IEEE CANDO EPE 2020
3rd International IEEE Conference AND workshop in Óbuda on Electrical and Power Engineering

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Dipartimento Energia "Galileo Ferraris"

Place-based atlas for energy communities using energy performance certificates database

Authors:

Mutani, Guglielmina
Beltramino, Simone
Schiavone, Matteopaolo

November 18-19, 2020

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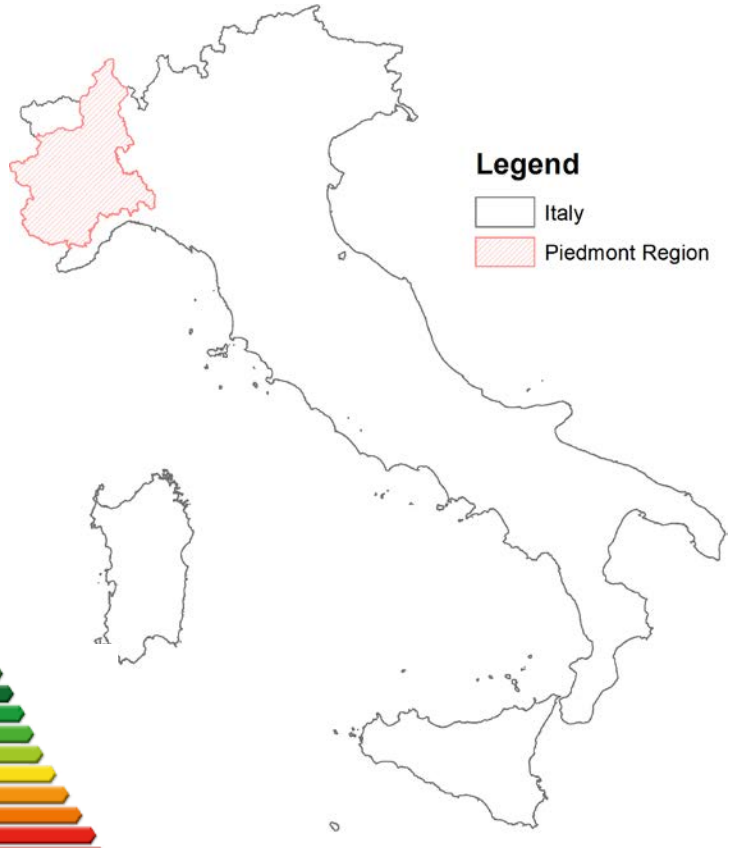
Aim of the work

- Definition of a **place-based methodology** to evaluate the energy performance and energy saving potential of the buildings heritage in different areas in a territory. The **Piedmont Region** (in N-W Italy) was taken as reference.

- Possible **benefits** coming from buildings'' **retrofit interventions**, **RES** installations, and **aggregation** of consumers and prosumers, could be evaluate giving the Atlas tool, based on integration of various public database.



Istat
Istituto Nazionale di Statistica

GEO Portale Piemonte
Commercio

APE
Attestato Prestazione Energetica

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Introduction

- **Italy** aims to reach a high share of clean technologies by 2030-50 (**Integrated National Energy and Climate Plan**) by promoting clean energy production and self-consumption, following the **EU Directives** (**2019/944** & **2001/2018**). The **Piedmont Region** promotes clean energy planning by supporting the economic and social growth of its territory. With the first regional law in Italy, the Piedmont region promotes the constitution of energy communities: **L.R. 12/2018** "Promotion of the institution of energy communities".
- To identify the potential for energy saving, linked to the characteristics of the building stock, the **EPCs database** was investigated. I
- The representation with maps of the place-based approach, provides information to stakeholders that want to join an energy community, about reducing their consumptions and emissions, or better, enhancing their self-consumption.

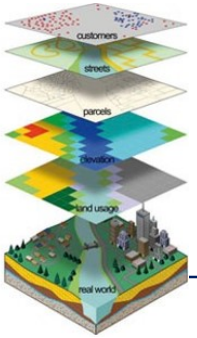
European Union Directives (2019/944 & 2001/2018)

Integrated National Energy and Climate Plan (PNIEC)

