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GREENChainSAW4Life

Project n° LIFE18 CCM/IT/001193

"GREEN energy and smart forest supply CHAIN as driverS for A mountain action plan toWards climate change"

Deliverable number DL.C3.2

Report on energy consumption, an overview of best available technology for small scale renewable energy production and funding guidelines

Action Number and Title	C3 Resources Consumption Model and Carbon Fluxes Baseline
Task	C3.1. Inventory and mapping of energy consumption C3.2. Business analysis
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Abstract

This deliverable is a final report of the activities performed within the task C3.1 (Inventory and mapping of energy consumption) and task C3.2 (Business analysis for a renewable energy action plan, analysis of technologies for the production of renewable energy from biomass and waste management).

The deliverable is divided into 3 parts. The section 1 contains a dataset and report of the of all the general, economic and technical data collected from the project area. The section 2 focused on the evaluation of the technical-economic sustainability of the replacement of fossil fuel plants with plants on local renewable biomass, analysing real case studies in the area. The last part summarizes all the forms of incentives present for energy efficiency and the possibilities and constraints of use.

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TABLE OF CONTENTS

1. INTRODUCTION 6
1.1. OBJECTIVES AND SCOPE OF THE DOCUMENT 6
1.2. STRUCTURE OF THE DELIVERABLE 6
1.3. GREENCHAINSAW4LIFE AREA (GC AREA) 7
2. REPORT OF DATA COLLECTION (TASK 3.1) 11
2.1. OBJECTIVES AND METHODOLOGY 11
2.2. ENERGY TOOL APP 13
2.3. SOCIAL AND ECONOMIC DATA 17
2.3.1. METHODOLOGY AND SOURCES 17
2.3.2. SOCIAL AND ECONOMIC DATA RESULTS 20
2.3.3. DATA ANALYSY 22
2.4. ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS DATA IN THE BUILDING SECTOR 25
2.4.1. GENERAL METHODOLOGY 25
2.4.2. METHODOLOGY FOR CALCULATING GREENHOUSE GAS EMISSIONS 25
2.4.3. RENEWABLE ENERGY PRODUCTION 28
2.4.4. ELECTRIC ENERGY CONSUMPTION AND EMISSIONS 31
2.4.4.1. DATA RESULTS 33
2.4.5. HVAC ENERGY CONSUMPTION AND EMISSIONS 35
2.4.5.1. DATA RESULTS 38
2.5. ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS DATA IN TRANSPORT SECTOR 45
2.5.1. METHODOLOGY AND SOURCES 45
2.5.2. DATA INPUT 47
2.5.3. DATA CALCULATION AND RESULTS 49
2.6. FINAL GC AREA RESULTS and analysys 55
3. FUNDING GUIDELINES (TASK 3.2) 59
3.1. METHODOLOGY AND SOURCES 59
3.2. KNOWLEDGE OF INCENTIVES 60
3.3. SUPERBONUS 110% 60

3.4. ECOBONUS 50% & 65% 63
3.5. CONTO TERMICO 67
3.6. CERTIFICATI BIANCHI 72
3.7. CAR = COGENERAZIONE AD ALTO RENDIMENTO 73
3.8. TABLE OF THE INCENTIVES 74
4. BUSINESS CASES ANALYSIS OF RENEWABLE ENERGY PRODUCTION TECHNOLOGIES (TASK 3.2) 81
4.1. METHODOLOGY AND SOURCES 81
4.2. RENEWABLE ENERGY PRODUCTION TECHNOLOGIES 83
4.2.1. CURRENT DISTRIBUTION OF BIOMASS TECHNOLOGIES 83
4.2.2. TECHNOLOGY ANALYSIS SUMMARY 84
4.2.3. WOOD PELLET CONDENSATION BOILER 85
4.2.4. WOOD CHIPS BOILER 86
4.2.5. WOOD CHIPS COGENERATION SYSTEM 88
4.2.6. OMNIVOROUS GREENPLASMA PYROLYSER 89
4.2.7. TECHNOLOGY ANALYSIS EVALUATION 92
4.3. BUSINESS CASES TECHNICAL-ECONOMIC ANALYSIS 94
4.3.1. BUSINESS CASES SELECTION 94
4.3.2. WORKPHASES 95
4.4. NANOSCALE: OSTANA 96
4.4.1. GENERAL DESCRIPTION 96
4.4.2. SITE AUDIT 97
4.4.3. INTERVENTION FOR ENERGY EFFICIENCY 98
4.4.4. ENERGY SIMULATION 99
4.4.5. FUNDING ANALYSIS AND SOCIO-ECONOMIC EVALUATION 102
4.5. MICROSCALE: PAESANA 104
4.5.1. GENERAL DESCRIPTION 104
4.5.2. SITE AUDIT 105
4.5.3. INTERVENTION FOR ENERGY EFFICIENCY 105
4.5.4. ENERGY SIMULATION 106
4.5.5. FUNDING ANALYSIS AND SOCIO-ECONOMIC EVALUATION 108
4.6. SMALL SCALE: BAGNOLO PIEMONTE RENEWABLE ENERGY COMMUNITY 110

4.6.1. ENERGY COMMUNITY 110
4.6.2. GENERAL DESCRIPTION - Renewable Energy Community 111
4.6.3. SITE AUDIT 112
4.6.4. INTERVENTION FOR ENERGY EFFICIENCY 116
4.6.5. ENERGY SIMULATION 120
4.6.6. FUNDING ANALYSIS AND ECONOMIC EVALUATION 124
4.6.7. SOCIAL EVALUATION 127
4.7. RESULTS AND FINAL EVALUATION 128
4.7.1. KPI BUSINESS CASES RESULTS 128
4.7.2. LIFE TERRITORY SIMULATION SCENARIO 130
5. CONCLUSIONS AND NEXT ACTIONS 134
5.1. CONCLUSIONS 134
5.2. NEXT ACTIONS 135
6. ANNEX 136

1. INTRODUCTION

1.1. OBJECTIVES AND SCOPE OF THE DOCUMENT

This deliverable is a final report of the activities performed within the task C3.1 (Inventory and mapping of energy consumption) and task C3.2 (Business analysis for a renewable energy action plan, analysis of technologies to produce renewable energy from biomass and waste management).
The main objectives of this deliverable are:

- collect and archive the general and economic data of the area relating to the territory and the building and plant heritage;
- collect and archive in a dataset the energy consumption and emissions within the GC Area deriving from the private and public buildings, lighting and transport sectors;
- create a simple guide of all the incentives present at a regional and national level for plant efficiency interventions.
- carry out a technical-economic analysis of the main biomass technologies for the production of thermal and electrical energy, simulating their applications to case studies of the territory;

The deliverable data results will be used also as a starting point for the drafting of the DSS platform (DLC4.1) and for the realization of the territorial PAESC (DL C4.2). The data are also used to define the community energy balance for the newborn “Monviso Energy Community” that is developing thanks to the GreenChainSaw4Life project.

1.2. STRUCTURE OF THE DELIVERABLE

The deliverable is divided into 3 parts:

- **REPORT OF DATA COLLECTION:** The section 1 contains a dataset of the of all the general, economic and technical data collected and analysed during the task C3.1 - INVENTORY AND MAPPING OF ENERGY CONSUMPTION.
- **BUSINESS CASES ANALYSIS OF RENEWABLE ENERGY PRODUCTION TECHNOLOGIES:** The section 2 focused on the evaluation of the technical-economic sustainability of the replacement of fossil fuel plants with plants on local renewable biomass, analysing real case studies in the area. This task is a final report of the results deriving from the task C3.2.
- **FUNDING GUIDELINES:** The last part summarizes all the forms of incentives present for energy efficiency and the possibilities and constraints of use. This task is a final report of the results deriving from the task C3.2.

1.3. GREENCHAINSAW4LIFE AREA (GC AREA)

The deliverable collects and processes all the data deriving from the analysis of the project territory defined “GCArea”.

The Area of the project includes 14 municipalities located in the province of Cuneo belonging to the Unione Monviso and the Unione Barge e Bagnolo.

The territory under examination is located in the plexus of the Alpi Cozie, at the northern limit of the Province of Cuneo. It borders to the south with the Val Varaita, to the west with France, to the north with the Val Pellice in the province of Turin and to the east with the Po plain in the stretch between Saluzzo and Cavour.

It is a territory that is mostly mountainous even if the municipalities of Barge and Bagnolo include a strip of plain territory, therefore excluded from the limits of administrative competence of the Mountain community but included in the GC Area.

The territory of the Forest Area amounts to has 28209 inhabitants and a total area of 479 km^2. The average altitude is around 651 m a.s.l.

The area is strongly characterized by the agricultural sector and, in particular, by the cultivation of fruit (apples) and, secondly, by breeding. The second important activity is the traditional manufacturing industry (paper mills, furniture district).

Woodworking to produce furniture is the sector in which there is the greatest specialization, and we can speak of a real wood district.

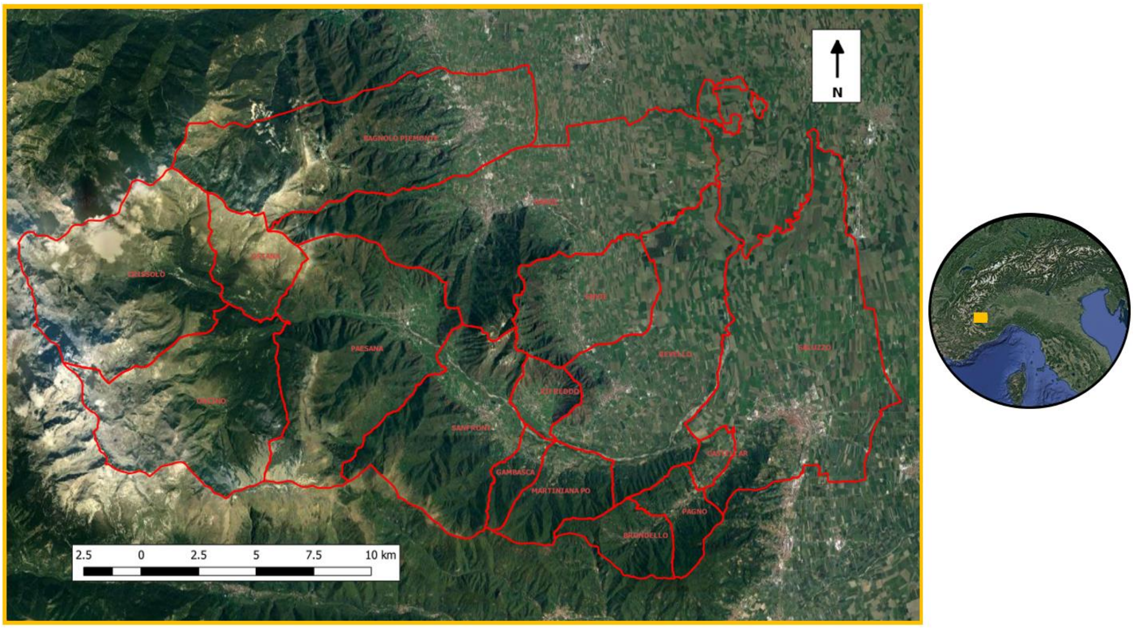


Figure 1 GC area

The general data, obtained from the ISTAT site, relating to the GC area were then inserted into a GIS in order to produce specific maps and graphs with the main information, in particular:

- Morphology
- Degree days
- Distribution of buildings according to the year of construction
- Outside temperature trend

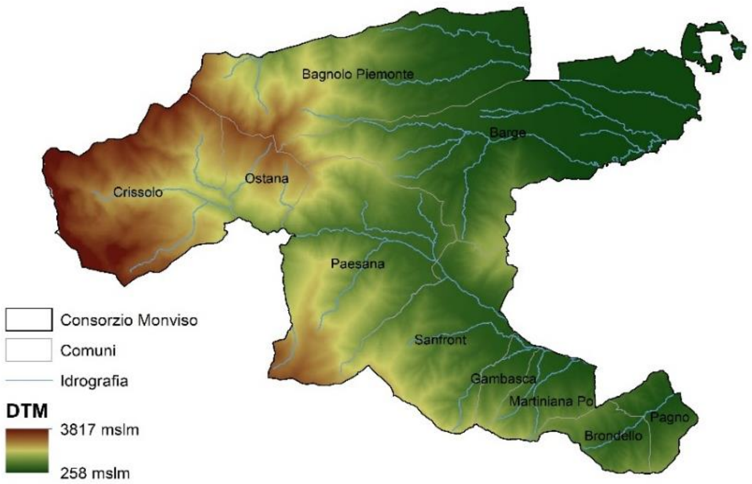


Figure 2 Territory Morphology

By accessing the Arpa Piemonte databases it was possible to evaluate the climate scenario of the Valley.

The Arpa monitoring stations are located in three points of the valley: in Barge, Crissolo Po and Paesana. From the analysis of the degree days, the area is mainly below class E, except for three municipalities such as Ostana, Paesana and Crissolo which are in class F.

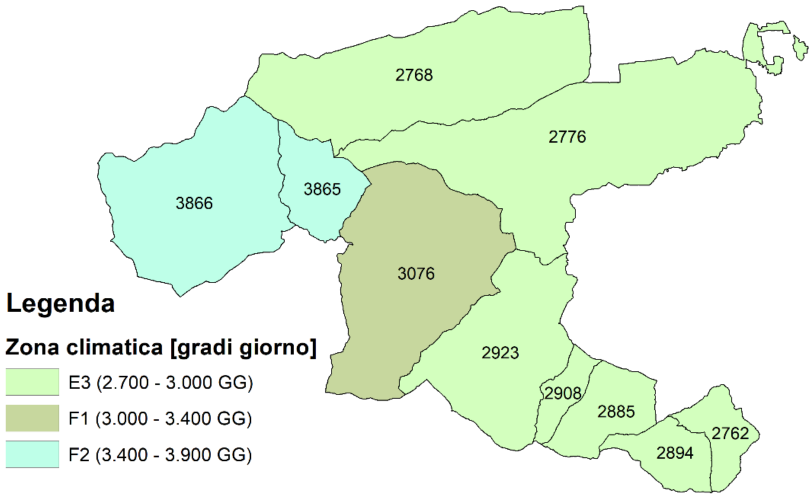


Figure 3 Degree days for each municipality

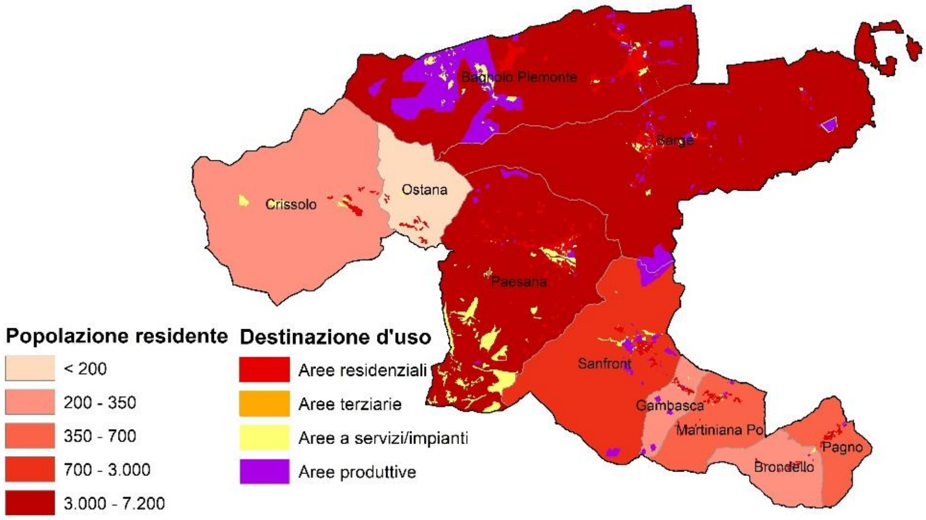


Figure 4 Distribution of Popoluation in relation to the destination of use

As regards the local building stock, the reference database for the analysis was CTR (BDTRE, updated to 2019) of the Geoportal of the Piedmont Region. Starting from the ISTAT code of each municipality, using the functions of the ArcGis software, for each of them information about the intended use of the buildings present was selected and geo-referenced: residential, productive, tertiary use and services of collective interest. Other information, present in Figure XX, refer to the 2011 Istat census and have also been geo-referenced by census section. Features such as the prevailing construction period allow you to make very general assessments about the technological systems and the use of building construction materials, also in relation to the current legislation of the time and the mandatory energy performance standards.

