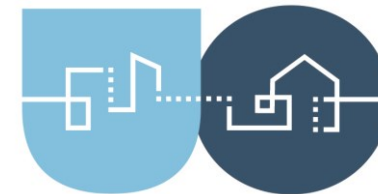
CityBES



TEASER
Tool for Energy Analysis and Simulation
for Efficient Retrofit



City Energy Analyst



URBAN
OPT

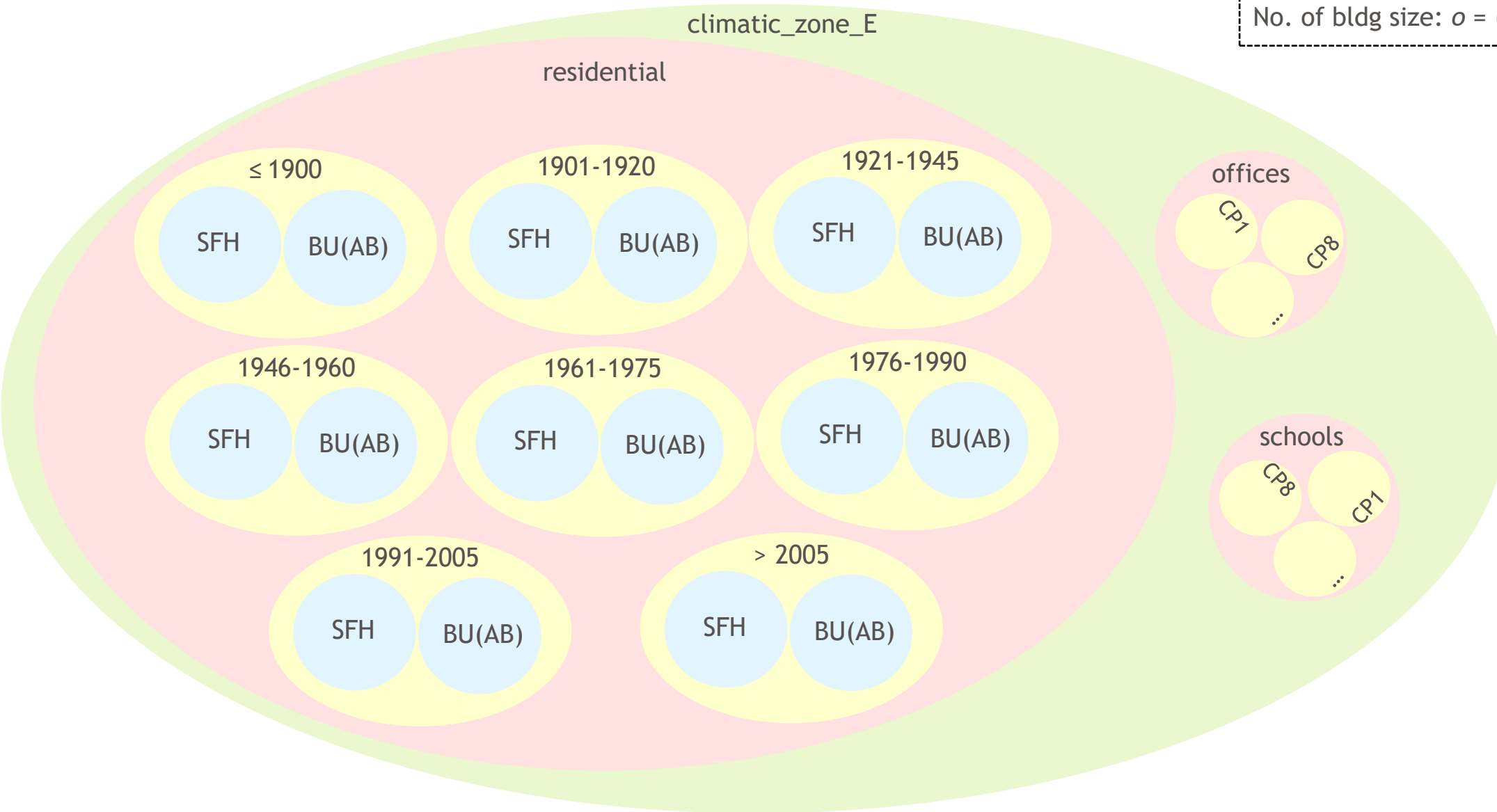
UBEM data

Description	Symbol	Unit	Standard reference
Thickness of the material layer in the component	d	m	EN ISO 6946:2017
Design thermal conductivity	λ	W/(m·K)	EN ISO 6946:2017
External surface resistance	R_{se}	(m ² ·K)/W	EN ISO 6946:2017
Internal surface resistance	R_{si}	(m ² ·K)/W	EN ISO 6946:2017
Hemispherical emissivity of the surface	ε	–	EN ISO 6946:2017
Emissivity of the inside surface		–	
Emissivity of the external surface		–	
Density of building component	ρ_m	kg/m ³	EN ISO 13786:2017
Specific heat capacity of building component	c_m	J/(kg·K)	EN ISO 13786:2017
Solar absorption coefficient of external opaque surfaces	$\alpha_{sol;k}$	–	EN ISO 52016-1:2017
Visible absorption coefficient of external opaque surfaces		–	
Water vapour resistance factor	μ	–	EN ISO 10456:2007
Roughness of building component			ISO 4287-1:1984
Thermal transmittance of the component	U	W/(m ² ·K)	EN ISO 10077-1:2017
U-value of the window	U_w	W/(m ² ·K)	EN ISO 10077-1:2017
U-value of the transparent part of the window	$g_{gl;wi}$	–	EN ISO 52016-1:2017
U-value of the opaque part of the window			
U-value of the side of the glazing facing the interior	ρ_e	–	ISO 52022-1:2017
U-value of the side of the glazing facing the exterior			
U-value of the side of the glazing facing the adjacent space			

Part of data needed to characterise the opaque building envelope components

EPC data clustering

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: $o = (1, 2)$



Colour caption

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

Building typology matrix

Climatic zone E	Residential bldgs		Non-residential bldgs	
	SFH	BU(AB)	OFF	EDUC
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)_CP1	E_OFF_CP1	E_EDUC_CP1
CP2	E_RES_SINGLE_CP2	E_RES_BU(AB)_CP2	E_OFF_CP2	E_EDUC_CP2
CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)_CP3	E_OFF_CP3	E_EDUC_CP3
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)_CP4	E_OFF_CP4	E_EDUC_CP4
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)_CP5	E_OFF_CP5	E_EDUC_CP5
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)_CP6	E_OFF_CP6	E_EDUC_CP6
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)_CP7	E_OFF_CP7	E_EDUC_CP7
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)_CP8	E_OFF_CP8	E_EDUC_CP8

CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8
≤ 1900	1901-1920	1921-1945	1946-1960	1961-1975	1976-1990	1991-2005	> 2005

Building typology matrix

Climatic zone E	Residential bldgs	
	SFH	BU(AB)
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)
CP2	E_RES_SINGLE_CP2	E_RES_BU(AB)
CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)

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;ig}	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 ·K)	1,295	0,221	0,262
	Mean thermal transmittance of transparent building envelope	U _{wi}	W/(m ² ·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)	η _{H;gn}	-	0,917	0,093	0,127
Mean seasonal efficiency of the heating generation sub-system (solid biomass)	η _{H;gn}	-	0,750	0,186	0,290	
Utilisation energy efficiency	η _{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	η _{s;H}	-	0,730	0,040	0,050
	Seasonal space cooling energy efficiency	η _{s;C}	-	1,190	1,440	0,470
	Seasonal domestic hot water energy efficiency	η _{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 typology matrix

Climatic zone E	Residential bldgs	
	SFH	BU(AB)
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)
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CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)

PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP1						
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Are the data in BA schema sufficient to build a detailed UBEM?



Building typology matrix

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	SFH	BU(AB)
CP1	E_RES_SINGLE_CP1	E_RES_BU(AB)
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CP3	E_RES_SINGLE_CP3	E_RES_BU(AB)
CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)

PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP1						
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	Renewable Energy Ratio	RER	%	1%	5%	1%

Are the data in BA schema sufficient to build a detailed UBEM?

NO



Building typology matrix

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CP4	E_RES_SINGLE_CP4	E_RES_BU(AB)
CP5	E_RES_SINGLE_CP5	E_RES_BU(AB)
CP6	E_RES_SINGLE_CP6	E_RES_BU(AB)
CP7	E_RES_SINGLE_CP7	E_RES_BU(AB)
CP8	E_RES_SINGLE_CP8	E_RES_BU(AB)

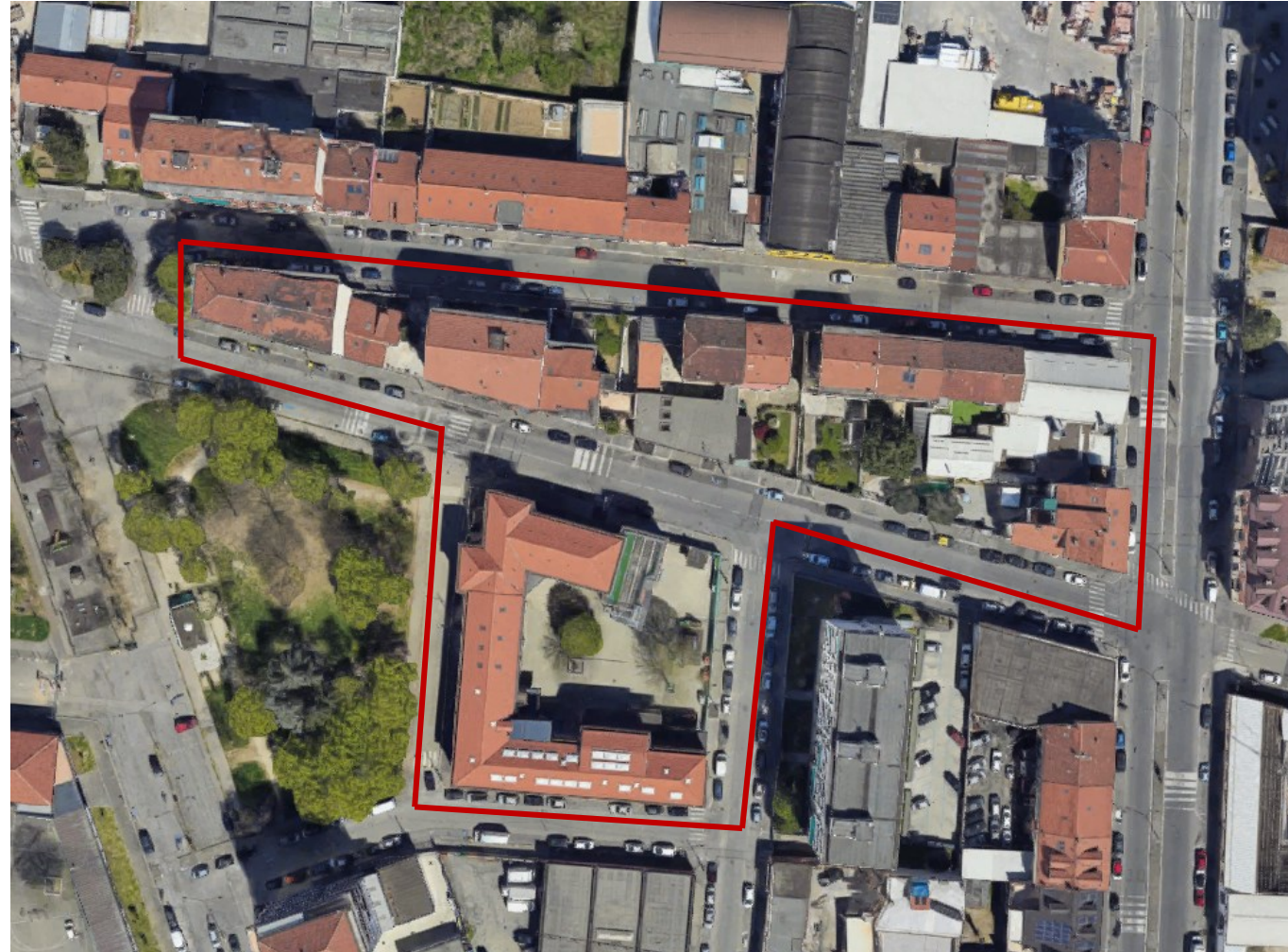
PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP1						
	Data	Symbol	Unit of measure	Median	(Q ₃ - Q ₂)	(Q ₂ - Q ₁)
Geometry	Compactness ratio	CR	m ⁻¹	0,754	0,128	0,114
	Thermally heated gross volume	V _{H;g}	m ³	457	+196	145
	Thermally heated floor area	A _{H;use;ztc}	m ²	110	47	35
	Transparent thermal envelope area on thermal envelope area	A _{wi} /A _{Env}	%	5%	2%	1%
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	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
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	Seasonal space cooling energy efficiency	η _{s;C}	-	1,190	1,440	0,470
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	Non-renewable energy performance per space heating	EP _{H;nren}	kWh/m ²	241,5	102,0	94,3
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	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%

Are the data in BA schema sufficient to build a detailed UBEM?