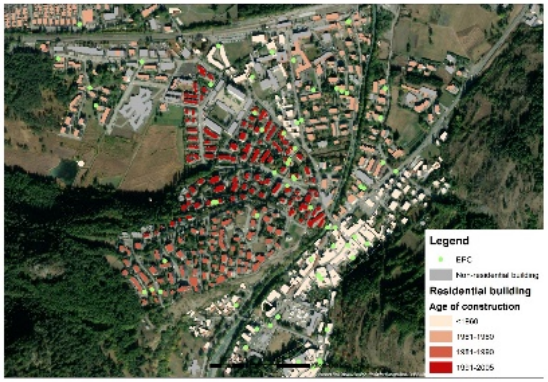
L.R. 12/2018

Database

GIS tool



Atlas



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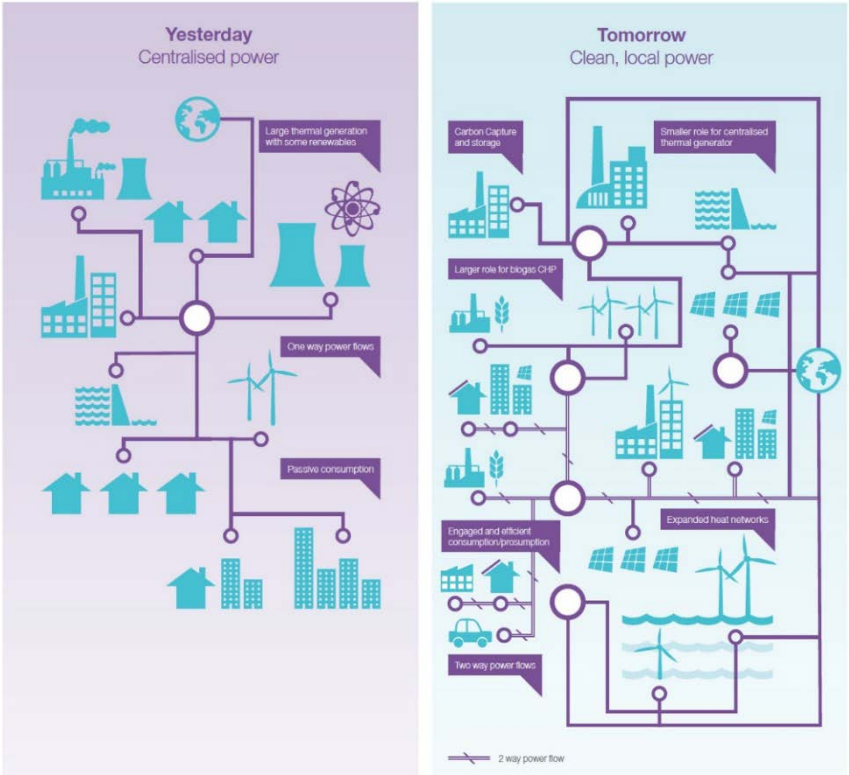
Energy Community

- Energy communities are defined as the **union of different users** (*consumers, producers and prosumers*), located in homogeneous areas, cooperating in order to enhance the **self-produced** and **self-consumed energy** from the renewable sources available locally.
- It is an innovative energy supply, distribution and consumption model on a territorial scale, which pursues the objectives of **self-sufficiency** and **energy efficiency**, as well as economic saving, sustainability of resources, and good governance of the territory.



(Realising Transition Pathways, 2015)

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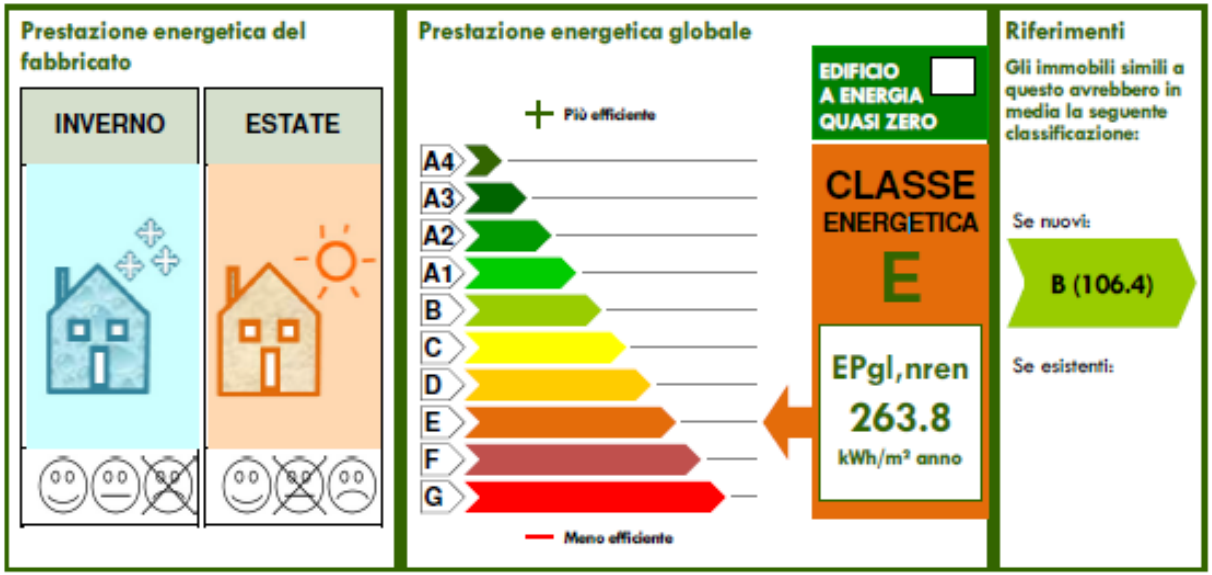
Energy Performance Certificates - EPC

- EPC (or in Italian: APE, *Attestato di Prestazione Energetica*) describes the **energy characteristics of buildings**. They are a **standardised document** throughout Italy and provide also information about the achievable energy saving and low carbon emission results, giving possible suggestions from the certifier. The output information are the **energetic class** and the **primary energy demand** per square meter of useful surface per year.
- The EPCs database referred to **residential buildings** issued between October **2015** and April **2019** was used.