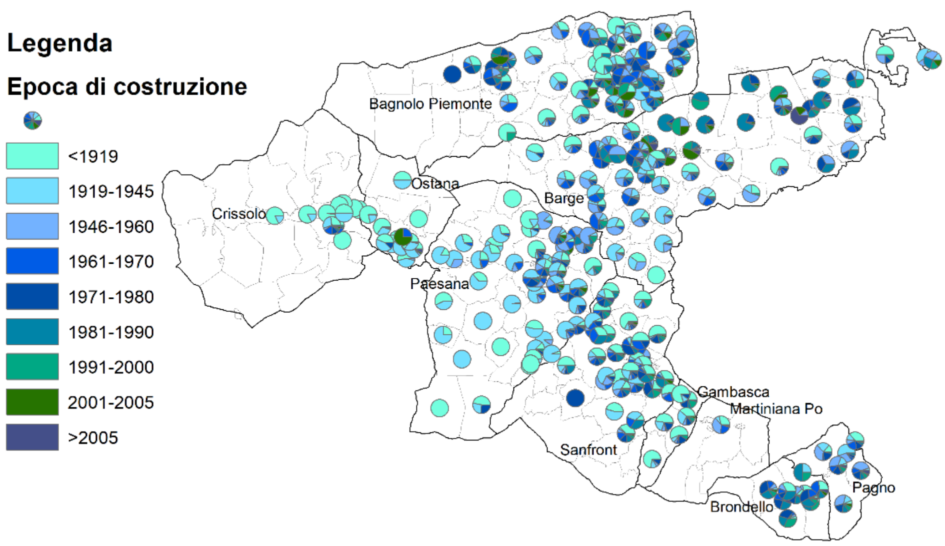


Figure 5 Distribution of buildings according to the year of construction

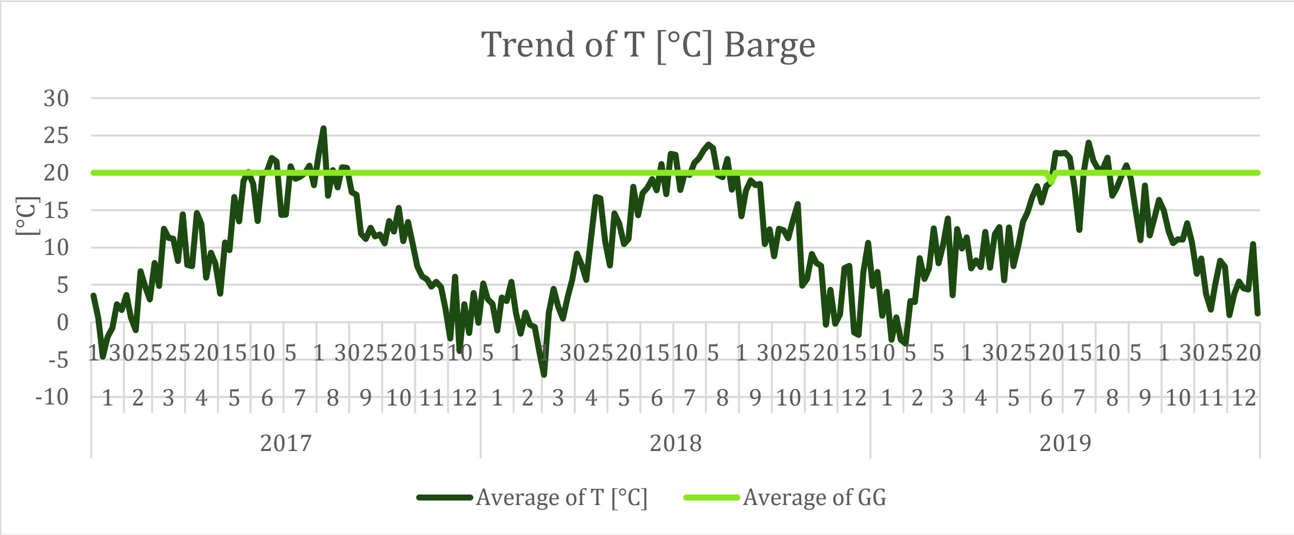


Figure 6 Outside temperature trend - Barge

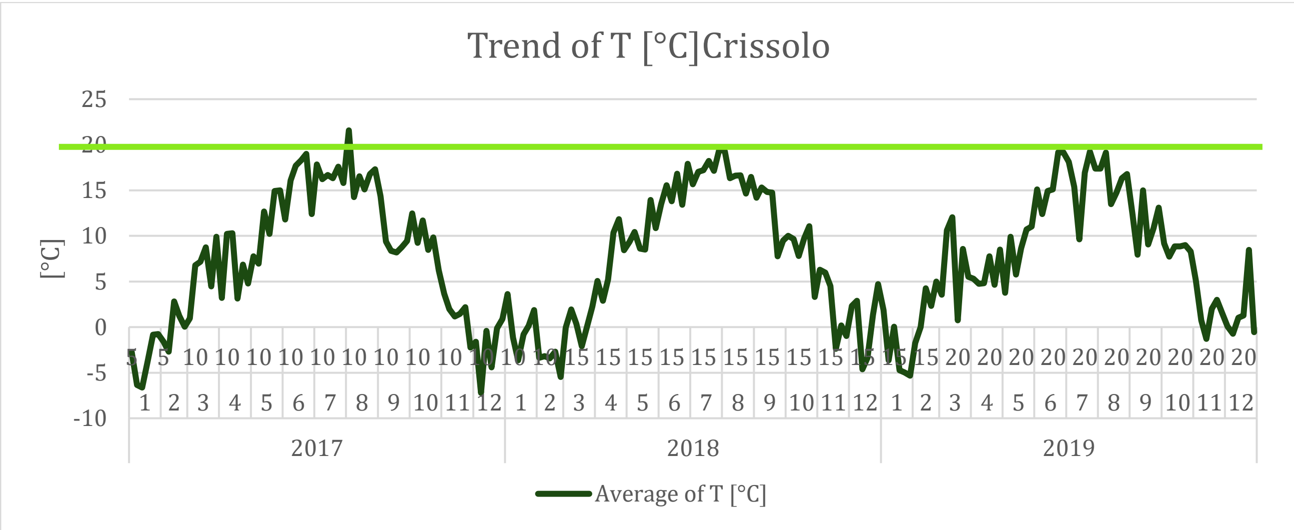


Figure 7 Outside temperature trend - Crissolo

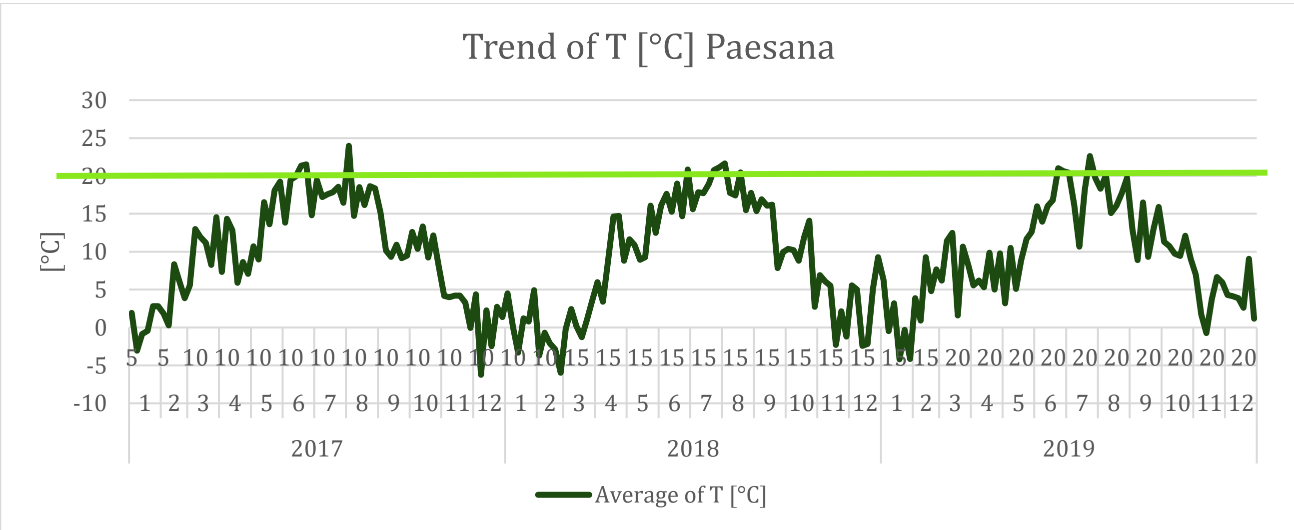


Figure 8 Outside temperature trend - Paesana

2. REPORT OF DATA COLLECTION (TASK 3.1)

2.1. OBJECTIVES AND METHODOLOGY

The objective of the Task C3.1 is to assess energy consumption within the GC Area:

- Energy consumption: classified by quantity, vector (i.e., fossil fuels, biomass, natural gas, solar, etc), use (i.e public/private, residential/commercial, heating/cooling/electricity, etc.);
- Emission deriving from the energy and transport sectors (tonnes CO_2)/year);
- Economics.

In the deliverable D3.1, the data were supposed to be collected and reported according to the division into three categories:

- **social and economic data**: analyses social/economic data following indicators D0 to D6 and D12 to D18. Methodology, sources, and results (tables and considerations) are available in the paragraphs 2.3.1.
- **energy consumption and greenhouse gas emissions in building sector** (HVAC, lighting, electric plants, equipment) (paragraph 2.4). The overall consumption and emissions due to the building sector have been determined and collected into the following sub-sectors:
    - o electric consumption and emission in public and private buildings and lighting (par. 2.2.2);
    - o HVAC consumption and emission in public and private buildings (par. 2.2.3).

The data involved in those evaluations are D19-D21, D73, D76-D79 and D81.

- **energy consumption and greenhouse gas emissions in the transport sector** (paragraph 2.5) provides the values for the KPIs D74 and D75.

For each category the relative paragraph contains:

- the methodology and source of data retrieval;
- the description of the data;
- the database with the data obtained or simulated or calculated.

The data were collected in different ways, depending on the sources available and the type of data. They were divided, in the first instance (DL C3.1) into:

- **direct data:** they can be obtained directly without additional calculations (e.g., geometric measurements, fuel typology, consumption data from bills);

- **secondary data:** they can be obtained with calculations or simulations from a series of direct data (e.g., HVAC efficiency, wall transmittance, CO_2 emissions, SIPEE database).

In this deliverable, it has been decided to develop a data analysis approach based on the following three types of data. The data are also determined based on a priority index, depending on the reliability and accessibility of the source:

- **real/monitored data (Priority 1)**: they can be obtained directly from a direct measure, without additional calculations (e.g., energy bills from local DSOs; aggregated or point data from market operators, such as E-distribuzione S.p.A., Iren S.p.a., Energetic S.r.l.; measurements of fuel consumption for energy production and HVAC systems) or from literature research (e.g., Atlante GSE, Istat database, local authorities). For energy consumption and emissions from non-traceable energy carriers (woody biomass, liquefied petroleum gas), an Energy Tool App was created that collects energy data from citizens and records them in a database.
- **simulated data (Priority 2):** they can be obtained with simulations from a series of direct data (e.g., HVAC efficiency, SIPEE database);
- **calculated data (Priority 3):** they can be obtained with calculations from a series of direct data (e.g., CO_2 emissions, the energy consumption of the transport sector). For the assessment of the energy consumption, IRIS has followed the methodology approved by the Covenant of Majors for Climate and Energy "Come sviluppare un piano di azione per l'energia sostenibile"[1]

The developed database has the following purposes of use:

- DL C3.2 to carry out the energy simulation of technical and economic convenience of biomass technologies for the production of electrical and thermal energy applied to buildings considered as a case study (Chap.3).
- DL C4.1 to supply the DSS platform with the data useful for the support an effective decision-making process.
- DLC4.2 the compilation of the PAESC (Sustainable Energy and Climate Action Plan) – Data 2018 MEI 2 - Second Monitoring Emissions Database.

[1] Bertoldi, P., Cayuela, D. B., Monni, S. & Raveschoot, R. P. De. " *Come Sviluppare Un Piano Di Azione Per L ' Energia Sostenibile - Paes* ". (2010). doi:10.2790/23962

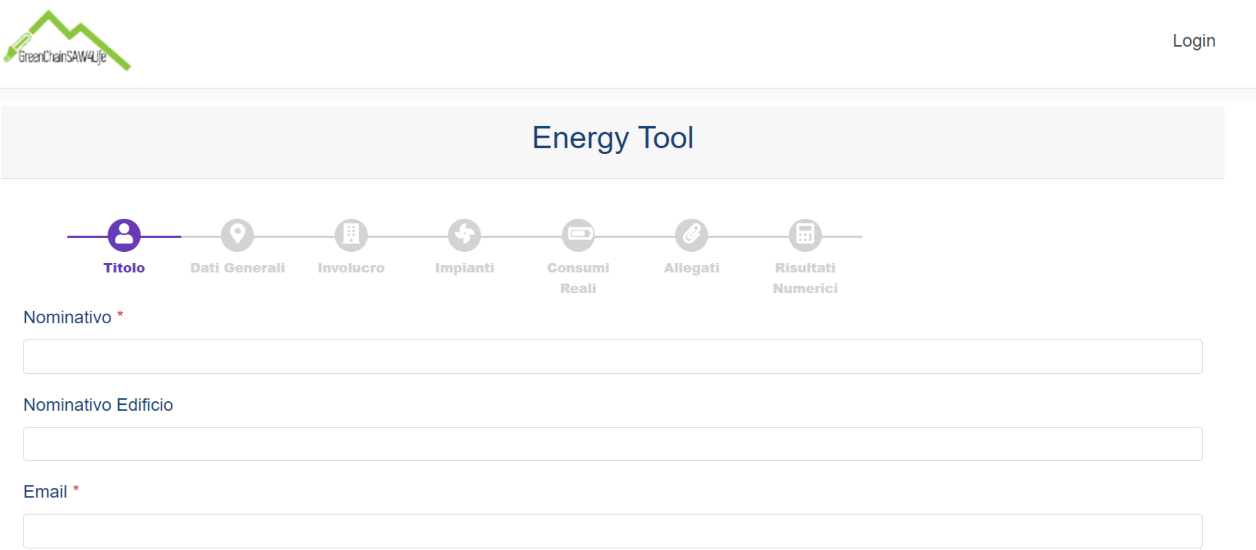
2.2. ENERGY TOOL APP

Among the activities of risk 3.1, an APP was developed for the collection of real consumption data among the inhabitants of the territory.

It is possible to use the APP from the project website:

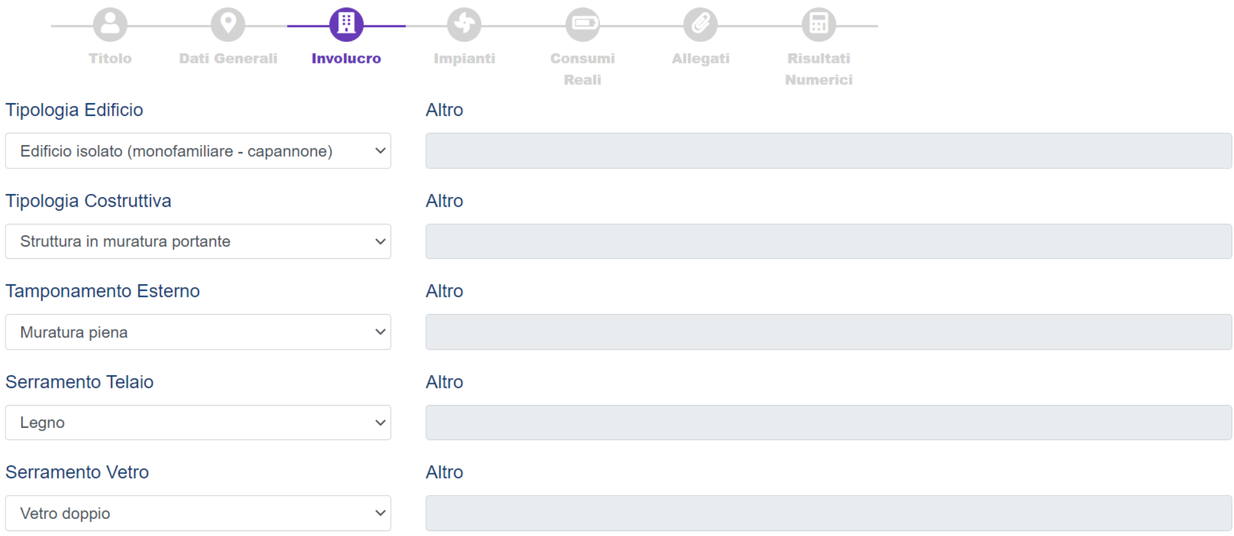
https://chainsaw4life.azurewebsites.net/EnergyTool/Create

1. User data

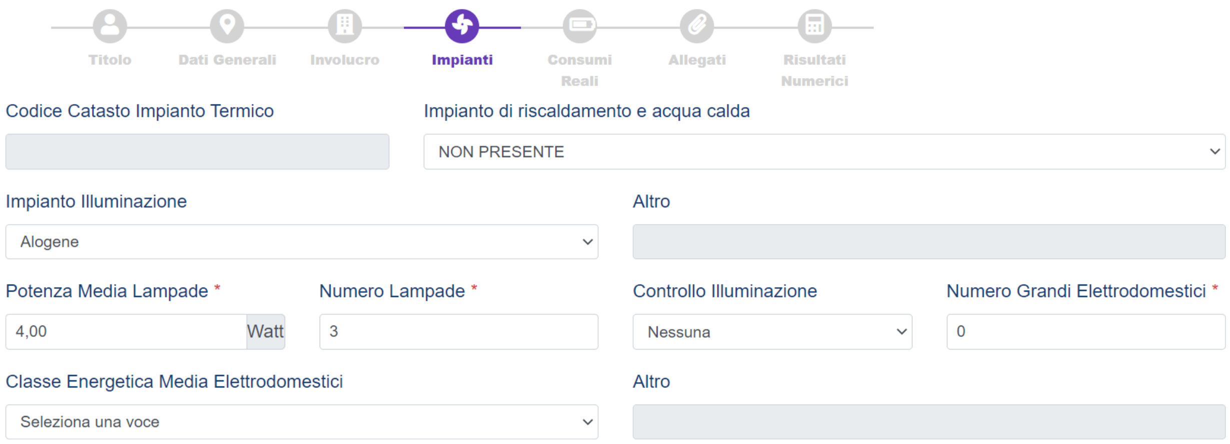


2. General Data

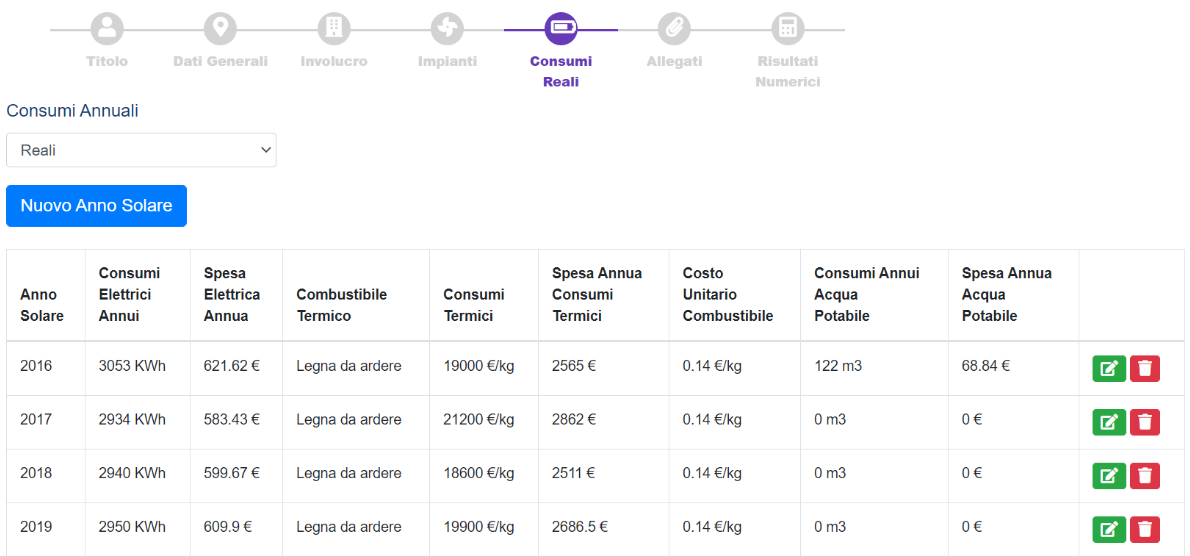
3. Envelope characteristics



4. Electric and HVAC system



5. Energy consumption divider by fuel



Anno Solare	Consumi Elettrici Annui	Spesa Elettrica Annua	Combustibile Termico	Consumi Termici	Spesa Annua Consumi Termici	Costo Unitario Combustibile	Consumi Annui Acqua Potabile	Spesa Annua Acqua Potabile	
2016	3053 KWh	621.62 €	Legna da ardere	19000 €/kg	2565 €	0.14 €/kg	122 m3	68.84 €	
2017	2934 KWh	583.43 €	Legna da ardere	21200 €/kg	2862 €	0.14 €/kg	0 m3	0 €	
2018	2940 KWh	599.67 €	Legna da ardere	18600 €/kg	2511 €	0.14 €/kg	0 m3	0 €	
2019	2950 KWh	609.9 €	Legna da ardere	19900 €/kg	2686.5 €	0.14 €/kg	0 m3	0 €	