NO, but they are helpful!

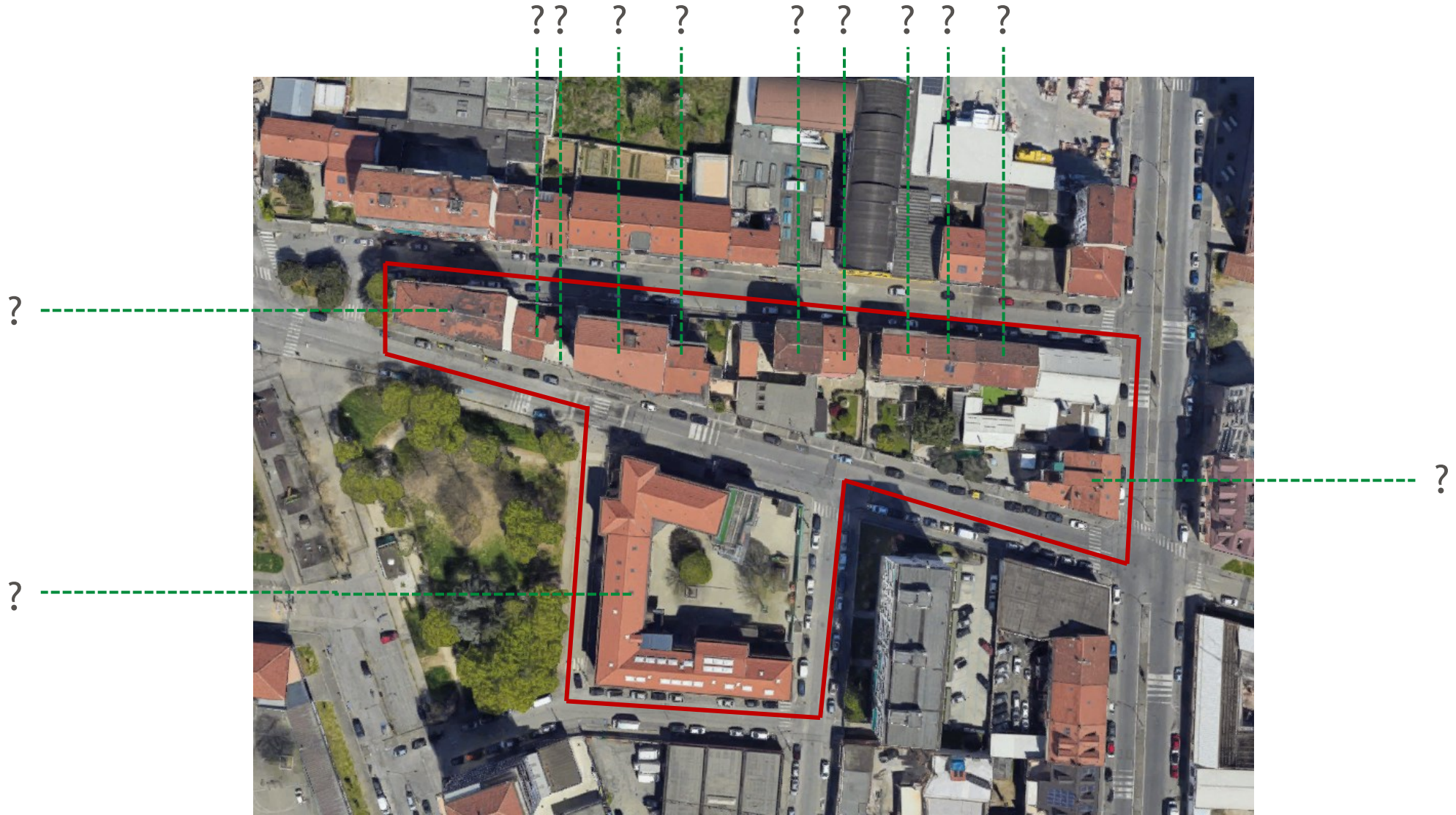


Building stock of Turin



Source: Google Maps ([google.com/maps](https://www.google.com/maps)).