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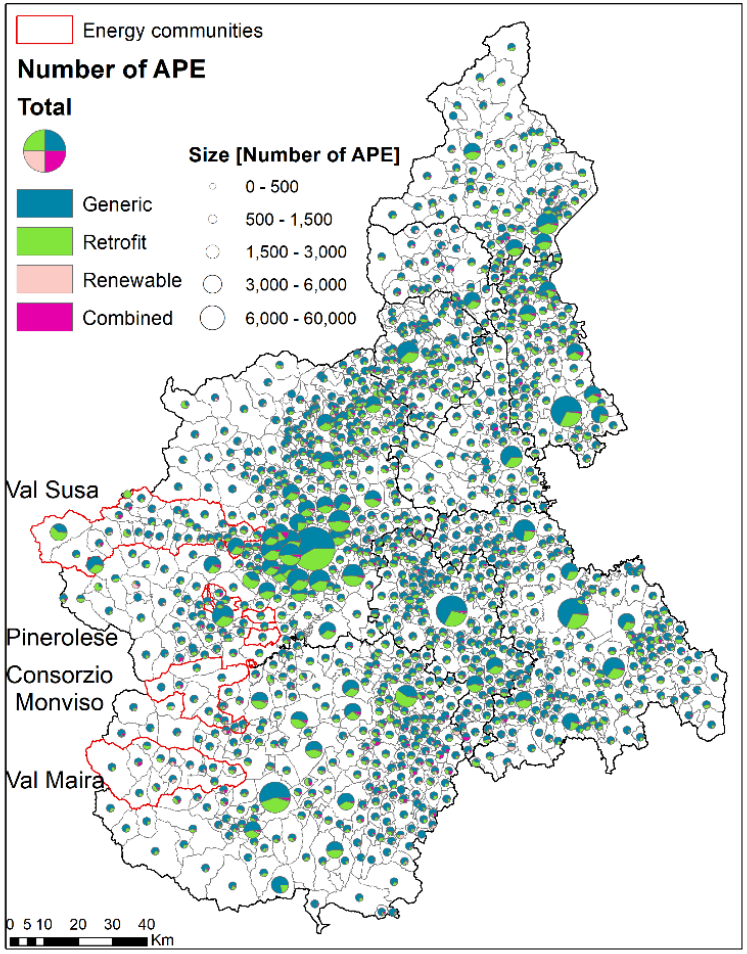
EPCs Key Aspects (1)

- Used parameters reported inside an EPC:
  - **building's characteristics** (type of users, useful surface, building's typology, number of residential units, …);
  - **age of construction** of the building;
  - mean **thermal transmittance** for the **opaque** (Uop) and the **transparent envelope** (Utr);
  - **annual non-renewable primary energy use** (Epgl,nren);
  - **generation system description** (type and supply fuel);
  - **generation system's power** (Pg) and **efficiency** (Etag);
  - **motivation of release**;
  - HDD**, heating degrees day**;
  - S/V: **surface to volume ratio**;
  - **geographical coordinates** and/or **address**.
- From the last point, it is possible to see that the **territorial** distribution is not homogenous.

NUMBER OF EPCs PER MOTIVATION OF RELEASE



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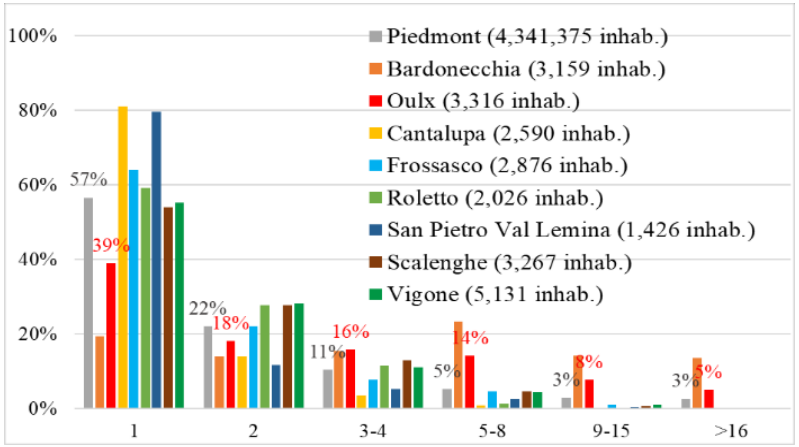
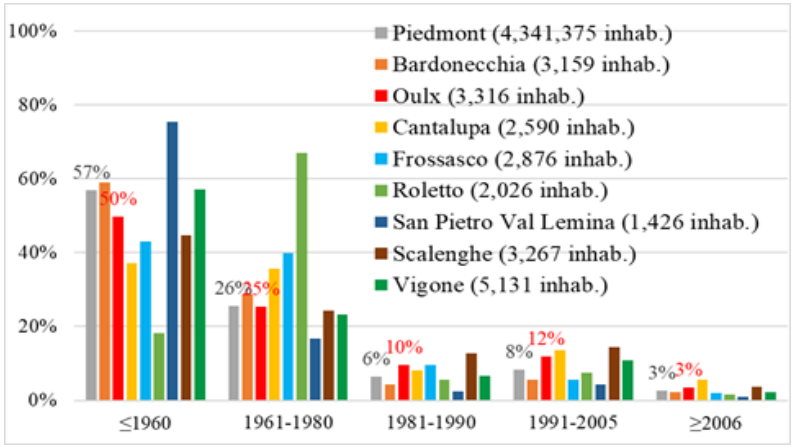
Building Archetypes

- A more specific analysis of the residential building stock on the municipalities of energy communities was focused on the **recurring building typologies** in the municipalities of the Piedmont Region and in the ECs.
- For this analysis two main parameters were used: the **number of dwellings** per building and the **period of construction**.
- Distributions are shifted towards **Detached House** (with 1 or 2 r.u.) and for a period of construction before **1960** for all the municipalities.