6. Annex

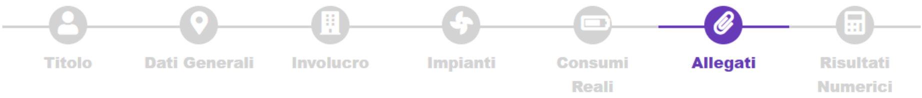


Foto Esterna

Salva

Scegli file Nessun file selezionato

Foto Interna

Salva

Scegli file Nessun file selezionato

Foto Planimetria

Salva

Scegli file Nessun file selezionato

Foto Bollette

Salva

Scegli file Nessun file selezionato

7. Results and emissions

Riepilogo Consumi

Anno	Elettrici	Termici	Acqua Potabile
2019	2950.00 KWh	19900.00 kg	0.00 m3
2018	2940.00 KWh	18600.00 kg	0.00 m3
2017	2934.00 KWh	21200.00 kg	0.00 m3
2016	3053.00 KWh	19000.00 kg	122.00 m3

Emissioni kgCO2

Anno Solare	Emissioni Elettriche kgCO2	Emissioni Termiche kgCO2	Totale Emissione kgCO2
2019	1357.00	3681.50	5038.50
2018	1352.40	3441.00	4793.40
2017	1349.64	3922.00	5271.64
2016	1404.38	3515.00	4919.38

8. Geo-localisation

The results collected by the app will be automatically uploaded to the DSS platform, updating the general data of the territory in the database. This allows to have a real data of the consumption deriving from biomass and fossil sources for which no reliable data was available (GLP, diesel).

Figure 9 publication of the tool on social networks

2.3. SOCIAL AND ECONOMIC DATA

2.3.1. METHODOLOGY AND SOURCES

In the first instance the data relating to the social aspects of each municipality were defined (obtained above all from public and official Istat surveys). Economic data were then defined at a territorial level as, given the very small size of the various municipalities, there are no specific data in the literature.

This analysis focused on the DATA from D0 to D18 of deliverable DL C3.1.

Compared to what is foreseen in Deliverable 3.1 some data have changed during the research. The reason for this change lies in improved data reliability and data retrieval capabilities.

In the Deliverable DL 3.1 the Local economic impact (LEI - [€LEI/kWh]) (project area) was considered to be generated by the consumption of 1 kWh (thermal and electric) of energy deriving from:

- fossil sources (D12);
- Renewable Energy Sources (RES = solar, hydroelectric, wind) (D13);
- local biomass (D14).

In this deliverable the LEI was considered to be generated by the consumption of 1 € invested (INV) on energy deriving from:

- electrical RES (photovoltaic, hydroelectric, wind) (D13);
- thermal RES (thermal solar, heat pumps, solid biomass) (D14);
- local electrical solid biomass (cogeneration) (D15);
- local thermal solid biomass (D16);
- total RES (D17).

The source for those Data is the report "La situazione energetica nazionale nel 2019" of Ministero dello Sviluppo Economico.

The local economic impact is the added value generated for the entire local economy, according to Istat (2012): it allows to estimate the growth of the economic system in terms of new goods and services made available to the community for final use.

It is the result of the difference between the value of the goods and services produced by the individual productive branches and the value of the intermediate goods and services consumed by them (raw and auxiliary materials used and services supplied by other production facilities)[2].

[2] Quadro, I. L., Internazionale, E., La, I. C. E., Energetica, S. & Famiglie, D. DEI SISTEMI ENERGETICI E GEOMINERARI LA SITUAZIONE ENERGETICA NAZIONALE NEL 2019 (2020)

The survey by the " Ministero dello Sviluppo Economico" also showed that for every 100.000 euros invested in a local biomass plant generated in the related industries, 1 full-time job in the supply chain (plant installation, transport, biomass harvest).

Table 1 Comparison between DATA present in Deliverable 3.1 and DATA collected in this deliverable D3.2

n°	DATA DL C3.1	DATA DL C3.2	METHODOLOGY AND SOURCES
D0	Total amount financed by the European Union	Total amount financed by the European Union	Life project
D1	Population	Population	Istat database (01/01/2019)
D2	Territory area	Territory area	Wikipedia
D3	Number and size of companies in the energy field	Number and size of companies in the energy field	Istat database ATECO: fornitura di energia elettrica, gas, vapore e aria condizionata (produzione, trasmissione e distribuzione di energia elettrica + produzione di gas, distribuzione di combustibili gassosi mediante condotte + fornitura di vapore e aria condizionata) installazione di impianti elettrici, idraulici ed altri lavori di costruzione e installazione.
D4	Number of employees in the energy field	Number of employees in the energy field	
D5	Percentage of empty public building	Percentage of empty public building	Value calculated only at the territorial level
D6	Percentage of empty private building	Percentage of empty private building	Istat database
D7	Investments in increasing the efficiency of HVAC systems	investment for energy efficiency per inhabitant	The single data were not provided by Enea. A value was determined relating to the investment for energy efficiency per inhabitant in the project area
D8	Investments in increasing the efficiency of HVAC systems powered by biomass		
D9	Investments in increasing the efficiency of building envelope (insulation)		
D10	Investments in increasing the efficiency of building envelope with wood materials		
D11	Percentage of the efficiency intervention cost covered by deductions or detraction		
D12	Local economic impact (project area) generated by the consumption of 1 kWh (thermal and electric) of energy		

	deriving from fossil sources		
D13	Local economic impact (project area) generated by the consumption of 1 kWh (thermal and electric) of energy deriving from RES (solar, hydroelectric, wind)	Local economic impact (LEI) (project area) generated by 1 € invested in electrical RES (photovoltaic, hydroelectric, wind)	Data deriving from the report “La situazione energetica nazionale nel 2019” of Ministero dello Sviluppo Economico.
D14	Local economic impact (project area) generated by the consumption of 1 kWh (thermal and electric) of energy deriving from local biomass	Local economic impact (LEI) (project area) generated by 1 € invested in thermal RES (thermal solar, heat pumps)	
D15	Total Local economic impact (project area) generated by the energy consumption of energy deriving from fossil sources	Local economic impact (LEI) (project area) generated by 1 € invested in local electrical solid biomass (cogeneration)	
D16	Total Local economic impact (project area) generated by the energy consumption of energy deriving from RES	Local economic impact (LEI) (project area) generated by 1 € invested in local thermal solid biomass	
D17	Total Local economic impact (project area) generated by the energy consumption of energy deriving from local biomass	Local economic impact (LEI) (project area) generated by 1 € invested in total RES (electric + thermal)	
D18	Total Local economic impact (project area) generated by the energy consumption of energy deriving from fossil sources + RES + local biomass		

2.3.2. SOCIAL AND ECONOMIC DATA RESULTS

Table 2 and Table 3 show the general and economic data of the municipalities involved in the project.

Table 2 - General data of the GC Area

GC AREA			GENERAL DATA		
Code	Sign	Municipality	Population	Territory area	Density
			[ab.°]	*[km^2]*	*[ab./km^2]*
			D1	D2	
			Real / monitored data - 01/01/2019 Istat	*Real / monitored data - Wikipedia*	*Real / monitored data - 01/01/2019 Istat*
1	BAP	BAGNOLO PIEMONTE	5.953	63	94
2	BAR	BARGE	7.616	82	93
3	BRO	BRONDELLO	282	10	28
4	CRI	CRISSOLO	165	52	3
5	ENV	ENVIE	1.989	25	80
6	GAM	GAMBASCA	350	6	61
7	MAP	MARTINIANA PO	747	13	56
8	ONC	ONCINO	78	47	2
9	OST	OSTANA	85	14	6
10	PAE	PAESANA	2.713	58	47
11	PAG	PAGNO	560	9	65
12	REV	REVELLO	4.273	52	81
13	RIF	RIFREDDO	1.044	7	153
14	SAN	SANFRONT	2.354	40	59
TOTAL			28.209	479	59

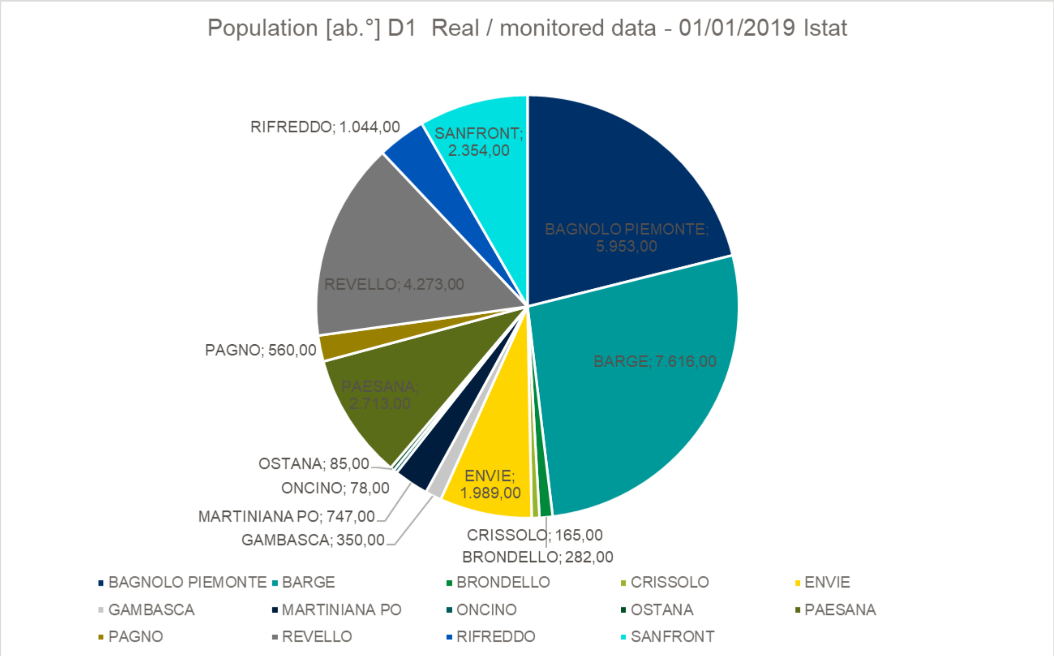


Figure 10 Graph of the distribution of inhabitants in GCArea

GreenChainSAW4LIFE project is co-funded by the **LIFE Programme** of the European Union under contract number LIFE18 CCM/IT/001193

Table 3 - Economic data of the GC Area

GC AREA		ECONOMIC DATA										
Code	Sign	Number of companies in the energy field	Number of employees in the energy field	Number of buildings	Number of buildings used	Percentage of empty private buildings	Investments in increasing the efficiency of buildings	Local economic impact (LEI) (project area) generated by 1 € invested in RES systems				
								Electrical RES	Thermal RES	Local electrical solid biomass (cogeneration)	Local thermal biomass	Total RES
		[n°]	*[n°]*	*[n]*	*[n]*	*[%]*	*[€/year]*	*[€$_{LEI}$/€$_{INV}$]*	*[€$_{LEI}$/€$_{INV}$]*	*[€$_{LEI}$/€$_{INV}$]*	*[€$_{LEI}$/€$_{INV}$]*	*[€/year]*
		D3	D4			D6	D7	D13a	D13b	D14a	D14b	D18
		Calculated data		*Real Istat*	*Real Istat*	*Real Istat*		*Calculated data - MISE*	*Calculated data - MISE*	*Calculated data - MISE*	*Calculated data - MISE*	*Calculated data - MISE*
1	BAP	39	57	2.847	2.518	12%	689.357					
2	BAR	28	41	4.064	3.174	22%	881.933					
3	BRO	0	0	244	146	40%	32.656					
4	CRI	2	3	835	112	87%	19.107					
5	ENV	7	9	918	831	9%	230.326					
6	GAM	0	0	253	180	29%	40.530	3,49	2,74	3,50	5,76	3,48
7	MAP	7	11	392	351	10%	86.503					
8	ONC	0	0	683	50	93%	9.032					
9	OST	1	1	592	60	90%	9.843					
10	PAE	7	15	2.652	1.412	47%	314.165					
11	PAG	1	1	326	259	21%	64.848					
12	REV	17	50	1.658	1.665	5%	494.813					
13	RIF	5	9	613	438	29%	120.895					
14	SAN	14	18	1.514	1.096	28%	272.593					
TOTAL		128	215	17.591	12.292	37%	3.266.602	3,49	2,74	3,50	5,76	3,48

2.3.3. DATA ANALYSY

The first analysis of these data allows us to highlight how the municipalities covered by the project can be divided into 2 main types: normally inhabited municipalities and mountain municipalities mainly intended for second homes.

The 37% of the buildings in the analysed area are empty or not used constantly.

The municipalities that are normally most inhabited have a percentage of empty buildings of 15%, against a percentage that rises to 50% in the holiday municipalities, reaching peaks of 90%.

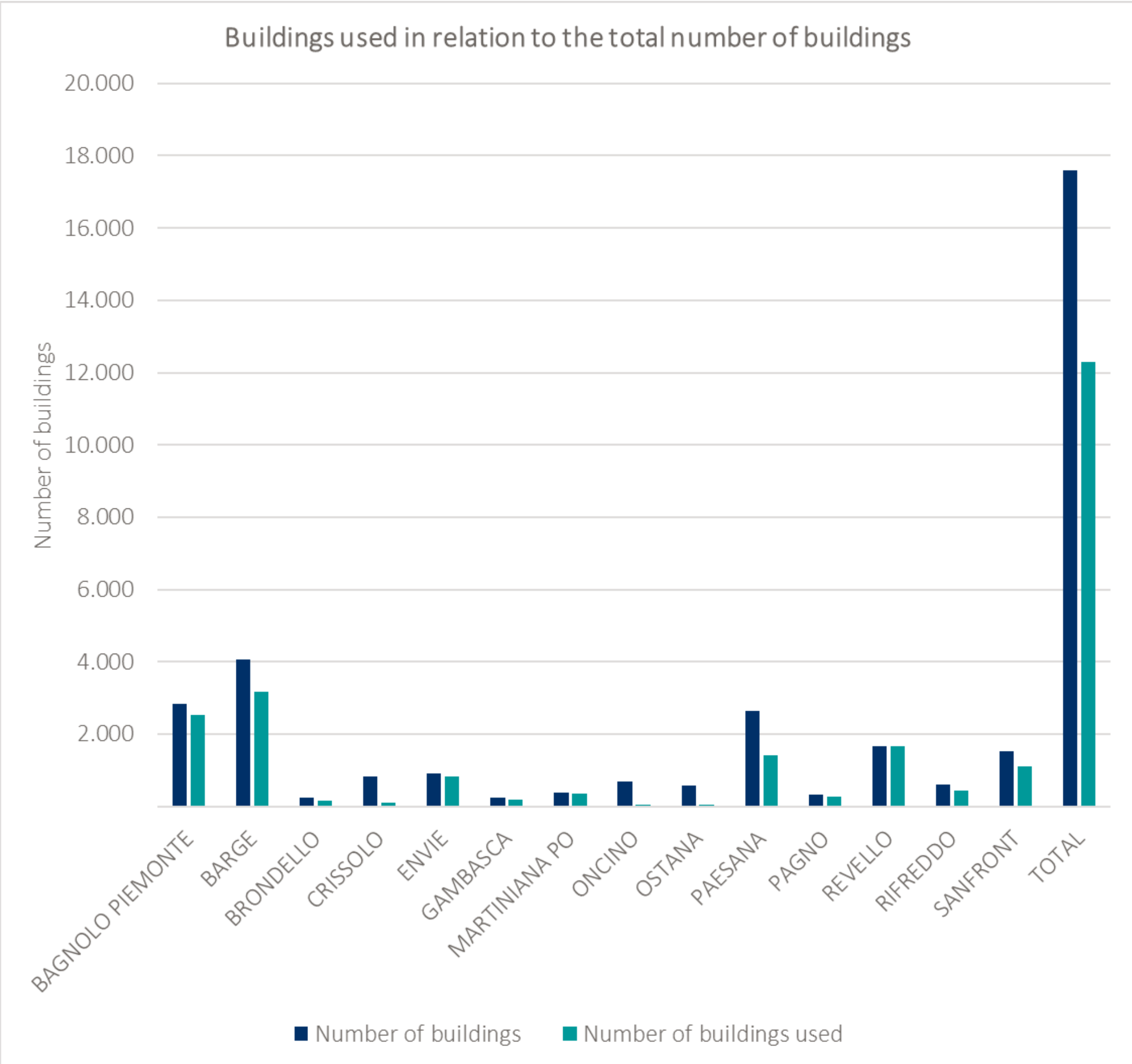


Figure 11 Buildings used in relation to the total number of buildings.