Building stock of Turin



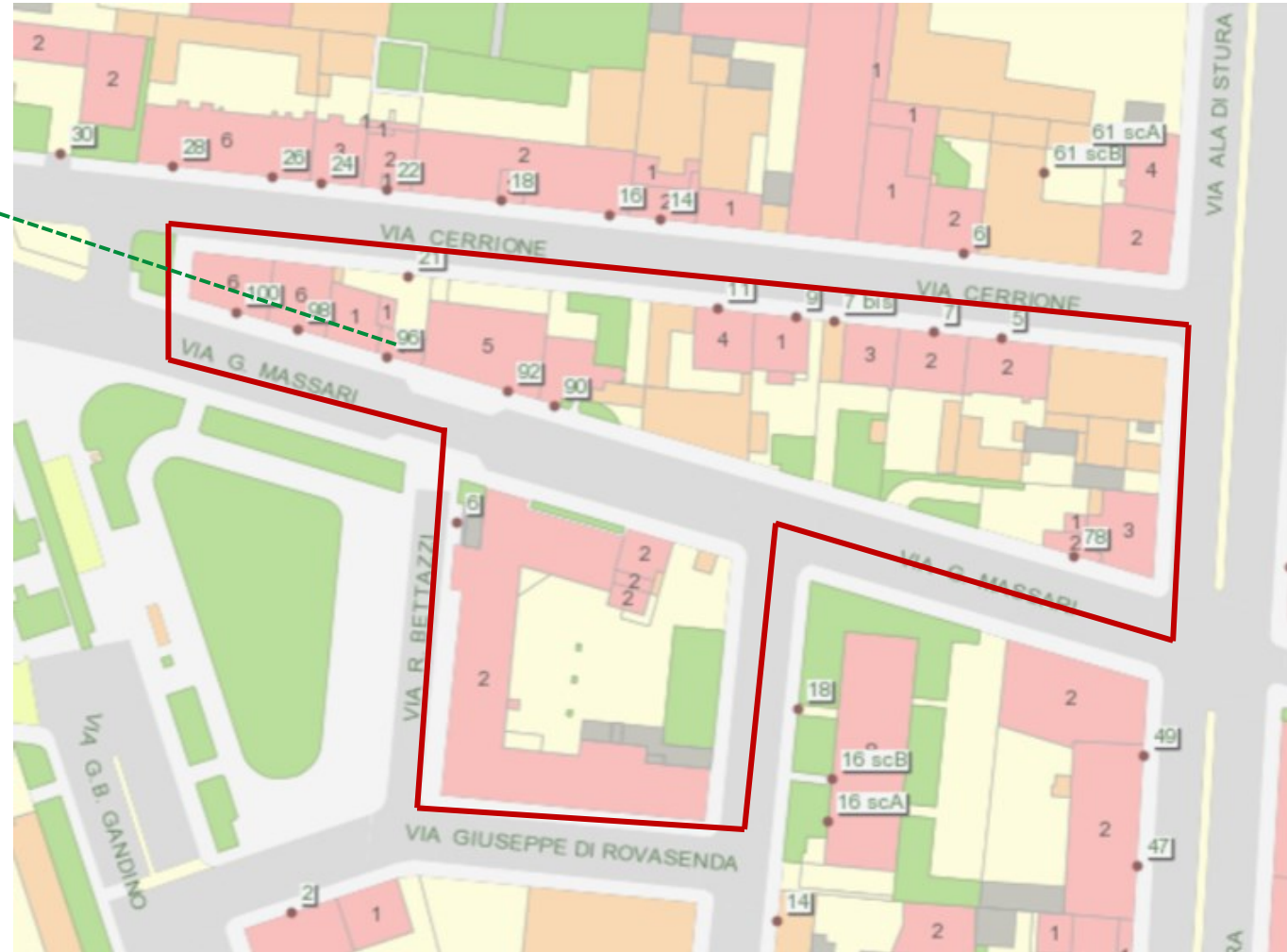
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Building stock of Turin

Informazione oggetto	
Carta Tecnica colori	
Livello	Carta Tecnica
codice_intesa	020102
gruppo	EDIFICI PRINCIPALI
descrizione	generica
categoria_uso	residenziale
epoca_costruzione	1946 - 1960
numero_piani	1
altezza_edificio	4.4
valenza_storica	non monumentale
nome	
fondo	
materiale	
uso	



Climatic zone E
Residential bldg.
1946-1960



Source: Geoportale del Comune di Torino (geoportale.comune.torino.it).

Building stock of Turin

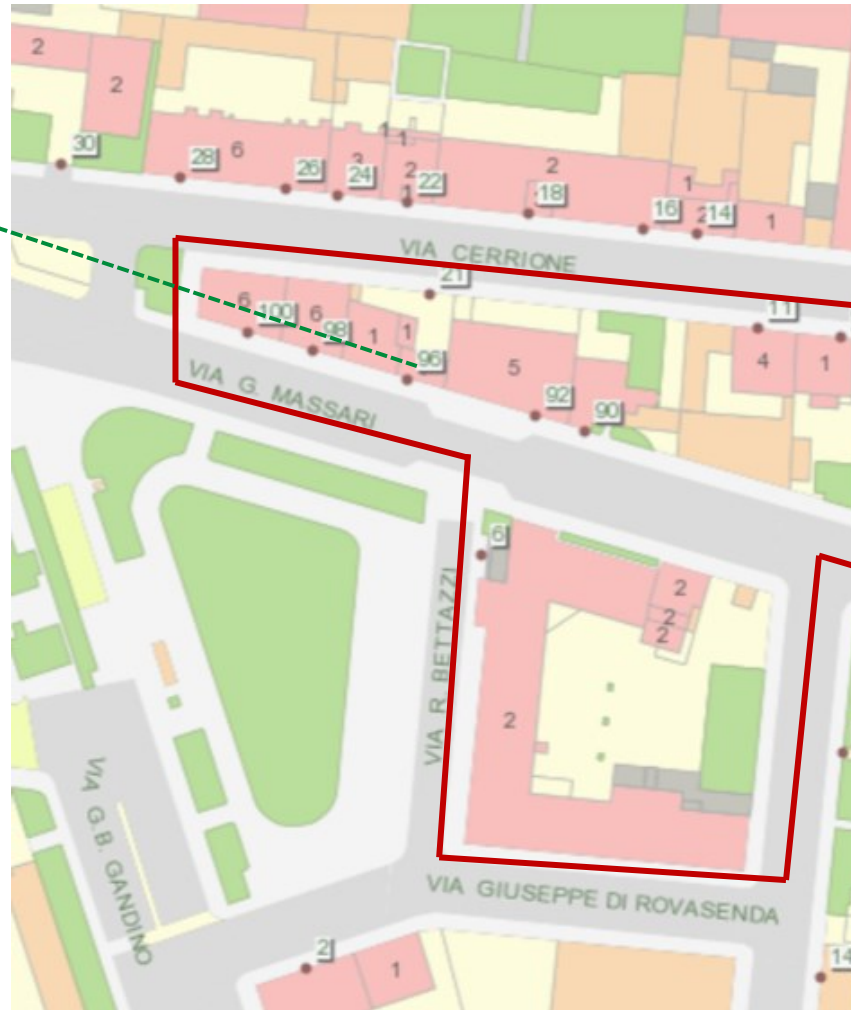
Informazione oggetto	
Carta Tecnica colori	
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epoca_costruzione	1946 - 1960
numero_piani	1
altezza_edificio	4.4
valenza_storica	non monumentale
nome	
fondo	
materiale	
uso	