PERCENTAGE DISTRIBUTION OF BUILDINGS PER NUMBER OF RESIDENTIAL UNITS



PERCENTAGE DISTRIBUTION OF BUILDING PER PERIOD OF CONSTRUCTION



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Case study: Energy Communities of the Piedmont Region

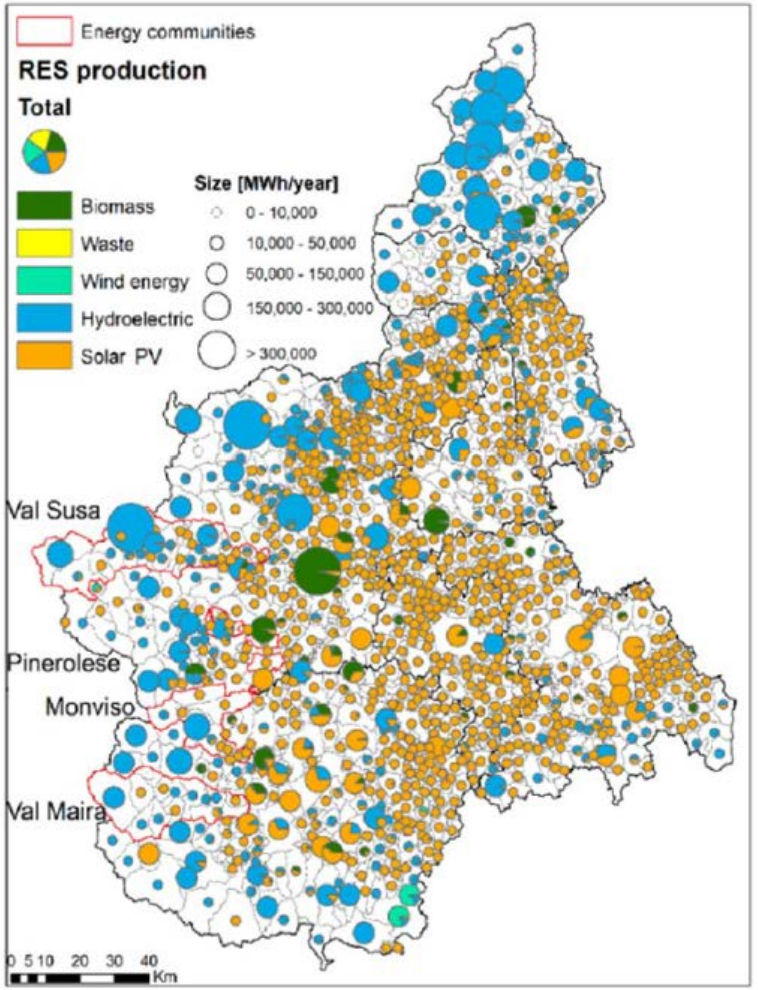
- The new **ECs** born as a result of the Regional Law 12/2018 on the promotion of the establishment of ECs are: **Pinerolese**, **Susa Valley**, **Monviso** and **Maira Valley**.

Territorial characteristics:

- The **Pinerolese EC** is made up of 6 municipalities and extends over an area of 126 km^2 in a plain-hilly territory and has a total population of about 17,316 inhabitants.
- The **Susa Valley EC** is made up of a total of 31 municipalities, covers a large plain-hilly-mountainous area of 832 km^2 and has a total population of about 73,593 inhabitants.
- The **Maira Valley EC** is made up of 13 municipalities over an area of 567 km^2 in the mountains and has a total population of about 11,450 inhabitants.
- The **Monviso EC** is made up of 10 municipalities over a hilly-mountainous area of 347 km^2 and have a total population of about 20,491 inhabitants.

ECs	N. municipalities	Area [km^2]	Inhabitants
Pinerolese	6	126	17,316
Susa Valley	31	832	73,593
Maira Valley	13	567	11,450
Monviso	10	347	20,491
Piedmont Region	1,181	23,387	4,341,375

RES SYSTEM PER TYPOLOGY



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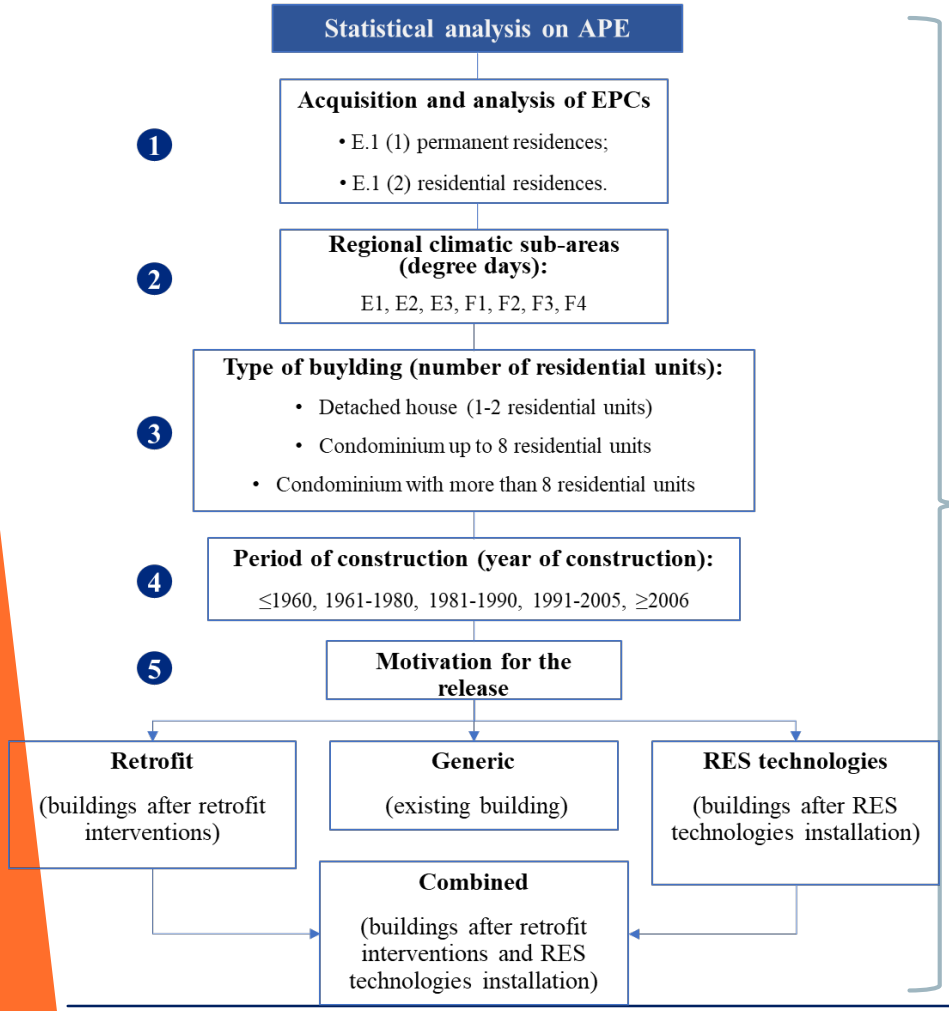
Methodology (1)