The economic data was based on studies relating to 2018 and 2019 drawn up by the MISE.

The study of MISE show that in 2019 about 1,6 billion euros were invested in new plants for the production of electricity from renewable sources (RES), a slight decrease compared to the 2018, especially by virtue of the lower investments in plants fuelled by solid biomass. Investments were concentrated in particular in the photovoltaic sector (approximately 835 million) and wind power (approximately 571 million). It is estimated that the design, construction and installation of the new plants in 2019 activated "temporary" employment corresponding to over 11,000 direct and indirect (full-time equivalent) work units.

The "permanent" management of the entire fleet of plants in operation, against an expenditure of over 3,4 billion in 2019, is believed to have activated over 33.600 direct and indirect (full-time equivalent) work units, of which the most of them related to the hydroelectric sector (about 35%) followed by that of biogas (18%) and photovoltaic (over 17%).

The added value for the entire economy generated by the complex of O&M investments and expenses associated with the various renewable sources in the electricity sector in 2019 was a total of over 2,9 billion euros.

Table 4 Economic and employment effects of the development of electric and thermal renewables in 2018

Tecnologia	Investimenti (mln €)	Spese O&M (mln €)	Valore Aggiunto generato per l'intera economia (mln €)	Occupati temporanei diretti+indiretti (ULA)	Occupati permanenti diretti+indiretti (ULA)
Fotovoltaico	582	368	551	3.749	5.780
Eolico	859	313	651	5.937	3.625
Idroelettrico	84	1.048	831	749	11.835
Biogas	50	527	436	446	5.834
Biomasse solide	293	586	439	2.616	3.719
Bioliquidi	0	511	115	3	1.622
Geotermoelettrico	-	59	44	-	607
Totale	**1.868**	**3.412**	**3.067**	**13.501**	**33.022**

Tecnologia	Investimenti (mln €)	Spese O&M (mln €)	Valore Aggiunto generato per l'intera economia (mln €)	Occupati temporanei diretti+indiretti (ULA)	Occupati permanenti diretti+indiretti (ULA)
Solare termico (naturale + forzato)	102	33	79	878	356
Stufe e termocamini a pellet	383	870	264	3.893	2.608
Stufe e termocamini a legna	261	1.841	1.301	3.241	15.737
Pompe di calore (aerotermiche, idrotermiche e geotermiche)	2.265	2.811	3.061	18.765	9.382
Totale	**3.012**	**5.555**	**4.705**	**26.778**	**28.082**

Analysing the economic data, it is possible to highlight that:

- every euro invested on renewable energy (electric and thermal) generates a local economic impact of about 3,5 € (indirect + direct O&M).
- every euro invested on local biomass energy (thermal) generates a local economic impact of about 5,76 € (indirect + direct O&M).
- every euro invested on local biomass energy (thermal + electric) generates a local economic impact of about 3,5 € (indirect + direct O&M). The LEI for biomass cogeneration is lower exclusively because the initial total investment is 10 times higher than for heating only (boiler) where market access prices are now competitive and slightly higher than fossil fuel systems (+ 20%). If calculated with respect to energy production, the induced would be the same (or even higher due to the greater maintenance required) compared to the biomass used for thermal only.

The impact of local biomass on the territory is therefore approximately double compared to the impact generated by photovoltaic panels, wind power and heat pumps. This is mainly due to the local work generated for forest management (cutting, accommodation, transport) with respect to solar sources.

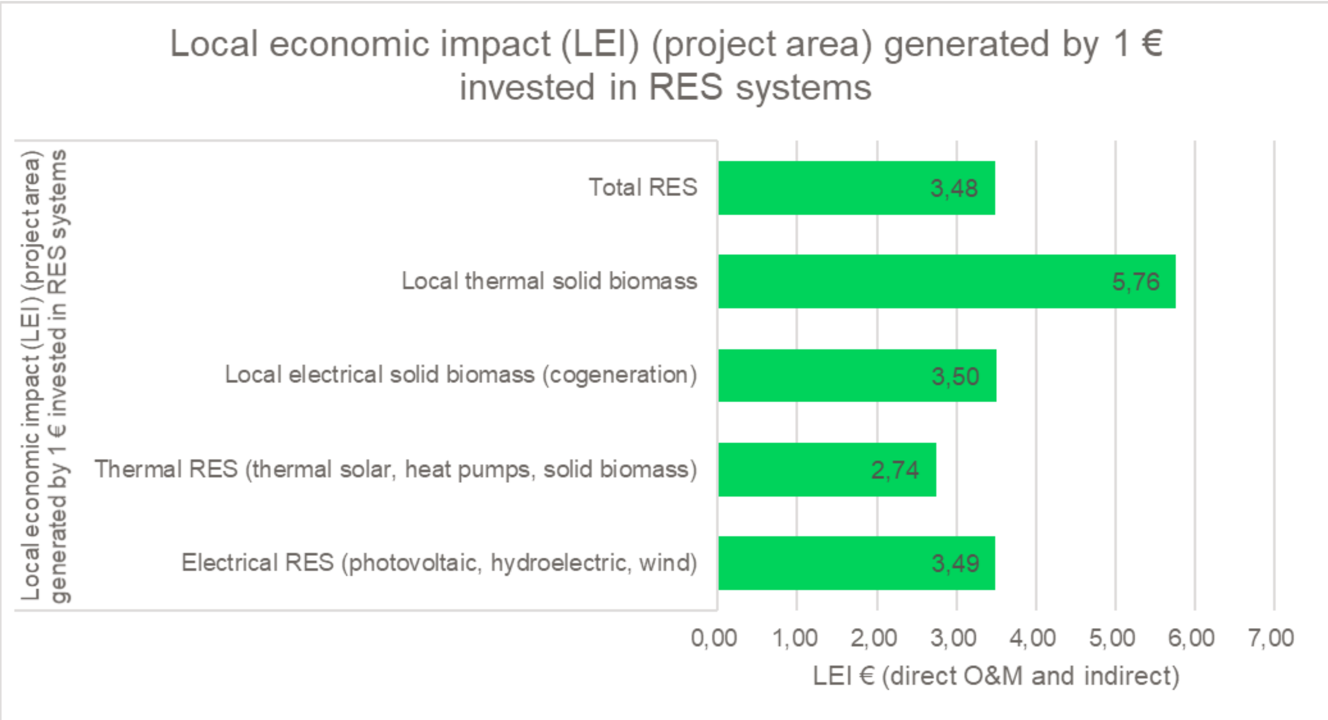


Figure 12 Local economic impact (LEI) (project area) generated for each euro invested in RES.

2.4. ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS DATA IN THE BUILDING SECTOR

2.4.1. GENERAL METHODOLOGY

The dataset contains the following types of data:

- renewable energy production;
- electrical Energy consumption and related CO_2 emissions;
- HVAC Energy consumption and related CO_2 emissions.

The deliverable contains the final aggregated data by municipality. The individual data of each public building are shown in Annex 01.

2.4.2. METHODOLOGY FOR CALCULATING GREENHOUSE GAS EMISSIONS

The CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector. The values of the emission factors used are reported in Table 6.

The source for the EFs is the IPCC (Intergovernmental Panel on Climate Change), and their unit of measure is *MWh/ tCO₂*.

As regards the biomass emission factor (EF), 2 types of emission factor are considered deriving from the values of:

- the standard CO_2 emission factors (from IPCC)
- and LCA emission factors equivalent to CO_2 (from ELCD).

Only the standard CO_2 emission factors were used for the calculations in this deliverable. The emission factors considering the entire LCA will be determined and analysed in Deliverable C3.4.

The values provided are equal to 0,0 t CO_2 / MWh (for biomass deriving from sustainable forest management, the IPCC emission factor must be reported as zero because the sustainability criteria are met) and 0,403 t CO_2 / MWh (for biomass deriving from unsustainable forest management and not local). In the case of the territory, an analysis of literature has allowed to define a weighted average coefficient according to the quantity of biomass deriving from forest management and that deriving from unsustainable management. The statistical data relating to the type of wood fuel used and its origin were then analysed.

The biomass purchased, according to the Literature[3], it is mainly of local origin and regional (70%), 14% national and foreign and in 16% of cases it is not known (Figure 14).

[3] AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Giugno 2020

Table 5 Type of biomass consumed by region [Source: AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Giugno 2020]

Regione	legna	pellet	cippato	bricchette	biomasse totali	utilizzatori frequenti
Valle d'Aosta	31,8%	9,3%	0,4%	0,0%	38,9%	37,2%
Piemonte	20,7%	7,3%	0,2%	0,1%	26,2%	24,4%
Lombardia	10,8%	4,0%	0,2%	0,0%	14,4%	12,7%
Veneto	23,9%	6,9%	0,3%	0,3%	29,7%	28,6%
Friuli Venezia Giulia	29,1%	5,2%	0,1%	0,1%	33,2%	31,2%
Emilia Romagna	15,8%	3,3%	0,1%	0,0%	18,5%	16,7%
Provincia autonoma di Bolzano	30,8%	7,2%	2,1%	1,5%	37,7%	36,9%
Provincia autonoma di Trento	40,6%	5,0%	0,8%	0,2%	44,6%	42,5%
Totale complessivo	**17,7%**	**5,1%**	**0,2%**	**0,1%**	**21,9%**	**20,3%**

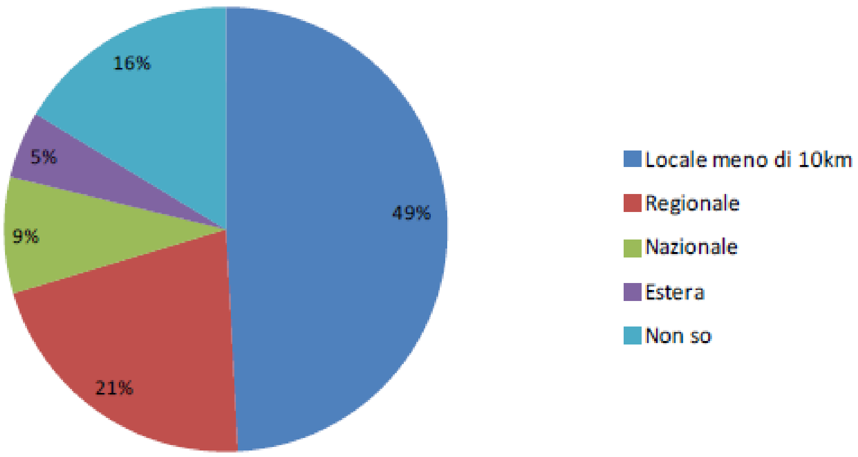


Figure 13 Origin of the biomass used for HVAC

Regarding the sources of supply of biomass:

- about half of the wood used for energy purposes by households it is self-produced/recovered and comes from rows, hedges or groves of rural origin (average of sample 67% of cases);
- only 27% have a forest origin;
- the remaining 6% add up to the other categories (waste and recycled material, other and origin non note).

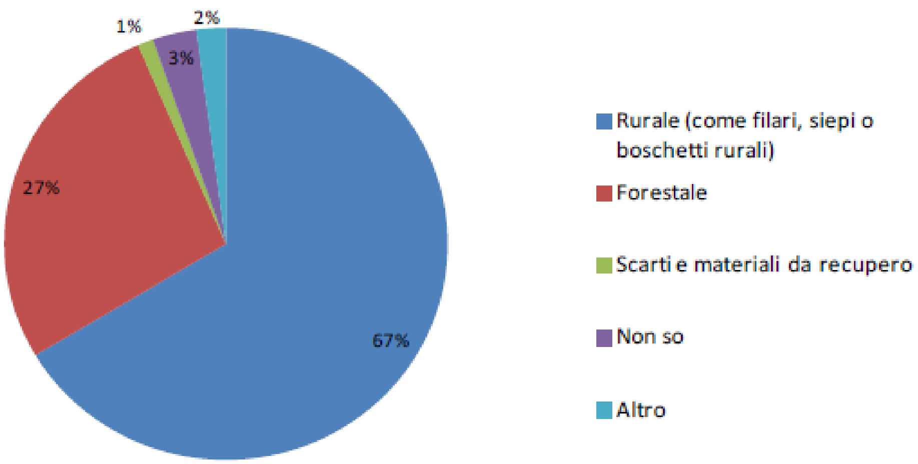


Figure 14 Origin of the biomass used for HVAC

Regarding the conservation methods, that is the seasoning, if the firewood is self-produced or recovered it is mainly used within a year of its stacking, while if it is purchased its consumption takes place more frequently within a few months.

The analysis of the data allowed us to identify a first average emission coefficient (which will be demonstrated and refined in deliverable 3.4) proportional to the type of fuel (wood - pellet) and to its origin (local or non-local). The results are as follows:

- 70%: local (<10km) and regional biomass;
- 30%: non regional biomass.

Table 6 Biomass Emission factors calculation

Type of biomass	Local	CO_2 emission factors	Non-local	CO_2 emission factors	Global CO_2 emission factors
	[%]	tCO_2/MWh	[%]	tCO_2/MWh	tCO_2/MWh
Average biomass	70%	0,000	30%	0,403	0,121

Table 7 Emission factors

Electricity	Fossil fuels					Renewable energies		
Local	Natural gas	Liquid gas	Heating oil	Diesel	Gasoline	Other biomass	Local Biomass	Gc Area Biomass
tCO_2/MWh								
0,312	0,202	0,227	0,267	0,267	0,249	0,403	0	0,121

In deliverable C3.4 (Fossil based goods and services Carbon Fluxes baseline report) the CO_2 emission factors, calculated in a preliminary and simplified way, will be analysed in detail.
The partners involved in the C3.4 will measure carbon fluxes with a Life Cycle Assessment approach, taking into account the European Reference Life Cycle Database (ELCD). The investigation is done assessing emissions from fossil fuels and sources of energy used in the territory and fossil-based products currently competing with wood-based materials potentially produced within the territory.
The emissions will then be calculated on the basis of the new coefficients both considering a traditional approach and an LCA approach.

2.4.3. RENEWABLE ENERGY PRODUCTION

Energy produced from renewable sources has been divided into 2 sub-categories: electricity and energy for HVAC systems (Figure 15).

- Electric energy production (Table 7):
    - Photovoltaic plants for electric energy production: derive from the sum of the public plants (real data) with the plants present in the GSE Atlas (real data);
    - Hydroelectric plants: data provided by public bodies on the basis of actual production in recent years (real data).
- HVAC (thermic) energy production (Table 8):
    - Biomass thermal plants: data determined by the simulations of the APE-ACE of the area
    - District heating plants fuelled by biomass: data determined by the simulations of the APE-ACE of the area

Table 8 Electric energy production by RES

GC AREA		ELECTRIC ENERGY PRODUCTION							
		Photovoltaic plants						Hydroelectric plants	
Code	Sign	Number Public plants	Annual production public plants	Number of private plants	Total Annual private production	Total Number of plants	Total Annual production	Number plants	Annual production
		[n°]	*[MWh_{el}/year]*	*[n°]*	*[MWh_{el}/year]*	*[n°]*	*[MWh_{el}/year]*	*[n°]*	*[MWh_{el}/year]*
		D19a	D19b	D19a	D19b	D19a	D19b	D19a	D19b
		Real - Public information	*Real / monitored data - Energy bills*	*Real Atlante GSE*	*Real Atlante GSE*	*Real - Public information + Atlante GSE*	*Real - Public information + Atlante GSE*	*Real - Public information*	*Real – Energy bills*
1	BAP	1	19	112	1.975	113	1.975		
2	BAR	4	39	129	8.730	133	8.730		
3	BRO			1	5	1	5		
4	CRI	1	21	3	46	4	46	1	129
5	ENV			30	1.554	30	1.554		
6	GAM			2	46	2	46		
7	MAP			10	128	10	128		
8	ONC			1	3	1	3		
9	OST	1	8	5	24	6	24		
10	PAE	1	12	36	373	37	373	1	971
11	PAG			14	133	14	133		
12	REV			108	5.741	108	5.741		
13	RIF			13	498	13	498		
14	SAN			33	1.012	33	1.012		
TOTAL		**8**	**99**	**497**	**20.266**	**505**	**20.266**	**2**	**1.100**

Table 9 Thermal energy production by RES

GC AREA		THERMAL ENERGY PRODUCTION			
Code	Sign	Biomass thermal plant		District heating plants fuelled by biomass	
		Power size	Annual production	Number	Annual production
		[kW$_{th}$]	*[MWh$_{th}$/year]*	*[n°]*	*[MWh$_{th}$/year]*
		D20a	D20b	D20c	D20d
		Real / monitored data - Atlante GSE	*Simulated data - SIPEE*	*Real / monitored data - Atlante GSE*	*Simulated data - SIPEE*
1	BAP	1.309	6.104		
2	BAR	1.323	15.045	2	204
3	BRO	68	426		
4	CRI	114	293		
5	ENV	830	2.715		294
6	GAM	130	197		
7	MAP	419	702	5	150
8	ONC	103	190		
9	OST	36	309		
10	PAE	987	4.092		
11	PAG	153	720		
12	REV	3.214	4.227		37
13	RIF	364	698		
14	SAN	861	1.231		
TOTAL		9.911	36.949	7	686