Climatic zone E
Residential bldg.
1946-1960



E_RES_SFH_CP4



PIEMONTE REGION EPC DATABASE - E_RES_SINGLE_CP4						
Data	Symbol	Unit of measure	Median	(Q ₃ - Q ₂)	(Q ₂ - Q ₁)	
Compactness ratio	CR	m ⁻¹	0,788	0,155	0,122	Geometry
Thermally heated gross volume	V _{H;g}	m ³	453	173	133	
Thermally heated floor area	A _{H;use;ztc}	m ²	110	43	31	
Transparent thermal envelope area on thermal envelope area	A _{wi} /A _{env}	%	5%	2%	1%	
Mean thermal transmittance of opaque building envelope	U _{op}	W/(m ² ·K)	1,170	0,239	0,344	Envelope
Mean thermal transmittance of transparent building envelope	U _{wi}	W/(m ² ·K)	2,907	1,212	1,024	
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)			
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)	η _{H;gn}	-	0,917	0,093	0,127	Energy indicators
Mean seasonal efficiency of the heating generation sub-system (solid biomass)	η _{H;gn}	-	0,750	0,186	0,290	
Utilisation energy efficiency	η _{H;u}	-	0,875	0,048	0,065	
Energy need for space heating	EP _{H;nd;ztc}	kWh/m ²	174,7	69,8	61,3	
Energy need for space cooling	EP _{C;nd;ztc}	kWh/m ²	9,2	7,4	5,3	
Energy need for domestic hot water	EP _{W;nd;ztc}	kWh/m ²	17,0	1,6	1,4	
Seasonal space heating energy efficiency	η _{S;H}	-	0,730	0,070	0,050	
Seasonal space cooling energy efficiency	η _{S;C}	-	1,160	0,940	0,420	
Seasonal domestic hot water energy efficiency	η _{S;W}	-	0,670	0,110	0,120	
Non-renewable energy performance per space heating	EP _{H;nren}	kWh/m ²	215,9	108,2	93,0	
Non-renewable energy performance per space cooling	EP _{C;nren}	kWh/m ²	7,5	7,6	4,6	
Non-renewable energy performance per domestic hot water	EP _{W;nren}	kWh/m ²	24,0	7,8	5,1	
Overall non-renewable energy performance	EP _{gl;nren}	kWh/m ²	242,8	112,1	96,1	
Overall renewable energy performance	EP _{gl;ren}	kWh/m ²	1,9	11,3	1,0	
Renewable Energy Ratio	RER	%	1%	5%	0%	

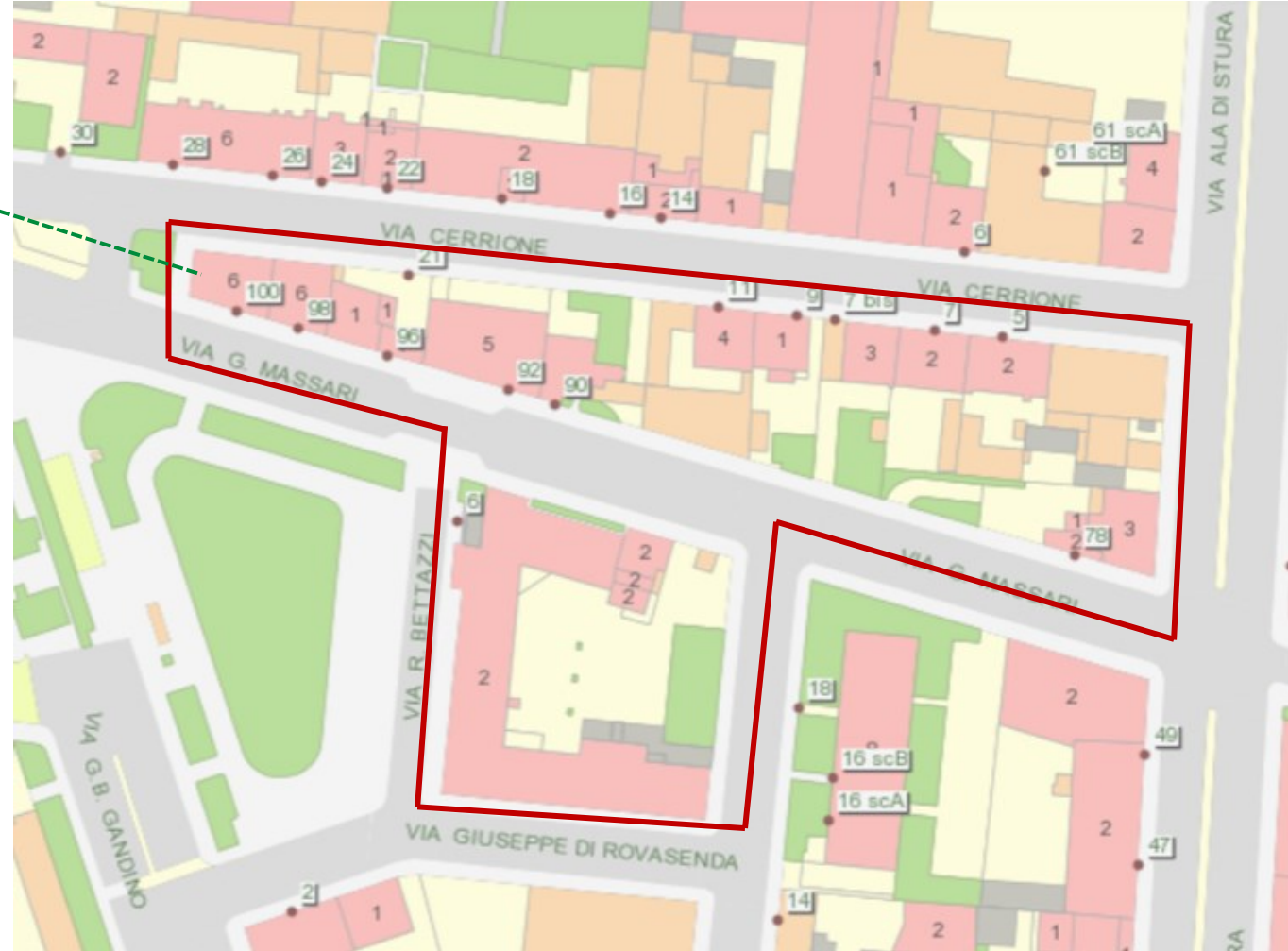
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Building stock of Turin

Informazione oggetto	
Carta Tecnica colori	
Livello	Carta Tecnica
codice_intesa	020102
gruppo	EDIFICI PRINCIPALI
descrizione generica	generica
categoria_uso	residenziale
epoca_costruzione	1946 - 1960
numero_piani	6
altezza_edificio	21.35
valenza_storica	non monumentale
nome	
fondo	
materiale	
uso	