FLOW CHART



NUMBER OF EPCS DIVIDED BY CLIMATE SUB-ZONES AND BUILDING TYPOLOGY

	Climate sub-zones						
Type of building	**E1**	**E2**	**E3**	**F1**	**F2**	**F3**	**F4**
Detached House 1 r.u.	3,740	29,704	20,065	7,626	1,604	437	262
Detached House 2 r.u.	851	6,338	5,505	2,093	400	99	40
Detached House 3-4 r.u.	1,441	10,837	6,577	2,499	473	179	87
Terrace Houses 5-8 r.u..	1,674	19,352	6,664	2,359	418	139	152
Condominiums 9-15 r.u.	1,640	22,660	5,728	1,858	284	174	174
Condominiums ≥ 16 r.u.	2,069	45,854	8,033	3,300	673	336	820

NUMBER OF EPCS DIVIDED BY CLIMATE SUB-ZONES AND BUILDING TYPOLOGY

Number of EPCs	**Generic**	**Retrofit**	**RES**	**Combined**	**Total n. EPCs**
Susa Valley	2,778 74.6%	641 17.2%	136 3.7%	167 4.5%	3,722
Pinerolese	419 56.9%	240 32.6%	20 2.7%	57 7.7%	736
Maira Valley	488 59.7%	212 25.9%	60 7.3%	58 7.1%	818
Monviso	757 66.8%	265 23.4%	62 5.5%	50 4.4%	1,134
Piedmont Region	138,817 59.9%	81,791 35.3%	4,213 1.8%	7,028 3.0%	231,849

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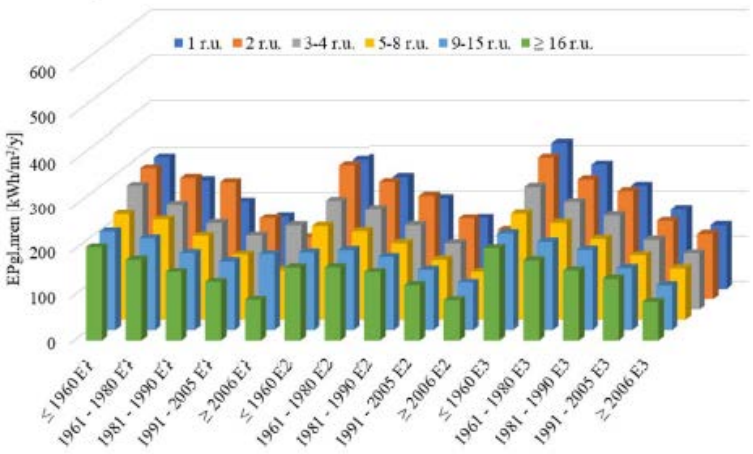
Methodology (2)

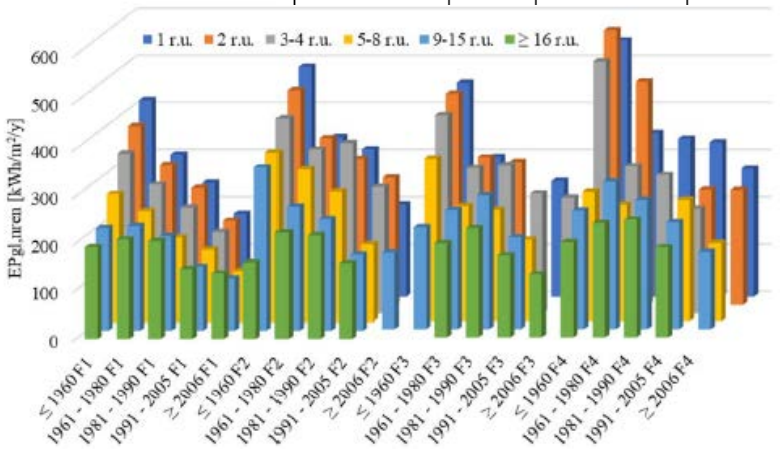
Main reasons for the classification of the EPCs:

- **Age of Construction**: different Italian laws, throughout the years, define the minimum constraints for new buildings characteristics.
- **Type of building**: compactness level influences the energy consumption and the achievable energy saving.
- **Climate sub-zones**: more rigid climate areas require an higher thermal energy supply.