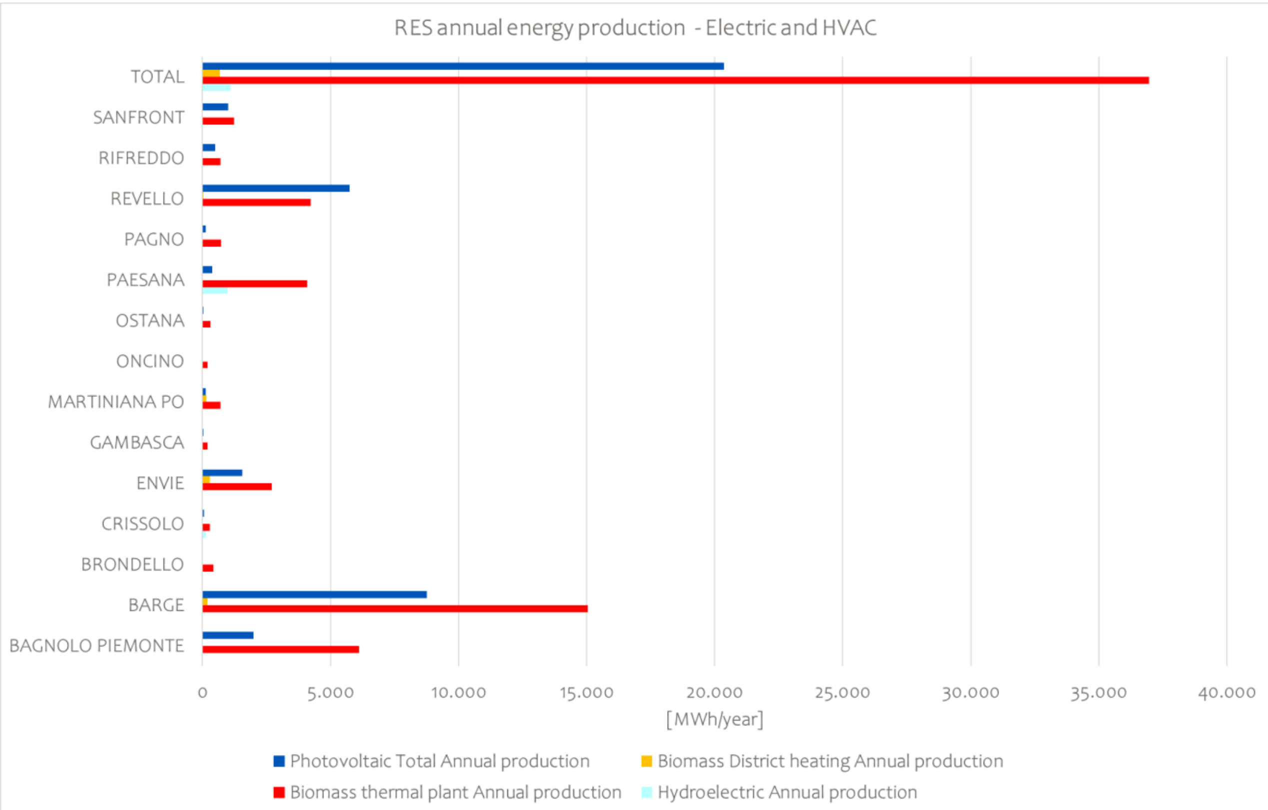


Figure 15 RES annual energy production divided for source.

The subsequent aerial images taken from the Atlaimpianti portal showed us the current distribution of RES.

Figure 16 Hydroelectric power plants

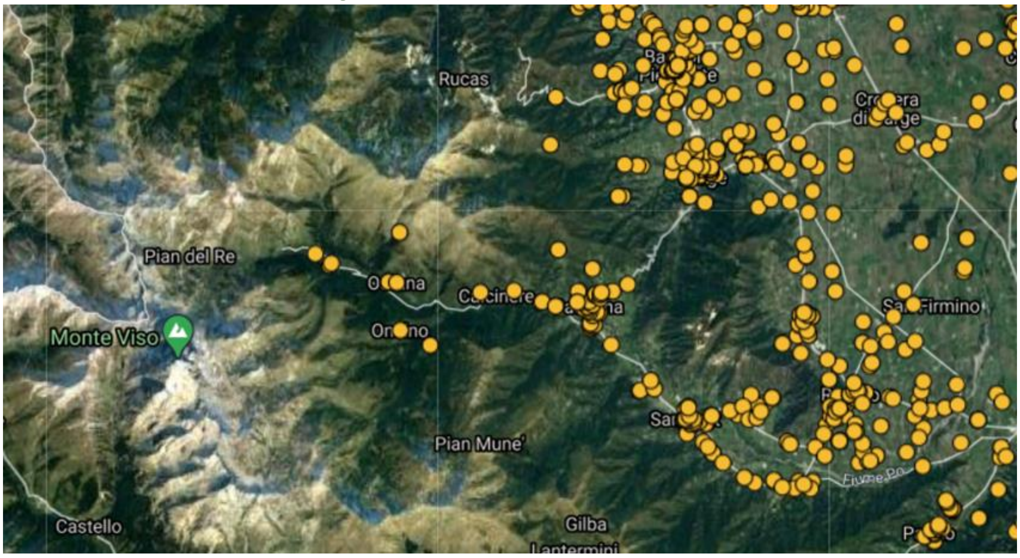


Figure 17 PV power plants

Figure 18 Biomass power plants

2.4.4. ELECTRIC ENERGY CONSUMPTION AND EMISSIONS

The data relating to electric energy consumption have been divided in the first instance between:

- Public: public buildings, public lighting.
- Private: residential sector and non-residential sectors (agriculture, industrial and tertiary).

The Data involved in the public sector are:

- D66a: electrical energy consumption in public buildings *[MWh_{el}/year]*: the data has been determined from municipalities' energy bills (2019 - real) and from the company "e-Distribuzione" (real);
- D73a: $C0_2$ emissions related to the electrical energy consumption in public buildings *[tCO_2/year]*: The CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.
- D66b: electrical energy consumption in public lightings *[MWh_{el}/year]*: the data has been determined from municipalities' energy bills (real) and from the company "e-Distribuzione" (real);
- D76: $C0_2$ emissions related to the electrical energy consumption in public lightings *[tCO_2/year]*. The CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.

The data have been taken from the annual consumption indicated on the bills. The definition of annual consumption is reported from the glossary of the Arera site[4]:

"Consumption of electricity or natural gas related to 12 months of supply derived from information on past consumption of the customer. If no actual data is available, this information is estimated. In the case of new activations, for which a data covering 12 months is not available, the seller must indicate in the bill that this is the consumption as detected or estimated from the beginning of supply, based on the data available to him, calling it "consumption from the supply commencement"; after 12 months should be available the actual data. The annual consumption for the electricity sector is further subdivided for each hourly time slot".

The Data involved in the private sector are:

- D66c: electrical energy consumption in private residential buildings *[MWh_{el}/year]*: the data were provided by "e-Distribuzione” as real aggregate data (2019 - real) and from the company".
- D66d: electrical energy consumption in private agricultural sector *[MWh_{el}/year]*: the data were provided by "e-Distribuzione” as real aggregate data (2019 - real) and from the company".
- D66e: electrical energy consumption in private tertiary and industrial sector *[MWh_{el}/year]*: the data were provided by "e-Distribuzione” as real aggregate data (2019 - real) and from the company".

[4] Glossario. https://bolletta.arera.it/bolletta20/index.php/glossario.

- D73c: CO_2 emissions related to the electrical energy consumption in private residential buildings *[tCO_2/year]*: the CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.
- D73d: CO_2 emissions related to the electrical energy consumption private agricultural sector *[[tCO_2/year]*: the CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.
- D76: CO_2 emissions related to the electrical energy consumption in private tertiary and industrial sector *[tCO_2/year]*: the CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.

The Data was collected in a special excel file reported completely for each municipality in the Annex. The dataset consists of a row for each building where all the data described below are collected.

Table 10 - Description of the electrical data collection tables

GENERAL DATA								
ABBREVIATIONS OF MUNICIPALITIES	PROGRESSION OF THE BUILDINGS	PROPERTIES	TYPE OF DATA	TYPE OF USERS	BUILDING / PLANT	P.O.D. ()	P.D.R.	ADDRESS
Univocal code for each municipality	Univocal code for each building	Public or private	Real, simulation	Electric, HVAC, or both	Name of building	Electric Point of Delivery	HVAC Point of Delivery	Address

ELECTRIC ENERGY						
CONSUMPTION		PRODUCTION				EMISSIONS ELECTRIC ENERGY
POWER TO THE METER	ENERGY CONSUMED	ENERGY SOURCE	ENERGY SOURCE	INSTALLED POWER	ENERGY GENERATED	
kW_p	kWh_e/year			kW_p	kWh_{el}/year	$kgCO_2$/year
maximum power withdrawn from the electric grid	electricity consumed in the last calendar year			maximum peak power that can be produced by the system (PV, CHP etc.)	electricity produced in the last calendar year	CO2 emissions generated by the energy consumed (considering the coefficients described above)

2.4.4.1. DATA RESULTS

The table 10 shows all the aggregated data at the municipal level. The data of the individual buildings are presented in Annex 1.

Table 11 Electrical energy consumption and related CO_2 emissions in public sector

GC AREA		Electrical energy consumption and related CO_2 emissions			
Code	Sign	Public buildings		Public lighting	
		[MWh$_{el}$/year]	*[tCO$_2$/year]*	*[MWh$_{el}$/year]*	*[tCO$_2$/year]*
		D66a	D73a	D66b	D73b
		Real / monitored data - Energy bills	*Calculated data*	*Real / monitored data - Energy bills*	*Calculated data*
1	BAP	142	44	607	189
2	BAR	165	52	677	211
3	BRO	7	2	46	14
4	CRI	19	6	74	23
5	ENV	Data not provided			
6	GAM	7	2	31	10
7	MAP	15	5	44	14
8	ONC	13	4	11	4
9	OST	46	14	16	5
10	PAE	265	83	331	103
11	PAG	20	6	81	25
12	REV	124	39	332	104
13	RIF	Data not provided			
14	SAN	87	27	138	43
TOTAL		909	284	2.388	745

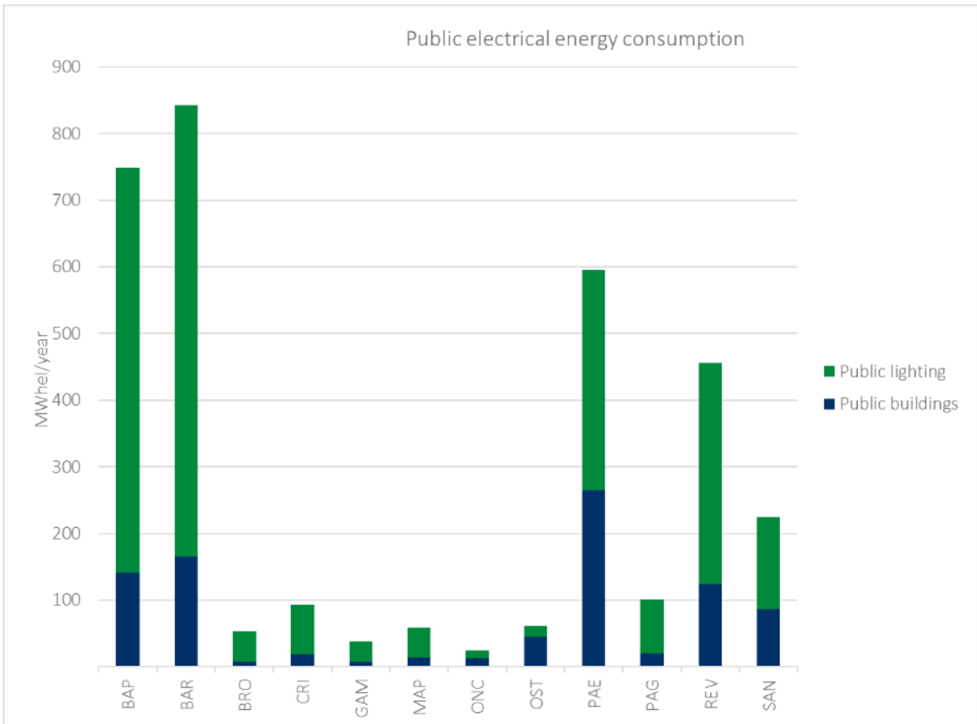


Figure 19 Distribution of electricity consumption between public lighting and public buildings

Table 12 Electrical energy consumption and related CO_2 emissions in private sector

GC AREA		Electrical energy consumption and related CO_2 emissions					
Code	Sign	Private buildings		Agriculture sector		Tertiary and Industrial sector	
		[MWh_{el}/year]	*[tCO_2/year]*	*[MWh_{el}/year]*	*[tCO_2/year]*	*[MWh_{el}/year]*	*[tCO_2/year]*
		D66c	D73c	D66d	D73d	D66e	D76
		Real data - e-distribuzione	*Calculated data*	*Real data - e-distribuzione*	*Calculated data*	*Real data - e-distribuzione*	*Calculated data*
1	BAP	6.012	1.876	337	105	9.875	3.081
2	BAR	7.238	2.258	3.347	1.044	29.097	9.078
3	BRO	286	89	3	1	74	23
4	CRI	344	107	29	9	332	103
5	ENV	3.978	1.241	597	186	3.381	1.055
6	GAM	361	113	17	5	174	54
7	MAP	840	262	49	15	182	57
8	ONC	95	30	0	0	20	6
9	OST	93	29	0	0	98	31
10	PAE	3.034	947	107	33	8.776	2.738
11	PAG	629	196	154	48	217	68
12	REV	4.099	1.279	3.808	1.188	6.451	2.013
13	RIF	2.088	651	522	163	1.566	489
14	SAN	2.337	729	451	141	3.372	1.052
TOTAL		31.434	9.807	9.422	2.940	63.614	19.848

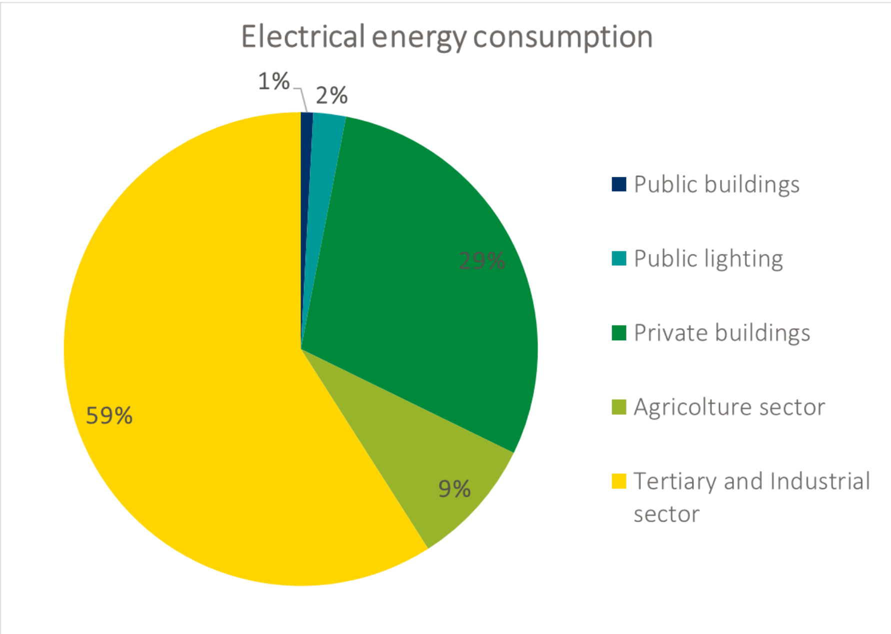


Figure 20 Electric energy consumption in the GC Area in relation to the sector

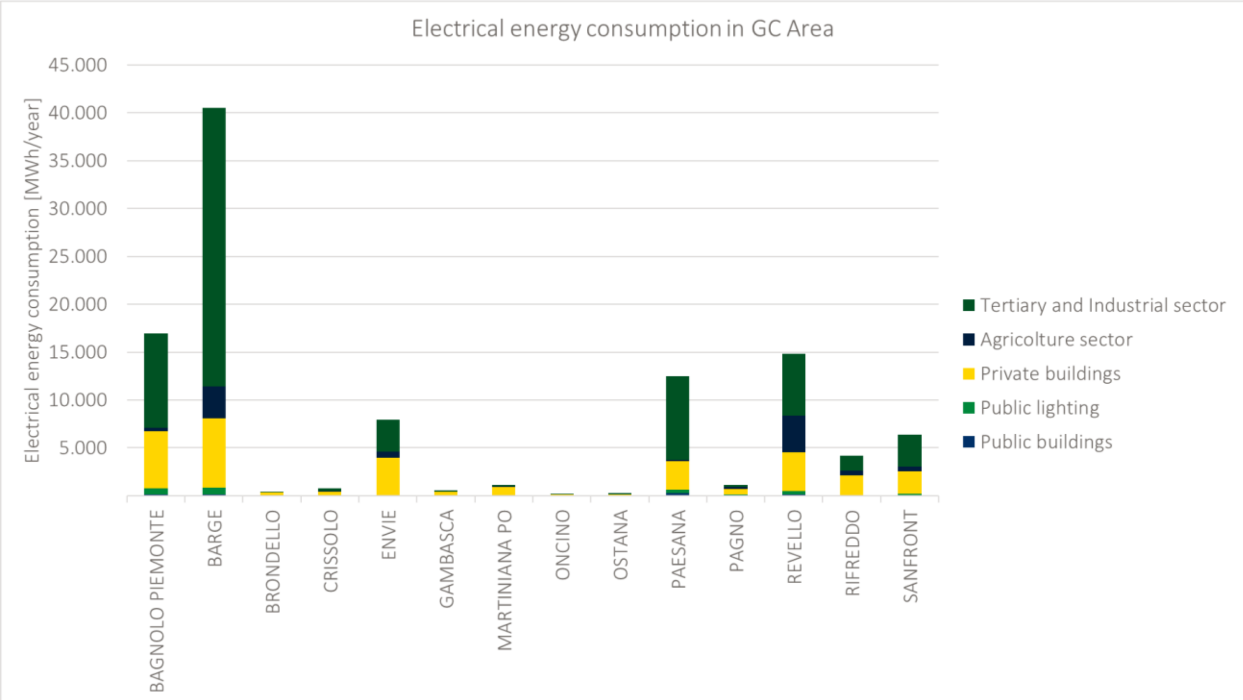


Figure 21 Electric energy consumption divided by municipality in relation to the sector.