Climatic zone E
Residential bldg.
1946-1960



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Building stock of Turin

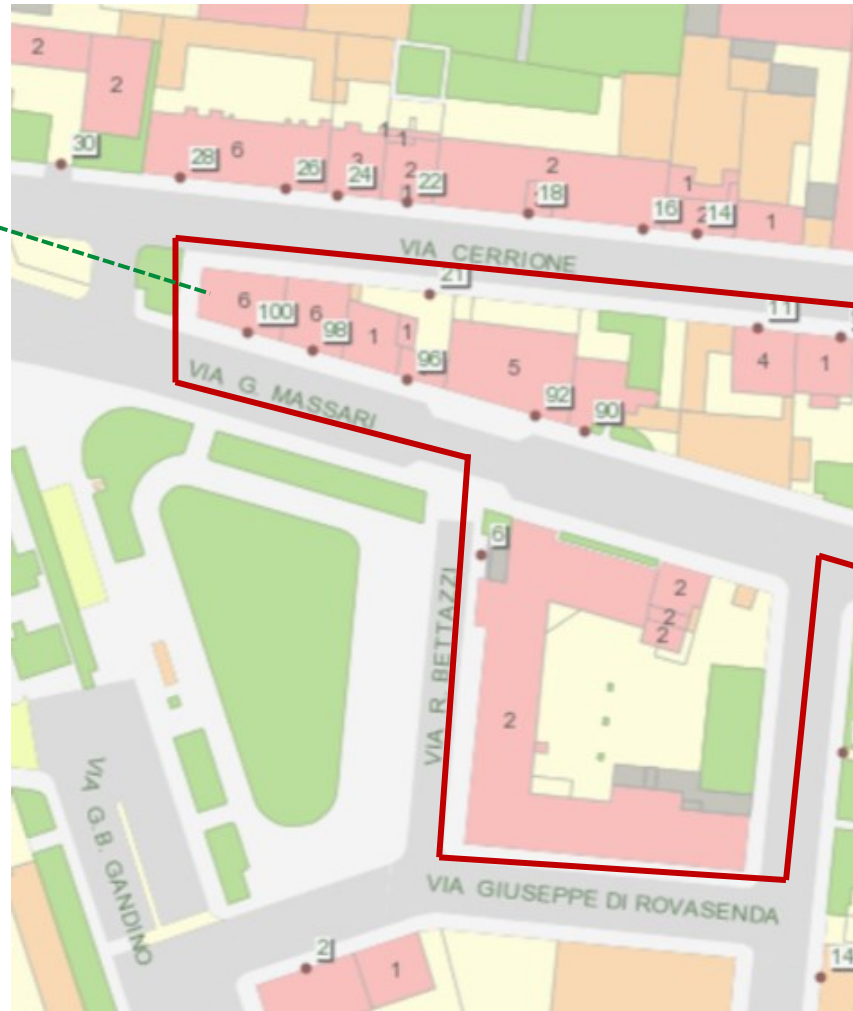
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Climatic zone E
Residential bldg.
1946-1960



E_RES_BU(AB)_CP4



PIEMONTE REGION EPC DATABASE - E_RES_BU(AB)_CP4					
Data	Symbol	Unit of measure	Median	(Q ₃ - Q ₂)	(Q ₂ - Q ₁)
Geometry					
Compactness ratio	CR	m ⁻¹	0,452	0,229	0,149
Thermally heated gross volume	V _{H;g}	m ³	254	75	58
Thermally heated floor area	A _{H;use;ztc}	m ²	65	19	15
Transparent thermal envelope area on thermal envelope area	A _{wi} /A _{env}	%	10%	5%	4%
Envelope					
Mean thermal transmittance of opaque building envelope	U _{op}	W/(m ² ·K)	1,183	0,226	0,239
Mean thermal transmittance of transparent building envelope	U _{wi}	W/(m ² ·K)	3,124	1,356	0,810
Energy carrier per space heating	Natural gas = 78%; district heating = 15%; others = 7% (of the analysed sample)				
Energy carrier per space cooling	Electricity = 99%; natural gas = 1% (of the analysed sample)				
Energy carrier per domestic hot water	Natural gas = 74%; electricity = 21%; others = 15% (of the analysed sample)				
Technical building system					
Mean seasonal efficiency of the heating generation sub-system (natural gas)	η _{H;gn}	-	0,926	0,126	0,136
Mean seasonal efficiency of the heating generation sub-system (district heating)	η _{H;gn}	-	0,960	0,040	0,263
Utilisation energy efficiency	η _{H;u}	-	0,878	0,046	0,050
Energy need for space heating	EP _{H;nd;ztc}	kWh/m ²	99,0	58,1	36,5
Energy need for space cooling	EP _{C;nd;ztc}	kWh/m ²	16,2	11,3	8,6
Energy need for domestic hot water	EP _{W;nd;ztc}	kWh/m ²	18,8	1,2	1,2
Seasonal space heating energy efficiency	η _{s;H}	-	0,720	0,070	0,110
Seasonal space cooling energy efficiency	η _{s;C}	-	1,000	0,360	0,340
Seasonal domestic hot water energy efficiency	η _{s;W}	-	0,620	0,110	0,260
Energy indicators					
Non-renewable energy performance per space heating	EP _{H;nren}	kWh/m ²	138,8	77,9	50,5
Non-renewable energy performance per space cooling	EP _{C;nren}	kWh/m ²	13,6	12,5	7,3
Non-renewable energy performance per domestic hot water	EP _{W;nren}	kWh/m ²	29,8	18,8	5,3
Overall non-renewable energy performance	EP _{gl;nren}	kWh/m ²	177,0	77,4	51,2
Overall renewable energy performance	EP _{gl;ren}	kWh/m ²	1,6	10,4	1,3
Renewable Energy Ratio	RER	%	1%	4%	1%

Source: Geoportale del Comune di Torino (geoportale.comune.torino.it).