Type of Building	EPCs %	Period of construction	U_{op} [W/m²/K]	U_{tr} [W/m²/K]	P_g [kW]	η_g [.]
Detached House 1 r.u.	4.9%	< 1919	1.4	4.0	24	0.80
	3.6%	1919 – 1945	1.4	3.7	24	0.83
	2.1%	1946 – 1960	1.3	3.5	24	0.85
	5.9%	1961 – 1980	1.2	3.2	25	0.85
	1.2%	1981 – 1990	1.1	3.0	25	0.85
	1.8%	1991 – 2005	0.8	2.8	25	0.85
	0.7%	≥ 2006	0.6	2.6	24	0.86
Detached House 2 r.u.	1.0%	< 1919	1.4	3.9	24	0.81
	0.7%	1919 – 1945	1.4	3.5	24	0.84
	0.5%	1946 – 1960	1.3	3.2	25	0.84
	1.7%	1961 – 1980	1.2	3.2	26	0.84
	0.3%	1981 – 1990	1.1	2.9	26	0.84
	0.3%	1991 – 2005	0.8	2.7	26	0.85
	0.1%	≥ 2006	0.6	2.6	25	0.85
Detached House 3-4 r.u.	1.7%	< 1919	1.4	3.5	24	0.84
	1.1%	1919 – 1945	1.3	3.4	24	0.84
	0.7%	1946 – 1960	1.3	3.2	24	0.87
	2.5%	1961 – 1980	1.2	3.2	24	0.85
	0.4%	1981 – 1990	1.1	2.9	24	0.83
	0.6%	1991 – 2005	0.8	2.8	24	0.83
	0.2%	≥ 2006	0.7	2.6	24	0.84
Terrace House 5-8 r.u.	1.6%	< 1919	1.3	3.2	24	0.86
	1.4%	1919 – 1945	1.3	3.3	24	0.87
	1.2%	1946 – 1960	1.3	3.5	24	0.89
	3.9%	1961 – 1980	1.2	3.4	24	0.86
	0.6%	1981 – 1990	1.1	3.0	24	0.83

GENERIC $EP_{GL,nren}$





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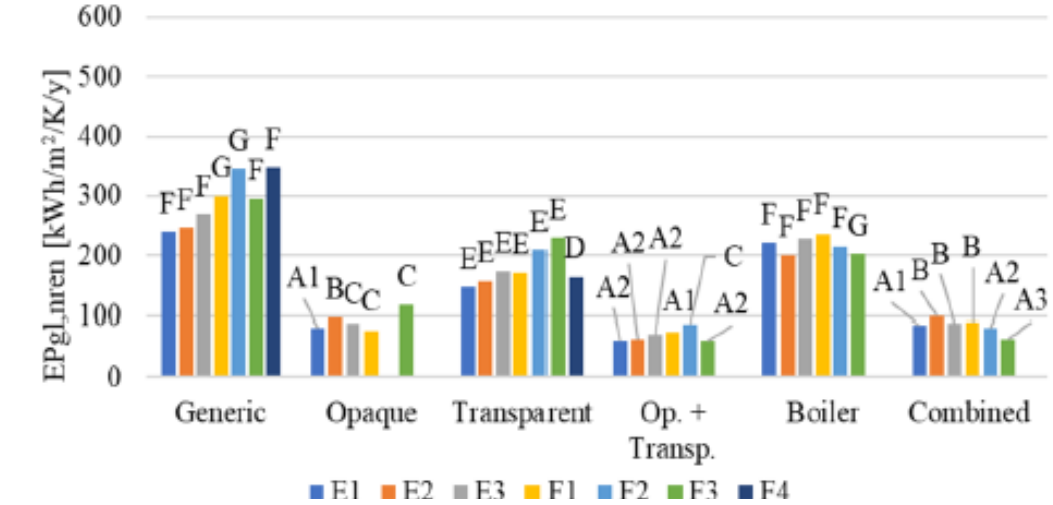
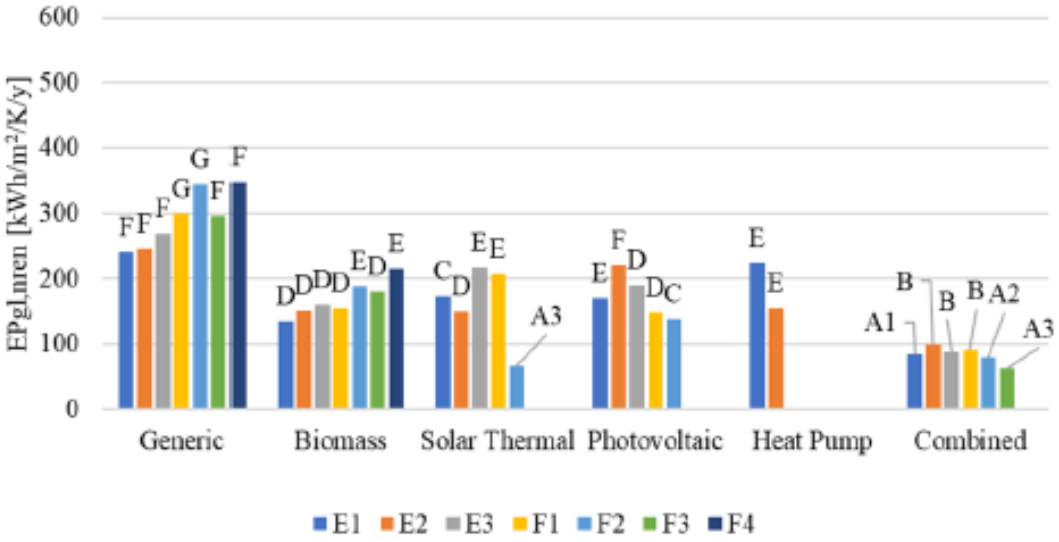
Results (1)



DETACHED HOUSE 1-2 r.u. 1961 – 1980
RETROFIT INTERVENTIONS



DETACHED HOUSE 1-2 r.u. 1961 – 1980
RES TECHNOLOGIES

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Results (2)

- **Energy savings**: defined as the **relative percentage** between the primary energy consumption of the **Generic building archetypes** and the primary energy consumption of the same archetypes but **refurbished** (Retrofit or RES).
- The **achievable** energy savings are based on the certifier's **suggestions**. They define the energy saving **potentials**, but they are evaluated and not referred to real interventions. They only tell us that there is still room to increase the energy efficiency.