2.4.5. HVAC ENERGY CONSUMPTION AND EMISSIONS

The data relating to HVAC energy consumption have been divided in the first instance between

- Public: public buildings
- Private: residential sector and non-residential sectors (agriculture, industrial and tertiary)

The Data involved in the public sector are:

- D65a: HVAC energy consumption in public buildings *[MWh_{el}/year]*: the data has been determined from municipalities' energy bills (2019 - real) (real).
- D73a: $C0_2$ emissions related to the HVAC energy consumption in public buildings *[tCO_2/year]*: The CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.

The Data involved in the private sector are:

- D65b: HVAC energy consumption in public buildings *[MWh_{el}/year]*: the data were obtained in different ways depending on the type of fuel:
  - Natural gas: real data from Siatel[5]
  - Biomass: simulated data deriving from (1) public databases of SIPEE and (2) dynamic loading and updating through the "Energy Tool" app developed by Compolab and IRIS during the GreenchainSaw4Life project

[5] https://www.consumienergia.it/portaleConsumi/

- Electric HVAC: simulated data deriving from public databases of SIPEE.
- Liquid Petroleum Gas: simulated data deriving from public databases of SIPEE.
- Diesel for Heating: simulated data deriving from public databases of SIPEE.
- Solar thermal: simulated data deriving from public databases of SIPEE.
- District heating: simulated data deriving from public databases of SIPEE.

- D72b: $C0_2$ emissions related to the HVAC energy consumption in private buildings *[tCO_2/year]*: The CO_2 emissions have been calculated in multiplying the energy consumption by the emission factor (EF) for the related energy vector.

The total HVAC consumption of the territory was then determined as the sum of public and private:

- D65: HVAC energy consumption in public and private buildings *[MWh_{el}/year]*
- D72c: C02 emissions related to the HVAC energy consumption considering both public and private buildings [tCO2/year]

The simulated data derive from public databases of SIPEE (Sistema Informativo per la Prestazione Energetica degli Edifici) of Regione Piemonte: in particular, the research has focused on APE (Attestato di Prestazione Energetica) and ACE (Attestato di Certificazione Energetica).

From the APE database, a simulation of the thermal loads has been carried out with calculations based on fuel consumption data, broken down by type of fuel and grouped across the entire building stock.

The buildings contained in the databases of SIPEE divide for construction categories, summarised in the following list based on the activities that are performed in the building and by the user type (art.3 del DPR 412/93):

- E.1 residential buildings
- E.2 collective residences, offices and similar buildings
- E.3 hospitals, clinics or nursing homes and similar buildings
- E.4 recreational, associative or cult activities and similar buildings
- E.5 commercial buildings
- E.6 buildings used for sports activities
- E.7 school Buildings
- E.8 agricultural, industrial and craft activities buildings

All the APE and ACE of all 14 municipalities of the investigated area were collected (provided by the environment sector of the Piedmont Region). The discriminating parameters used are:

- the total energy consumption, with a ceiling set at 100.000 kWh;
- the total energy consumption per unit area, with a ceiling set at 400 kWh/m^2.

The Data was collected in a special excel file reported completely for each municipality in the Annex. The dataset consists of a row for each building where all the data described below are collected.

Table 13 - Description of the HVAC data collection tables

GENERAL DATA								
ABBREVIATIONS OF MUNICIPALITIES	PROGRESSION OF THE BUILDINGS	PROPERTIES	TYPE OF DATA	TYPE OF USERS	BUILDING / PLANT	P.O.D. ()	P.D.R.	ADDRESS
Univocal code for each municipality	Univocal code for each building	Public or private	Real, simulation	Electric, HVAC, or both	Name of building	Electric Point of Delivery	HVAC Point of Delivery	Address

HVAC ENERGY					
FUEL / ENERGY SOURCE	ELECTRICITY CONSUMPTION FOR HVAC	THERMAL ENERGY CONSUMPTION FOR HVAC			EMISSION HVAC ENERGY
		INSTALLED POWER	FUEL CONSUMPTION	ENERGY CONSUMED	
	kWh_{el}/year	*kW_p*	*litres/year - Sm^3/year - kg/year*	*kWh_{th}/year*	*$kgCO_2$/year*
Type of fuel used by the HVAC system	Part of electricity consumption due to electrical HVAC systems	Sum of the peak power of HVAC systems	Sum of monthly fuel consumption of the last year available (2019)	Thermal energy consumed calculated with the conversion coefficients of measurement units and with the low heating values of each type of fuel	CO_2 emissions generated by the energy consumed (considering the coefficients described above)

2.4.5.1. DATA RESULTS

The table 13 and Table 14 shows all the aggregated data at the municipal level. The data of the individual buildings are presented in Annex 1.

Table 14 HVAC energy consumption and related CO_2 emissions in public and private sector

GC AREA			HVAC energy consumption and related CO_2 emissions					
			Public buildings		Private buildings		Total HVAC consumption and emissions	
Code	Sign	Municipality	*[MWh$_{th}$/year]*	*[tCO$_2$/year]*	*[MWh$_{th}$/year]*	*[tCO$_2$/year]*	*[MWh$_{th}$/year]*	*[tCO$_2$/year]*
			D65a	D72a	D65b	D72b	D65	D72
			Real / monitored data - Energy bills	*Calculated data*	*Real (Siatel) + Simulated data (SIPEE)*	*Calculated data*	*Calculated data*	*Calculated data*
1	BAP	BAGNOLO P.	861	177	33.824	6.883	34.685	7.059
2	BAR	BARGE	1.221	241	46.808	8.762	48.029	9.005
3	BRO	BRONDELLO	25	5	1.375	260	1.399	265
4	CRI	CRISSOLO	53	14	1.037	215	1.091	229
5	ENV	ENVIE	Data not provided		8.998	1.703	1.703	8.998
6	GAM	GAMBASCA	46	9	1.444	292	1.490	301
7	MAP	MARTIN. PO	196	27	4.109	822	4.305	849
8	ONC	ONCINO	Data not provided		413	71	71	413
9	OST	OSTANA	217	60	596	108	813	168
10	PAE	PAESANA	685	138	15.300	3.030	15.986	3.168
11	PAG	PAGNO	121	24	2.851	531	2.972	555
12	REV	REVELLO	Data not provided		23.910	4.839	4.839	23.910
13	RIF	RIFREDDO	Data not provided		4.138	838	838	4.138
14	SAN	SANFRONT	970	249	10.130	2.098	11.100	2.347
TOTAL			4.395	947	154.934	30.452	159.328	31.399

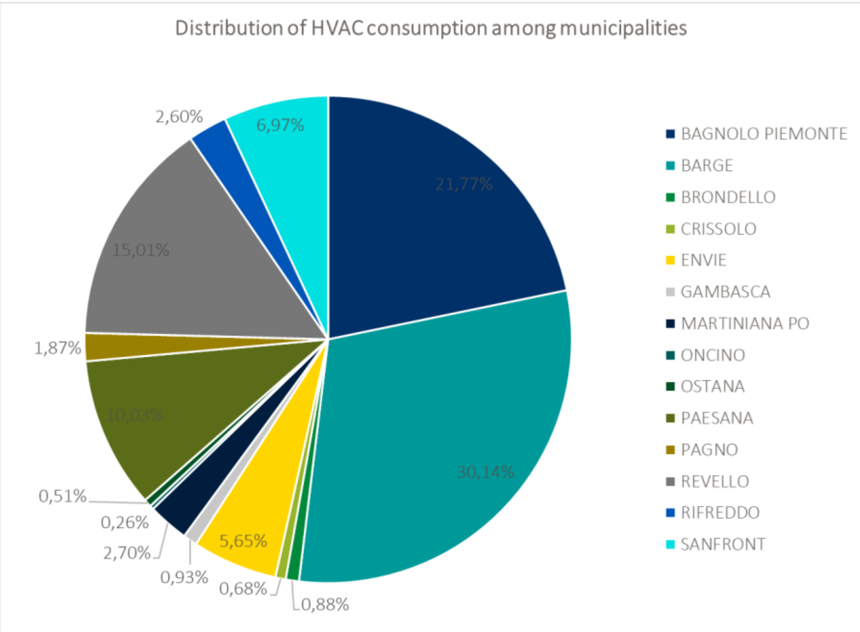


Figure 22 Distribution of HVAC consumption among the municipalities of the territory

Table 15 HVAC energy consumption in Gc area by type of fuel

Municipality	Biomass		Natural gas		Diesel fuel		LPG		Solar thermal panels		Biomass district heating		HVAC TOTAL	Unitary HVAC
	MWh_{el}/year	*tCO_2/year*	*MWh_{el}/year*	*tCO_2/year*	*MWh_{el}/year*	*tCO_2/year*	*MWh_{el}/year*	*tCO_2/year*	*MWh_{el}/year]*	*tCO_2/year*	*MWh_{el}/year*	*tCO_2/year*	*MWh_{el}/year*	*MWh_{el}/person*
	D65		D65		D65		D65		D65		D65		D65	
BAP	6.104	739	15.443	3.119	6.390	1.706	5.810	1.319	78				33.824	5,68
BAR	15.045	1.820	19.934	4.027	6.610	1.765	4.983	1.131	81		155	36	46.808	6,15
BRO	426	52	456	92	108	29	385	87					1.375	4,88
CRI	293	35	200	40	402	107	142	32	1				1.037	6,29
ENV	2.715	328	3.109	628	1.518	405	1.349	306	14		294	19	8.998	4,52
GAM	197	24	855	173	151	40	241	55					1.444	4,12
MAP	852	103	2.352	475	411	110	493	123					4.109	5,50
ONC	190	23	168	34	49	13	5	1					413	5,30
OST	265	32	181	37	128	34	22	5	0				596	7,02
PAE	4.092	495	6.518	1.317	4.047	1.081	605	137	38				15.300	5,64
PAG	720	87	1.825	369	173	46	128	29	6				2.851	5,09
REV	4.227	511	12.707	2.567	5.074	1.355	1.771	402	95		37	5	23.910	5,60
RIF	698	84	2.348	474	816	218	271	62	6				4.138	3,96
SAN	1.231	149	6.024	1.217	2.170	579	674	153	31				10.130	4,30
TOT.	37.055	4.484	72.119	14.568	28.045	7.488	16.879	3.842	348		486	59	154.934	5,49

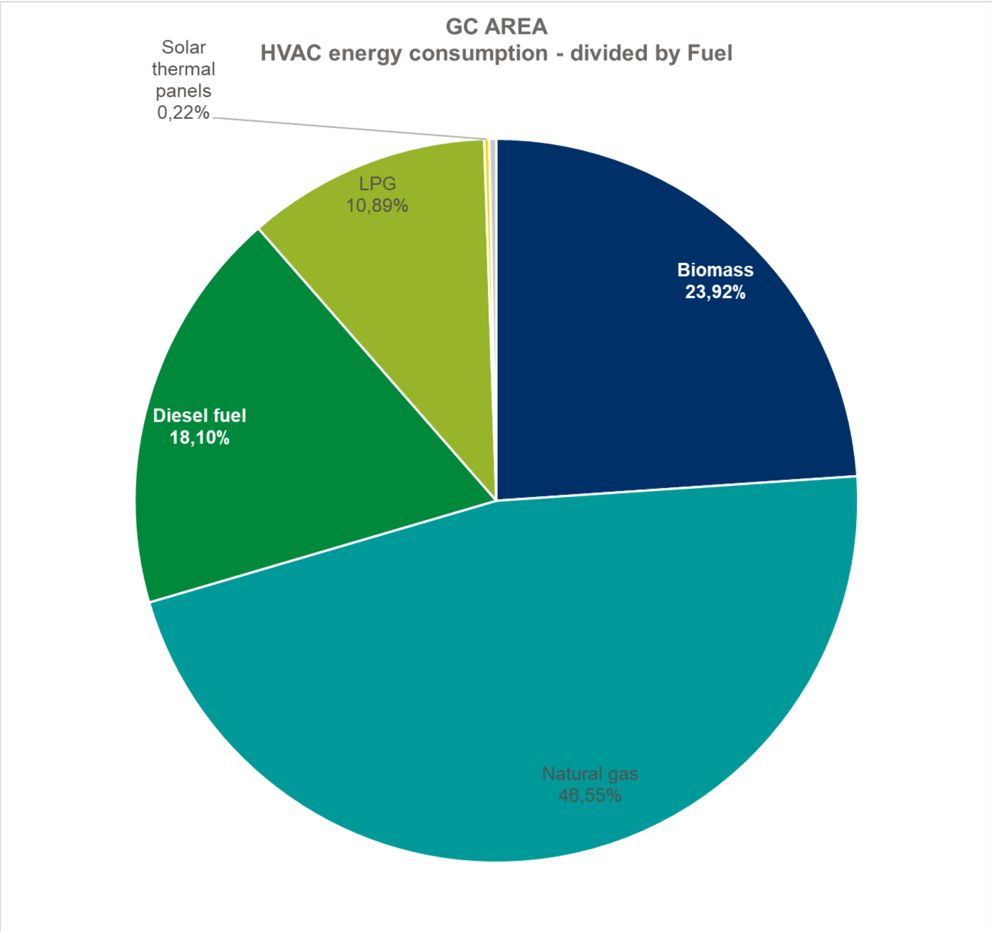


Figure 23 HVAC energy consumption divided by fuel.

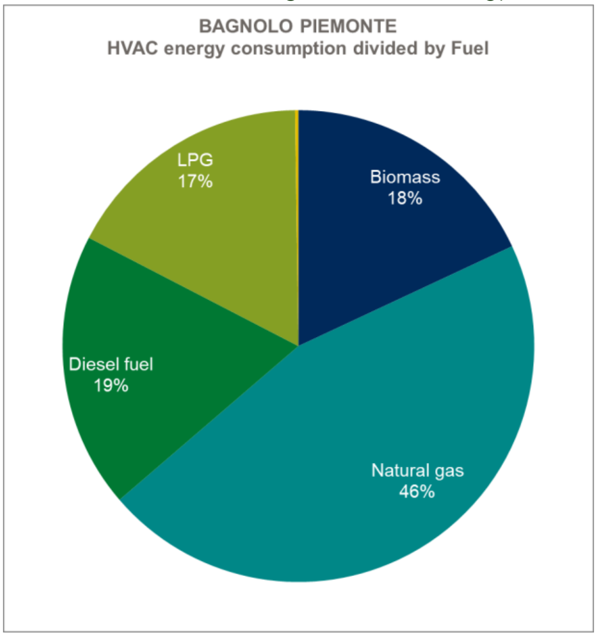
A HVAC energy consumption per inhabitant was then defined by dividing the total consumption of the municipality by the number of inhabitants-residents in the municipality. The consumption was determined taking into consideration the occupancy factor of the buildings from ISTAT source. The average per capita consumption value is 5,49 MWh year/person.

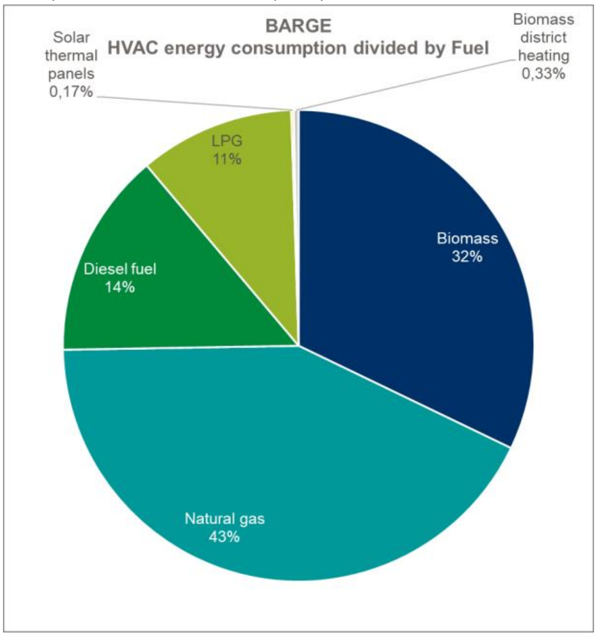
The graph (Figure 20) highlights how 75% of HVAC consumption comes from fossil sources and only the remaining 25% from renewable sources. The presence of electric and geothermal heat pumps is neglected as in most cases they are secondary systems supporting main fossil fuel systems.

Natural gas is the most used fuel (almost 47% of MWh/year - real data deriving from real SIATEL consumption), followed by biomass (24% data deriving from the survey and simulation - APE and ACE Regione archive). This allows us to highlight how about 24% (Figure 21) of consumption derives from biomass, a figure completely in line with the literature[6] (Table 4 and Table 22). In 2013, according to the ISTAT report, 20% of Italian families and 24,4% Piedmonts families used as main source of domestic heating biomass of plant origin. Between these, those of woody origin are the majority component. From the ISTAT report that the families make greater use of biomass as a source of heating in municipalities smaller ones, especially in the mountains.

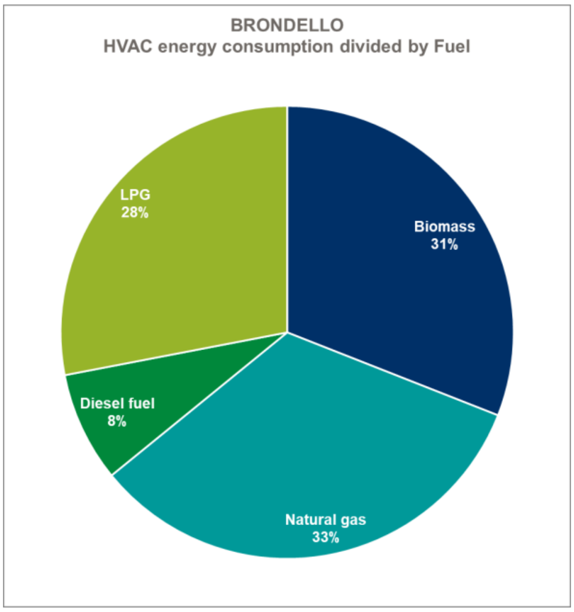
The graphs (Figure 21) on the following pages allow you to highlight the breakdown of HVAC consumption by fuel for each municipality. It is easy to highlight how in some higher and smaller municipalities (Oncino and Ostana for example) biomass represents the main source of heating with over 40% of total consumption. In some municipalities there are small biomass district heating and solar thermal systems for the production of domestic hot water. In some municipalities, although there is no natural gas grid, there is still a consumption attributable to the use of storage tanks disconnected from the grid.