Building stock of Turin

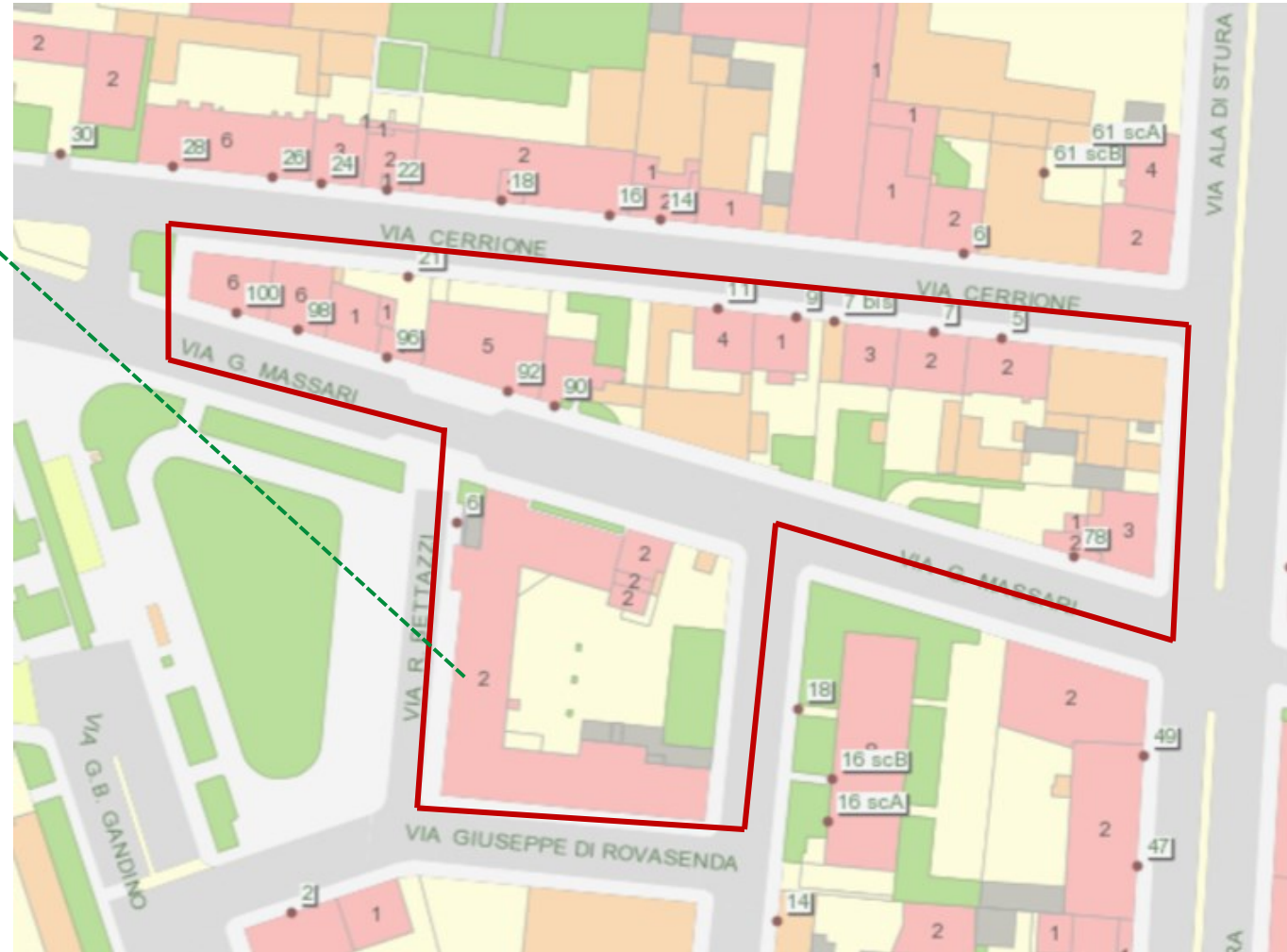
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Livello	Carta Tecnica
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gruppo	EDIFICI PRINCIPALI
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epoca_costruzione	2
numero_piani	5.17
altezza_edificio	non conosciuto
valenza_storica	SCUOLA D'INFANZIA E PRIMARIA
nome	
fondo	
materiale	
uso	



Climatic zone E
Educational bldg.
???



???



Source: Geoportale del Comune di Torino (geoportale.comune.torino.it).

Building stock of Turin

Informazione oggetto

Carta Tecnica colori

Livello

Carta Tecnica

codice_intesa 020102

gruppo EDIFICI PRINCIPALI

descrizione generica

categoria_uso **servizi - istruzione - sede di scuola**

epoca_costruzione **non conosciuto**

numero_piani 2

altezza_edificio 5.17

valenza_storica non conosciuto

nome SCUOLA D'INFANZIA E PRIMARIA

fondo

materiale

uso



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> ricerca A.P.E.

> ricerca certificatore

Guida al servizio

Contatti

Risultato ricerca A.P.E.

Un risultato trovato. pagina 1

	Codice A.P.E.	Indirizzo	Data Invio	Data Scadenza	Stato
<input type="radio"/>	2013 307558 0008	VIA RODOLFO BETTAZZI, 6 - TORINO - (TORINO)	16/03/2014	16/03/2024	Inviato

Un risultato trovato. pagina 1

[stampa report](#)

[nuova ricerca](#) [vedi sostituzioni](#)



Climatic zone E
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1965



Dettaglio A.P.E.

Descrizione	Valore
DATI ANAGRAFICI IMMOBILE	
Codice A.P.E.	2013 307558 0008
Provincia	TORINO
Comune	TORINO
Zona climatica	E
Gradi giorno	2617
Indirizzo	VIA RODOLFO BETTAZZI,6
DATI TECNICI GENERALI	
Destinazione d'uso	E7
Tipo impianto	Autonomo
Tipologia dell'edificio	
Caratteristiche dell'edificio	
Edificio pubblico o ad uso pubblico	Si
Anno costruzione	1965

Source: SIPEE Sistema Informativo Prestazione Energetica Edifici (servizi.regione.piemonte.it).