Average Energy savings Detached house 1-2 r.u.

Type of Retrofit	≤ 1960	1961-80	1981-90	1991-05	≥ 2006
Opaque	73%	65%	63%	51%	46%
Transparent	49%	38%	33%	20%	24%
Op. + Transp.	81%	75%	56%	58%	53%
Boiler	24%	22%	22%	29%	30%
Combined	74%	69%	48%	47%	55%
Achievable Retrofit	*64%*	*56%*	*44%*	*34%*	*42%*

Average Energy savings Apartments Block ≤ 8 r.u.

Type of Retrofit	≤ 1960	1961-80	1981-90	1991-05	≥ 2006
Opaque	68%	60%	63%	51%	35%
Transparent	41%	31%	19%	27%	30%
Op. + Transp.	74%	73%	48%	38%	53%
Boiler	25%	25%	13%	25%	15%
Combined	70%	54%	43%	57%	54%
Achievable Retrofit	*59%*	*50%*	*35%*	*38%*	*51%*

Average Energy savings Apartments Block > 8 r.u.

Type of Retrofit	≤ 1960	1961-80	1981-90	1991-05	≥ 2006
Opaque	45%	31%	32%	37%	48%
Transparent	23%	22%	22%	21%	37%
Op. + Transp.	64%	58%	63%	46%	54%
Boiler	23%	13%	23%	23%	35%
Combined	58%	59%	43%	74%	54%
Achievable Retrofit	*42%*	*37%*	*37%*	*29%*	*51%*

Average Energy savings Detached house 1-2 r.u.

Type of RES	≤ 1960	1961-80	1981-90	1991-05	≥ 2006
Biomass	47%	42%	33%	19%	41%
Solar Thermal	57%	40%	37%	27%	28%
Photovoltaic	57%	36%	35%	26%	43%
Heat Pump	45%	22%	38%	21%	42%
Combined	74%	69%	48%	47%	55%

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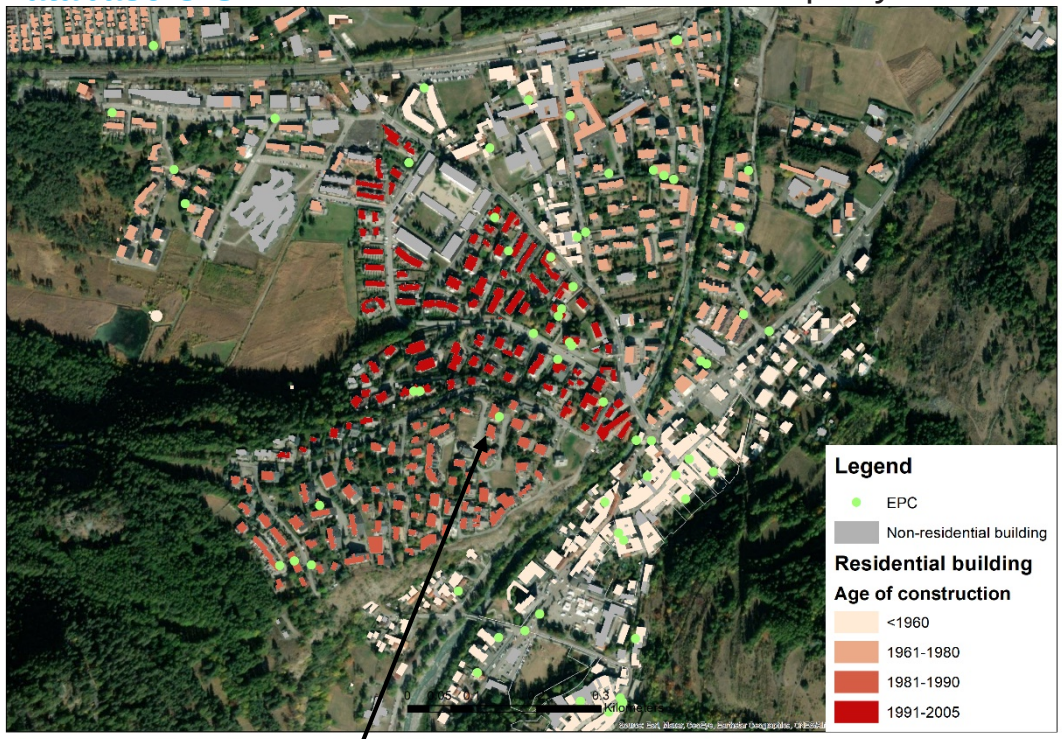
Application (1)

- **Peer effect**: using this Atlas a citizen can evaluate its energy **performance** and search for possible **real solutions** in its nearby. In this way, we can **entice** peoples to perform retrofits and RES installation on their buildings, pursuing the PNIEC goals.