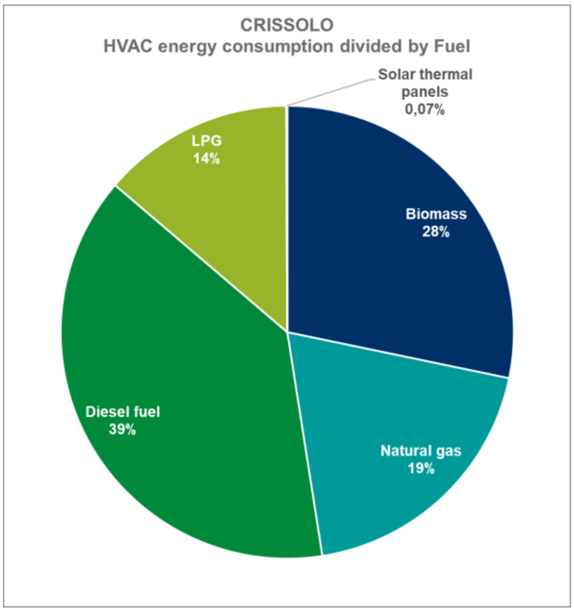
Figure 24 HVAC energy consumption by fuel for each municipality

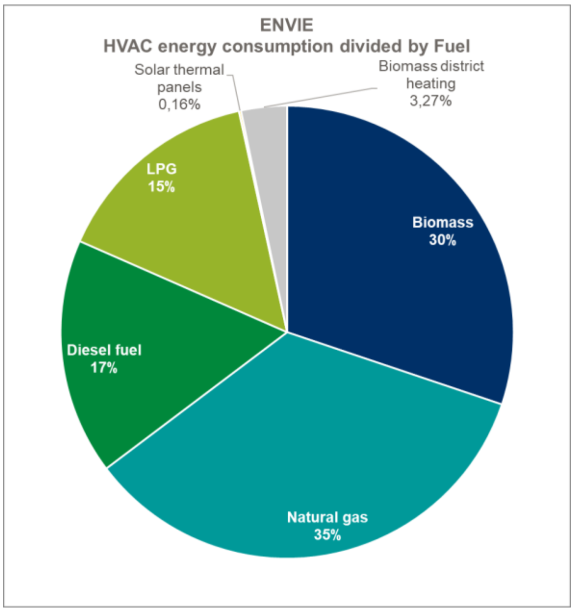


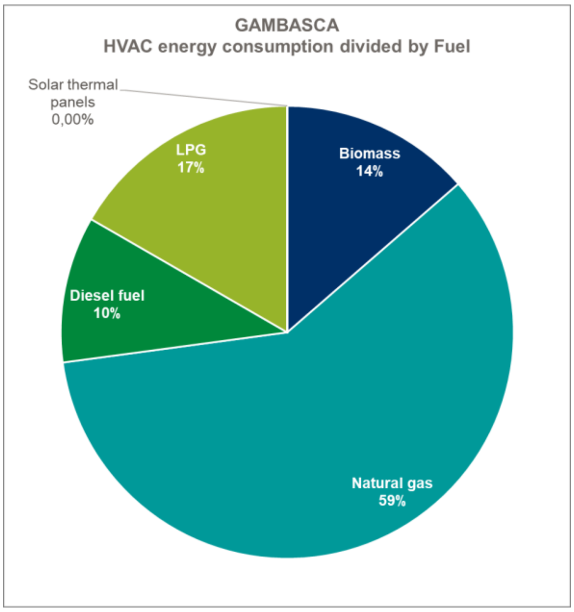


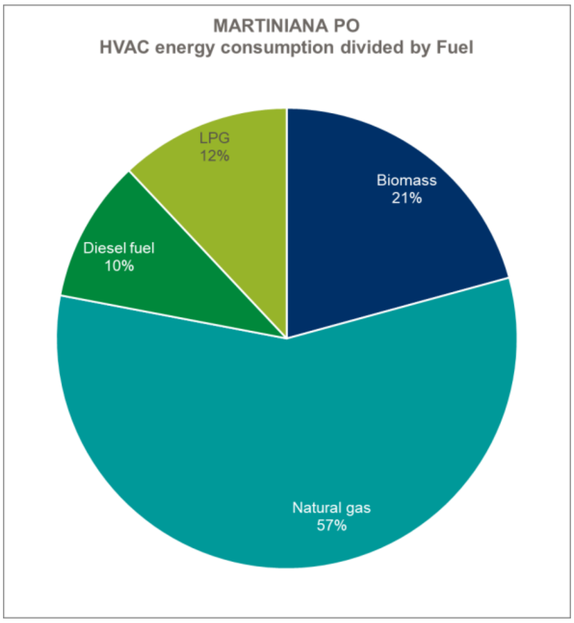
[6] AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Febbraio 2020

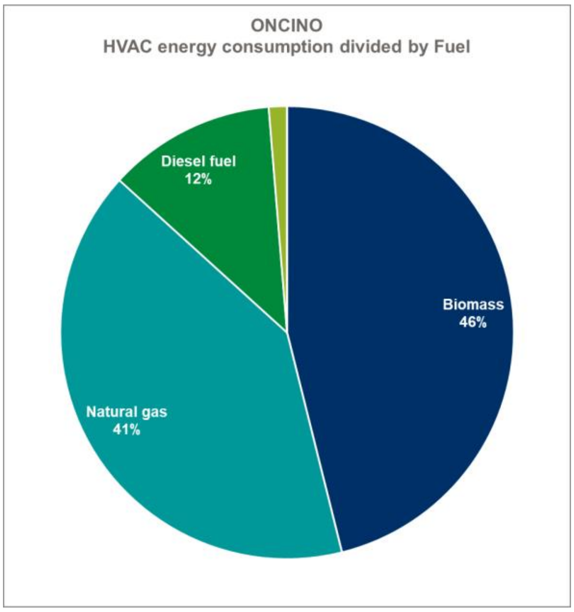

BRONDELLO
HVAC energy consumption divided by Fuel
LPG
28%
Biomass
31%
Diesel fuel
8%
Natural gas
33%

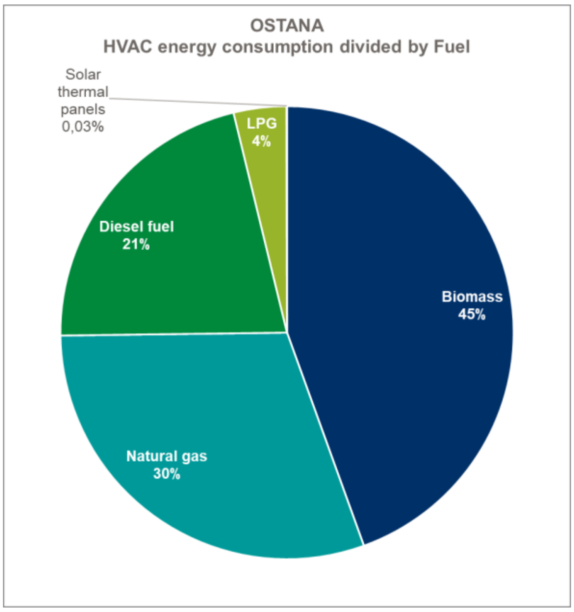

CRISSOLO
HVAC energy consumption divided by Fuel
Solar thermal
panels
0,07%
LPG
14%
Biomass
28%
Diesel fuel
39%
Natural gas
19%

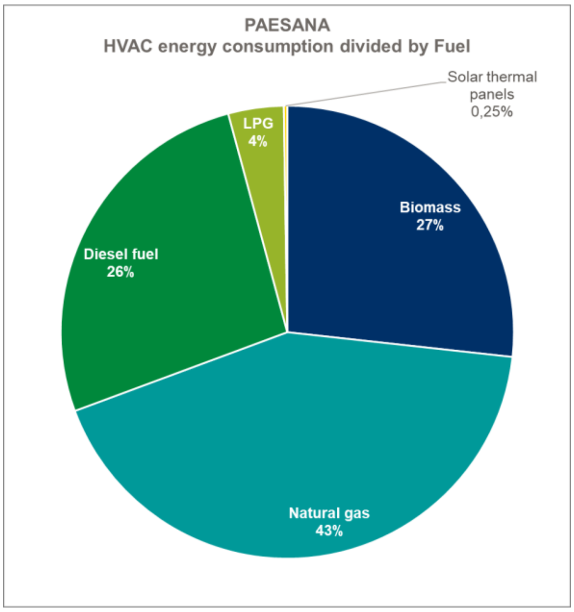

ENVIE
HVAC energy consumption divided by Fuel
Solar thermal
panels
0,16%
Biomass district
heating
3,27%
LPG
15%
Biomass
30%
Diesel fuel
17%
Natural gas
35%

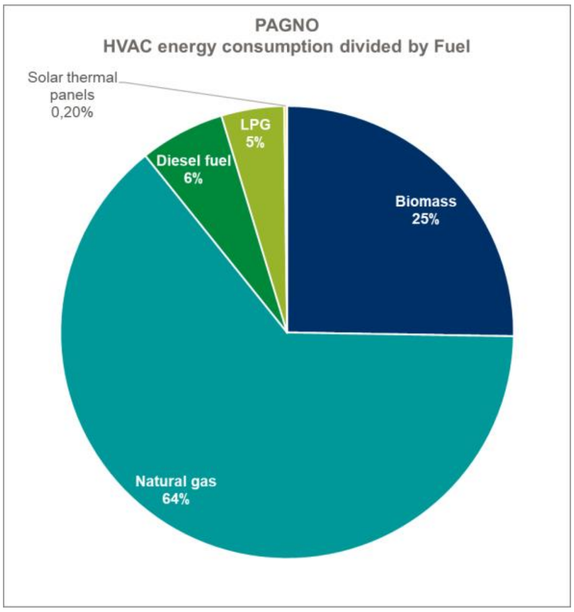

GAMBASCA
HVAC energy consumption divided by Fuel
Solar thermal
panels
0,00%
LPG
17%
Biomass
14%
Diesel fuel
10%
Natural gas
59%

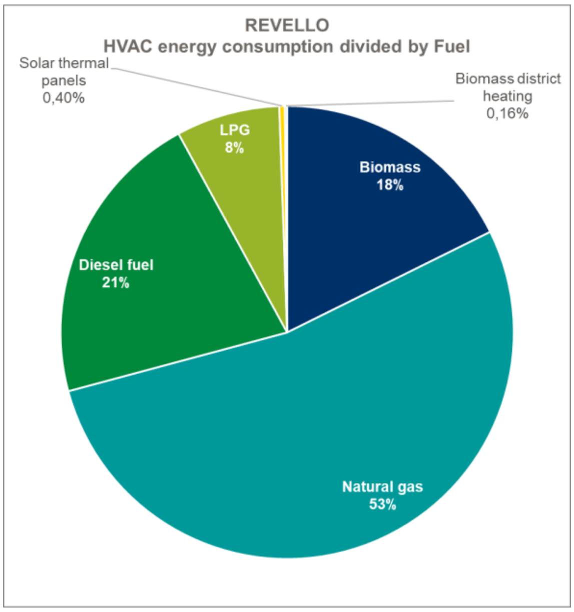

MARTINIANA PO
HVAC energy consumption divided by Fuel
LPG
12%
Biomass
21%
Diesel fuel
10%
Natural gas
57%

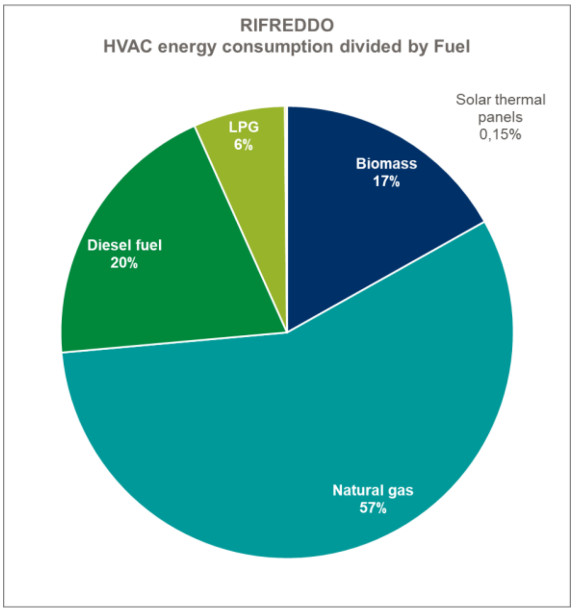

ONCINO
HVAC energy consumption divided by Fuel
Diesel fuel
12%
Biomass
46%
Natural gas
41%

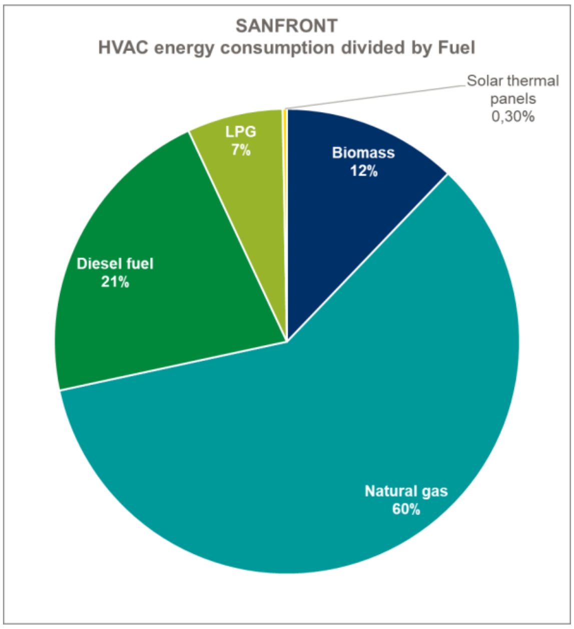

OSTANA
HVAC energy consumption divided by Fuel
Solar thermal panels 0,03%
LPG 4%
Diesel fuel 21%
Biomass 45%
Natural gas 30%


PAESANA
HVAC energy consumption divided by Fuel
Solar thermal panels 0,25%
LPG 4%
Biomass 27%
Diesel fuel 26%
Natural gas 43%


PAGNO
HVAC energy consumption divided by Fuel
Solar thermal panels 0,20%
LPG 5%
Diesel fuel 6%
Biomass 25%
Natural gas 64%


REVELLO
HVAC energy consumption divided by Fuel
Solar thermal panels 0,40%
Biomass district heating 0,16%
LPG 8%
Biomass 18%
Diesel fuel 21%
Natural gas 53%


RIFREDDO
HVAC energy consumption divided by Fuel
Solar thermal panels 0,15%
LPG 6%
Biomass 17%
Diesel fuel 20%
Natural gas 57%


SANFRONT
HVAC energy consumption divided by Fuel
Solar thermal panels 0,30%
LPG 7%
Biomass 12%
Diesel fuel 21%
Natural gas 60%

After determining the total consumption data divided by fuel, the consumption deriving from biomass was analysed in detail. By analysing in detail, the HVAC system biomass consumption, some important parameters are determined such as the consumption per building (calculated considering the number of buildings in each municipality heated mainly by biomass).
An average calorific value (LHV) of the biomass (dry u.r.<10%) of 4 kWh/kg was used for the calculations. This value is an average deriving from a weighted average between the use of pellets (4,4 kWh/kg), and wood chips (<4 kWh/kg).
In the case of the territory, an analysis has allowed us to define a weighted average coefficient according to the quantity of biomass deriving from forest management and that deriving from unsustainable management:

- wood chip and wood (70% of total biomass) with LHV < 4 kWh/kg
- pellet (30% of total biomass) with LHV of 4,4 kWh/kg

POTERI CALORIFICI	SPECIE LEGNOSE
4,0 kWh/kg	Faggio
4,1 kWh/kg	Pioppo, Acero, Robinia, Olmo
4,2 kWh/kg	Frassino, Quercia
4,3 kWh/kg	Larice
4,4 kWh/kg	Pino, Douglasia
4,5 kWh/kg	Picea, Abete

Variazione del P.C.I. del legno in vari stati idrici - (Fonte: Jonas e Haneder)

Stato del legno	Contenuto idrico (w)	Potere calorifico inferiore
Boschivo fresco	50 - 60%	2,0 kWh/kg = 7,2 MJ/kg
Stagionato per una estate	25 - 35%	3,4 kWh/kg = 12,2 MJ/kg
Stagionato per più anni	15 - 25%	4,0 kWh/kg = 14,4 MJ/kg
Stato anidro	0%	5,2 kWh/kg = 19 MJ/kg

Figure 25 Average LHV of biomass for energy valorisation – Source: Regione Piemonte "L'energia dal legno"

Table 15 collects the detailed data relating to the consumption of biomass for HVAC among the municipalities of the project.

Table 16 Biomass user for HVAC – data detail

Code	Sign	HVAC energy consumption - Biomass	HVAC emissions biomass	HVAC biomass consumption	Incidence of use of biomass for HVAC	Average biomass consumption per building
		[MWh_{el}/year]	*[tCO_2/year]*	*t/year*	*[%]*	*t/year*
		D65		D65		
		Real (Siatel) + Simulated data (SIPEE)	*Calculated data*	*Calculated data*	*Calculated data*	*Calculated data*
1	BAP	6.104	739	1.526	18,04%	3,36
2	BAR	15.045	1.820	3.761	32,14%	3,69
3	BRO	426	52	106	30,97%	2,35
4	CRI	293	35	73	28,26%	2,32
5	ENV	2.715	328	679	30,17%	2,71
6	GAM	197	24	49	13,62%	2,01
7	MAP	852	103	213	20,75%	2,93
8	ONC	190	23	48	46,11%	2,07
9	OST	265	32	66	44,49%	2,48
10	PAE	4.092	495	1.023	26,74%	2,71
11	PAG	720	87	180	25,26%	2,75
12	REV	4.227	511	1.057	17,68%	3,59
13	RIF	698	84	174	16,86%	2,36
14	SAN	1.231	149	308	12,16%	2,31
TOTAL	TOTAL	37.055	4.484	9.264	23,92%	3,15

In order to validate the biomass consumption data per building, the data deriving from ISTAT surveys and the data deriving from our analysis were compared. The comparison made it possible to obtain two completely concordant values: an average consumption per building equal to 3,2 t/year from Istat source against an average value of 3,15 t/year per building from our simulations.