Building stock of Turin

Informazione oggetto

Carta Tecnica colori

Livello Carta Tecnica

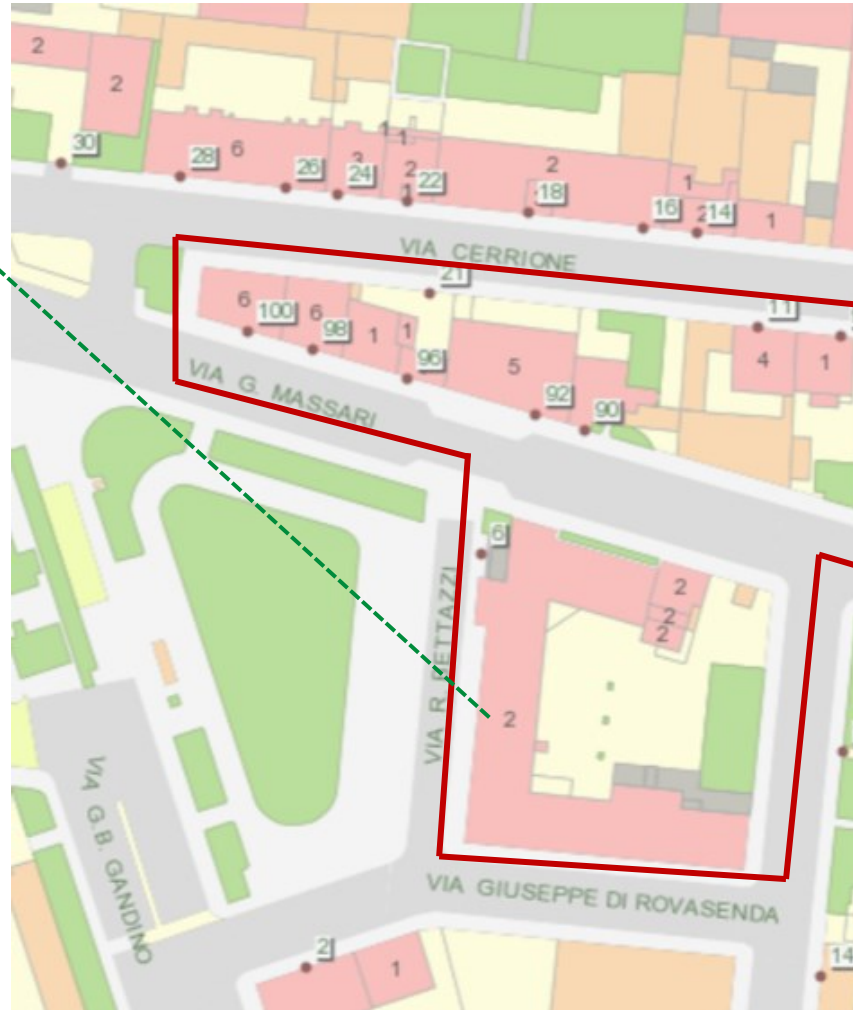
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gruppo	EDIFICI PRINCIPALI
descrizione	generica
categoria_uso	servizi - istruzione - sede di scuola
epoca_costruzione	non conosciuto
numero_piani	2
altezza_edificio	5.17
valenza_storica	non conosciuto
nome	SCUOLA D'INFANZIA E PRIMARIA
fondo	
materiale	
uso	



Climatic zone E
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1965



E_EDUC_CP5



PIEMONTE REGION EPC DATABASE - E_EDUC_CP5					
Data	Symbol	Unit of measure	Median	(Q ₃ - Q ₂)	(Q ₂ - Q ₁)
Geometry					
Compactness ratio	CR	m ⁻¹	0,451	0,119	0,060
Thermally heated gross volume	V _{H;g}	m ³	8486	5710	4495
Thermally heated floor area	A _{H;use;ztc}	m ²	1868	1294	930
Transparent thermal envelope area on thermal envelope area	A _{wi} /A _{env}	%	10%	2%	3%
Envelope					
Mean thermal transmittance of opaque building envelope	U _{op}	W/(m ² ·K)	1,072	0,244	0,296
Mean thermal transmittance of transparent building envelope	U _{wi}	W/(m ² ·K)	3,219	1,043	1,261
Energy carrier per space heating	Natural gas = 79%; district heating = 14%; others = 7% (of the analysed sample)				
Energy carrier per space cooling	Electricity = 98%; district cooling = 2% (of the analysed sample)				
Energy carrier per domestic hot water	Electricity = 48%; natural gas = 44%; others = 8% (of the analysed sample)				
Technical building system					
Mean seasonal efficiency of the heating generation sub-system (natural gas)	η _{H;gn}	-	1,000	4,930	0,123
Mean seasonal efficiency of the heating generation sub-system (district heating)	η _{H;gn}	-	0,980	2,763	0,022
Utilisation energy efficiency	η _{H;u}	-	0,802	0,079	0,802
Energy need for space heating	EP _{H;nd;ztc}	kWh/m ²	168,9	45,9	36,9
Energy need for space cooling	EP _{C;nd;ztc}	kWh/m ²	4,6	19,0	4,0
Energy need for domestic hot water	EP _{W;nd;ztc}	kWh/m ²	0,4	2,1	0,1
Seasonal space heating energy efficiency	η _{S;H}	-	0,760	0,070	0,100
Seasonal space cooling energy efficiency	η _{S;C}	-	0,875	0,235	0,293
Seasonal domestic hot water energy efficiency	η _{S;W}	-	0,290	0,133	0,000
Energy indicators					
Non-renewable energy performance per space heating	EP _{H;nren}	kWh/m ²	232,3	59,7	73,4
Non-renewable energy performance per space cooling	EP _{C;nren}	kWh/m ²	18,5	0,9	17,9
Non-renewable energy performance per domestic hot water	EP _{W;nren}	kWh/m ²	1,2	4,0	0,6
Overall non-renewable energy performance	EP _{gl;nren}	kWh/m ²	258,8	68,7	60,7
Overall renewable energy performance	EP _{gl;ren}	kWh/m ²	9,4	5,4	2,8
Renewable Energy Ratio	RER	%	4%	2%	1%

Source: Geoportale del Comune di Torino (geoportale.comune.torino.it).

Pros

- **Enhance the quality of representation** of the private and public real estate.
- **Benchmarks** to define the energy and environmental performance *status* of the building stock.
- BAs as a support tool to monitor **national** or **regional energy renovation programs**.

Cons

- The **EPC** is an energy-related document considered **technically poor** with **limited data**.
- The BAs have been **entirely created** from EPCs.
- The only use of BA schemas is **not sufficient** to cover the **UBEM data picture**. Therefore, information from local, regional, and national databases is required.

Conclusion

- A **robust methodology** to assess and exploit the EPC data to be used at large-scale analysis have been defined.
- The **TIMEPAC objective** is to generate the enhanced EPC that will improve the **reliability** of the **building archetype**.
- The overview of the national building stock for different building types will play a crucial role for the **national building renovation plan** development.

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

Thanks for your attention!