Database GIS

Municipality of Oulx



Database EPCs

EPgl nren reachable [kWh/m²/a]	EPgl nren [kWh/m²/a]	EPgl ren [kWh/m²/a]	Uop [W/m²/K]	Utr [W/m²/K]	Supply Fuel	Generation System type	Year of installation
161.92	666.15	1.26	1.73	3.34	Natural gas	Boiler	1990

Age of construction	Climatic zone	Dispersing surface [m²]	Heated surface [m²]	Building typology	Motivation for the release	EPC's Class	Achievable EPC's Class
1960-1980	F1	334.6	80	Detached House	Change of ownership	G	C

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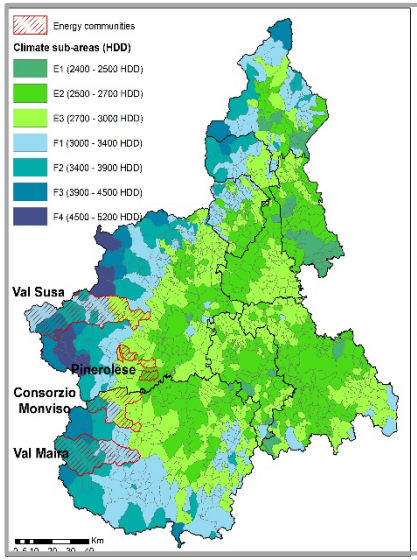
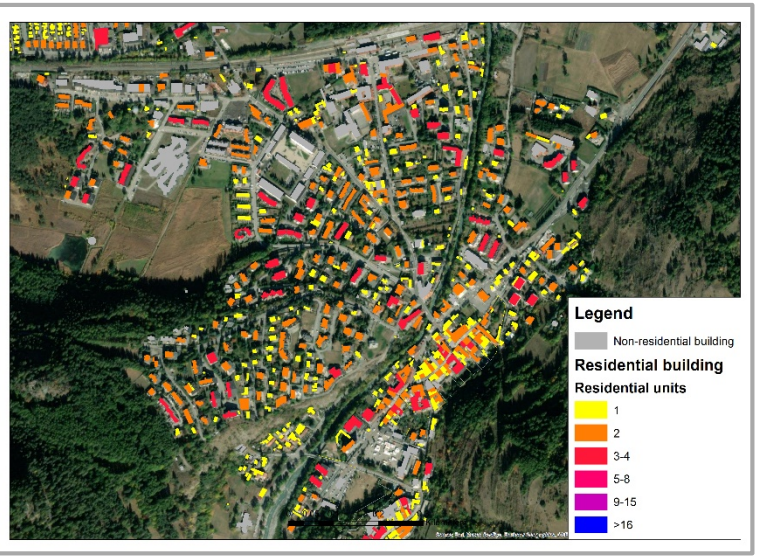
Application (2)

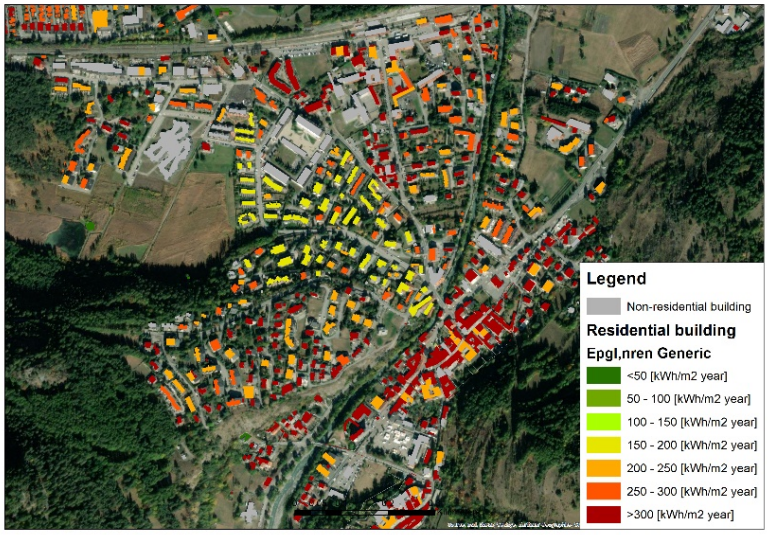
Territorial characteristics

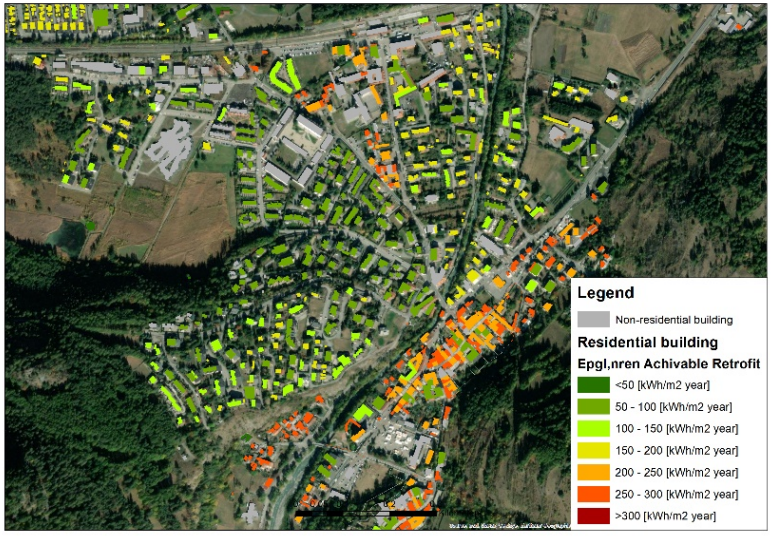




Municipality of Oulx

Energy performance





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Conclusions

- It is not possible to define a type of retrofit intervention or RES system suitable for all territories; their effects can vary according to the **territory**, **climate** and type and entity of the **building stock**. However, the place-based methodology presented allows to be **flexible** and **continuously updated** to evaluate the actual effect of energy retrofit measures and of the use of RES systems.
- Hence, supporting tool for **decision makers** and to identify effective territorial plans (orienting incentives' strategies, supporting the **consumers/prosumers aggregation**, and defining the best refurbishment giving the building's category) can be established
- Furthermore, this methodology is useful to evaluate the best practices to achieve the **PNIEC goals**, and also the actual grade of **achievement** that has already been done.
- **Future research field**:
  - Create a WebGIS tool to make information open
  - Methodology applied on non-residential buildings
  - Methodology as a support for an effective energy community