Table 17 Total biomass consumption - [Source: AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Giugno 2020]

	Stima 2018		Indagine ISTAT 2013	
	pellet	legna	pellet	legna
Valle d'Aosta	11.624	66.246	13.368	74.241
Piemonte	249.833	1.227.531	138.203	1.759.641
Lombardia	282.245	1.134.936	250.018	1.461.341
Veneto	227.385	1.288.429	192.823	1.589.578
Friuli Venezia Giulia	47.510	464.119	53.134	565.285
Emilia Romagna	117.243	799.122	85.589	828.609
Provincia autonoma di Bolzano	27.213	299.118	36.185	312.741
Provincia autonoma di Trento	19.027	360.812	16.906	350.235
Totale complessivo	**982.081**	**5.640.312**	**786.226**	**6.941.671**

2.5. ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS DATA IN TRANSPORT SECTOR

2.5.1. METHODOLOGY AND SOURCES

Measuring transport emissions and collecting associated data is vital to guide climate change mitigation actions but can also guide more comprehensive transport policy and planning.

This section aims to provide practical approaches to build emission inventories for the transport macro-sector focusing on CO_2. Different resources and capabilities of local authorities are taken into account, and options are provided that are considered to be feasible to be implemented in mid-sized and even smaller local authorities.

Among the most common methodologies are fuel sales method, territorial method, residential method and city induced method. The method to be used to collect data is the territorial method. The reason for recommending the use of this bottom-up approach is that it is the only one fully in-line with the scope and principles of the Covenant of Mayors. It is based on the mileage driven within the local territory, and it can be relatively simple to apply while allowing identifying and quantifying mitigation actions. Using a territorial approach is also a good compromise in terms of accuracy and needed resources concerning the data collection, the estimation of the CO_2 emissions and the analysis of the impact of local actions.

It can be challenging to account for emissions from road transport activity sector in urban areas, given the nature of the road transport, which contains numerous mobile sources moving within but also across the boundaries of the urban territory, according to various patterns. Depending on the aim of the inventory, the energy consumption and associated emissions could be accounted for in different ways.

The following parameters are the base of the territorial method[7,8].

So, it has been used the below equation, to assess the total GHG emissions.

$$\boldsymbol{GHG\ emissions} = \Sigma_{\mathrm{MODES}}\, \Sigma_{\mathrm{FUELS}}\, [Emission\ factor * VKT * Energy\ intensity]$$

The input data are:

- **Fleet type distribution [n°]**: indicates the number of vehicles present in each municipality divided by type. This parameter was supplied for in each single municipality from ACI Automobile Club Italia[9] data and public vehicle data provided by the municipalities. The fuel used was also determined in the same way. In order to simplify the calculations, all the fuels in 3 main ones

[7] Pascua, P. & Rivas, I. S. Guidebook: 'How to develop a Sustainable Energy Access and Climate Action Plan (SEACAP) in Sub-Saharan Africa' Extended Document. (2018).
[8] Bertoldi, P. et al. Guidebook 'How to develop a Sustainable Energy and Climate Action Plan (SECAP)' PART 3-Policies, key actions, good practices for mitigation and adaptation to climate change and Financing SECAP(s). Publications Office of the European Union (2018). doi:10.2760/58898.
[9] Osservatorio ACI

(gasoline, diesel and electricity) have been combined. The percentage of electric cars is less than 0,04%[10] of the total fleet and therefore have not been included in the calculations.

- **Average mileage [km/year]**: the average number of km travelled each year (10,000 km) has been multiplied by a reduction coefficient equal to 50% as the remaining part of the trips are made outside the project area[11,12].
- **Average fuel consumption of each type of vehicle [l fuel/km]**: it depends on the types of vehicles in the category, their age and also on several other factors, such as the driving cycle. The data are available at EMEP/EEA 2016 air pollutant emission inventory guidebook 2016 (EEA, 2016)
- **Net Calorific Values (NCV) [Wh/l]** of each type of fuel are available as default values from IPCC.
- **Emission factors (EF) [tCO_2/MWh]** of each type of fuel are available as default values from IPCC.

Calculated parameters:

- **Vehicle-Kilometres Travelled (VKT)** [million km/year]: it is a measure of traffic flow. The value is determined by multiplying the **Fleet type distribution with the Average mileage.**
- **Fleet type distribution (D_{FT}) [% of VKT]**: indicates the percentage of distribution of motor vehicles according to the following classes: Municipal fleet, Public transport, Private and commercial transport.
- **Energy intensity (EI) [Wh/km]**: is a measure of the energy consumption for each kilometre travelled and deriving from the multiplication between consumption per km of fuel and the calorific value of the fuel.
- **Estimated Final energy consumption per fleet type (E_{FIN})** [MWh/year]: it is a measure of the total energy consumption in the municipality and derives from the multiplication between unit energy intensity and - Vehicle-Kilometres Travelled (VKT).
- **Estimated GHG emissions per fleet type (Em_{CO2}) [tCO_2/year]**: indicates the total emissions for each municipality determined by multiplying the Final energy consumption per fleet type for each fuel by the emission factor.

The calculation of the energy consumption and GHG emission related is explained in the following steps:

1. *Step 1*: Estimated activity/**mileage per fleet type** [million km/year] = Total VKT [million km/year] x Fleet type distribution (in % of VKT).
2. *Step 2*: **Energy intensity** per fleet type [Wh/km] = Average fuel consumption [l/km] x Net calorific value [Wh/l].
3. *Step 3*: Estimated **Final energy consumption** per fleet type [MWh/year] = Estimated mileage per fleet type [million km/year] x Energy intensity [Wh/km].

[10] Osservatorio ACI
[11] Osservatorio UnipolSai Assicurazioni
[12] Osservatorio ACI

4. *Step 4*: Estimated **GHG emissions** per fleet type [tCO_2] = Estimated Final energy consumption [MWh/year] x Emission factors [tCO_2/MWh].

The aggregated results have been put in the "FINAL DATA" sheet on Excel, where they cover the DATA D74a and D74b (Energy consumed by the transport sector and related CO_2 emissions).

2.5.2. DATA INPUT

The following tables show the input data for the entire project area and the calculations results.

Table 18 - Input data: Fleet type distribution [n°]

Input data: Fleet type distribution [n°]												
D_{FT}	Municipal fleet				Public transport			Private and commercial transport				Total
	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Mobility sharing	Mobility sharing (two	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	
	[n°]	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*
BAGNOLO PIEMONTE	4	3	4	1	2			4.478	7	803	676	**5.978**
BARGE	6	2	3	1	8			5.756	12	958	781	**7.527**
BRONDELLO	2	1	2					232	1	32	42	**312**
CRISSOLO	3	1	5					122	1	33	29	**194**
ENVIE					4			1.568	8	234	230	**2.044**
GAMBASCA			3					311	2	47	51	**414**
MARTINIANA PO	1		3					558	3	66	110	**741**
ONCINO								64		18	24	**106**
OSTANA	2	1	2					63	1	7	11	**87**
PAESANA	2		8		11			2.053	13	251	288	**2.626**
PAGNO	1		3					426		85	106	**621**
REVELLO								3.353	5	494	600	**4.452**
RIFREDDO					1			813	2	110	143	**1.069**
SANFRONT	2	1	6					1.799	6	244	338	**2.396**
GC AREA	23	9	39	2	26			21.596	61	3.382	3.429	28.567

Table 19 - Input data: Total mileage VKT (vehicle-kilometres travelled) and Fleet type distribution [n°]

Input data: Total mileage VKT (vehicle-kilometres travelled) and Fleet type distribution [n°]			
D_{FT}, VKT	TOTALE	Average mileage	Total mileage VKT (vehicle-kilometres travelled)
	[n°]	*[km/year]*	*[million km/year]*
BAGNOLO PIEMONTE	**5.978**	5.000	30
BARGE	**7.527**	5.000	38
BRONDELLO	**312**	5.000	2
CRISSOLO	**194**	5.000	1
ENVIE	**2.044**	5.000	10
GAMBASCA	**414**	5.000	2
MARTINIANA PO	**741**	5.000	4
ONCINO	**106**	5.000	1
OSTANA	**87**	5.000	0
PAESANA	**2.626**	5.000	13
PAGNO	**621**	5.000	3
REVELLO	**4.452**	5.000	22
RIFREDDO	**1.069**	5.000	5
SANFRONT	**2.396**	5.000	12
GREENCHAINSAW 4 LIFE AREA	**28.567**	5.000	143

Table 20 Input data: Average fuel consumption, NCV and Emission factors

Input data: Average fuel consumption, NCV and Emission factors													
FC_{AVG}, NCV, EF	Municipal fleet				Public transport			Private and commercial transport				Net Calorific value (NCV)	Emission factors (EF)
	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Mobility sharing	Mobility sharing	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers		
	[l/km]	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[l/km]*	*[Wh/l]*	*[tCO_2/MWh]*
Gasoline	0,077	0,130		0,040		0,069	0,040	0,077	0,130		0,040	9.200	0,249
Diesel	0,066	0,098	0,298		0,292	0,059		0,066	0,098	0,298		10.000	0,267
Electricity													0,479

Table 21 Input data: Energy intensity

Input data: Energy intensity											
EI	Municipal fleet				Public transport			Private and commercial transport			
	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Mobility sharing (cars)	Mobility sharing (two	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers
	[Wh/km]	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*	*[Wh/km]*
Gasoline	707	1.196		368		636	368	707	1.196		368
Diesel	658	980	2.980		2.920	592		658	980	2.980	
Electricity								186			

2.5.3. DATA CALCULATION AND RESULTS

Table 22 Calculation: Fleet type distribution (in % of VKT)

Fleet type distribution (in % of VKT)													
D_{FT}		Municipal fleet				Public transport			Private and commercial transport				Total
		Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Mobility sharing	Mobility sharing (two	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	
		[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
BAGNOLO PIEMONTE	**All fuels**	**0,1%**	**0,1%**	**0,1%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**74,9%**	**0,1%**	**13,4%**	**11,3%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				41,2%	0,0%	1,3%	11,3%	53,9%
	Diesel	0,0%	0,0%	0,1%		0,0%			33,7%	0,1%	12,1%		46,1%
	Electricity												0,0%
BARGE	**All fuels**	**0,1%**	**0,0%**	**0,0%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**76,5%**	**0,2%**	**12,7%**	**10,4%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				42,1%	0,0%	1,3%	10,4%	53,8%
	Diesel	0,0%	0,0%	0,0%		0,1%			34,4%	0,1%	11,5%		46,2%
	Electricity												0,0%
BRONDELLO	**All fuels**	**0,6%**	**0,3%**	**0,6%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**74,4%**	**0,3%**	**10,3%**	**13,5%**	**100,0%**
	Gasoline	0,4%	0,0%	0,1%	0,0%				40,9%	0,0%	1,0%	13,5%	55,9%
	Diesel	0,3%	0,3%	0,6%		0,0%			33,5%	0,3%	9,2%		44,1%
	Electricity												0,0%
CRISSOLO	**All fuels**	**1,5%**	**0,5%**	**2,6%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**62,9%**	**0,5%**	**17,0%**	**14,9%**	**100,0%**
	Gasoline	0,9%	0,1%	0,3%	0,0%				34,6%	0,1%	1,7%	14,9%	52,4%
	Diesel	0,7%	0,5%	2,3%		0,0%			28,3%	0,5%	15,3%		47,6%
	Electricity												0,0%
ENVIE	**All fuels**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,2%**	**0,0%**	**0,0%**	**76,7%**	**0,4%**	**11,4%**	**11,3%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				42,2%	0,0%	1,1%	11,3%	54,6%
	Diesel	0,0%	0,0%	0,0%		0,2%			34,5%	0,4%	10,3%		45,4%
	Electricity												0,0%
GAMBASCA	**All fuels**	**0,0%**	**0,0%**	**0,7%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**75,1%**	**0,5%**	**11,4%**	**12,3%**	**100,0%**
	Gasoline	0,0%	0,0%	0,1%	0,0%				41,3%	0,0%	1,1%	12,3%	54,9%
	Diesel	0,0%	0,0%	0,7%		0,0%			33,8%	0,4%	10,2%		45,1%
	Electricity												0,0%
MARTINIANA PO	**All fuels**	**0,0%**	**0,0%**	**0,7%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**75,1%**	**0,5%**	**11,4%**	**12,3%**	**100,0%**
	Gasoline	0,0%	0,0%	0,1%	0,0%				41,3%	0,0%	1,1%	12,3%	54,9%
	Diesel	0,0%	0,0%	0,7%		0,0%			33,8%	0,4%	10,2%		45,1%
	Electricity												0,0%
ONCINO	**All fuels**	**0,1%**	**0,0%**	**0,4%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**75,3%**	**0,4%**	**8,9%**	**14,8%**	**100,0%**
	Gasoline	0,1%	0,0%	0,0%	0,0%				41,4%	0,0%	0,9%	14,8%	57,3%
	Diesel	0,1%	0,0%	0,4%		0,0%			33,9%	0,4%	8,0%		42,7%
	Electricity												0,0%
OSTANA	**All fuels**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**60,4%**	**0,0%**	**17,0%**	**22,6%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				33,2%	0,0%	1,7%	22,6%	57,5%
	Diesel	0,0%	0,0%	0,0%		0,0%			27,2%	0,0%	15,3%		42,5%
	Electricity												0,0%
PAESANA	**All fuels**	**2,3%**	**1,1%**	**2,3%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**72,4%**	**1,1%**	**8,0%**	**12,6%**	**100,0%**
	Gasoline	1,3%	0,1%	0,2%	0,0%				39,8%	0,1%	0,8%	12,6%	55,0%
	Diesel	1,0%	1,0%	2,1%		0,0%			32,6%	1,0%	7,2%		45,0%
	Electricity												0,0%
PAGNO	**All fuels**	**0,1%**	**0,0%**	**0,3%**	**0,0%**	**0,4%**	**0,0%**	**0,0%**	**78,2%**	**0,5%**	**9,6%**	**11,0%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				43,0%	0,0%	1,0%	11,0%	55,0%
	Diesel	0,0%	0,0%	0,3%		0,4%			35,2%	0,4%	8,6%		45,0%

	Electricity												0,0%
REVELLO	**All fuels**	**0,2%**	**0,0%**	**0,5%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**68,6%**	**0,0%**	**13,7%**	**17,1%**	**100,0%**
	Gasoline	0,1%	0,0%	0,0%	0,0%				37,7%	0,0%	1,4%	17,1%	56,3%
	Diesel	0,1%	0,0%	0,4%		0,0%			30,9%	0,0%	12,3%		43,7%
	Electricity												0,0%
RIFREDDO	**All fuels**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**75,3%**	**0,1%**	**11,1%**	**13,5%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				41,4%	0,0%	1,1%	13,5%	56,0%
	Diesel	0,0%	0,0%	0,0%		0,0%			33,9%	0,1%	10,0%		44,0%
	Electricity												0,0%
SANFRONT	**All fuels**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**76,1%**	**0,2%**	**10,3%**	**13,4%**	**100,0%**
	Gasoline	0,0%	0,0%	0,0%	0,0%				41,8%	0,0%	1,0%	13,4%	56,3%
	Diesel	0,0%	0,0%	0,0%		0,1%			34,2%	0,2%	9,3%		43,7%
	Electricity												0,0%
PROJECT AREA	**All fuels**	**0,4%**	**0,1%**	**0,6%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**73,0%**	**0,3%**	**11,9%**	**13,6%**	**100,0%**
	Gasoline	**0,4%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**72,6%**	**0,1%**	**2,1%**	**24,7%**	**100,0%**
	Diesel	**0,4%**	**0,3%**	**1,2%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**73,4%**	**0,7%**	**23,9%**	**0,0%**	**100,0%**
	Electricity	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**100,0%**

Table 23 Calculation of final energy consumption

Calculation of final energy consumption											
E_{FIN}		Municipal fleet				Public transport	Private and commercial transport				Total
		Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	
		[MWh/year]	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*	*[MWh/year]*
BAGNOLO PIEMONTE	All fuels	14	15	54	2	29	15.331	35	10.768	1.244	27.491
	Gasoline	8	2		2		8.701	4		1.244	9.960
	Diesel	6	13	54		29	6.630	31	10.768		17.531
	Electricity										
BARGE	All fuels	21	10	40	2	117	19.706	60	12.847	1.437	34.239
	Gasoline	12	1		2		11.184	7		1.437	12.643
	Diesel	9	9	40		117	8.522	53	12.847		21.596
	Electricity										
BRONDELLO	All fuels	1	0	2	0	5	817	2	533	60	1.419
	Gasoline	0	0		0		464	0		60	524
	Diesel	0	0	2		5	353	2	533		895
	Electricity										
CRISSOLO	All fuels	4	3	17			494	3	267	48	836
	Gasoline	2	0				280	0		48	332
	Diesel	2	3	17			214	3	267		504
	Electricity										
ENVIE	All fuels	108	53	706			4.401	53	4.663	562	10.546
	Gasoline	61	6				2.498	6		562	3.134
	Diesel	47	46	706			1.903	46	4.663		7.412
	Electricity										
GAMBASCA	All fuels					12	1.087	8	636	86	1.829
	Gasoline						617	1		86	704
	Diesel					12	470	7	636		1.125
	Electricity										
MARTINIANA PO	All fuels			72			1.906	18	1.128	168	3.292
	Gasoline						1.082	2		168	1.252

	Diesel			72			824	16	1.128		2.040
	Electricity										
ONCINO	**All fuels**			10			273	3	161	24	471
	Gasoline						155	0		24	179
	Diesel			10			118	2	161		292
	Electricity										
OSTANA	**All fuels**	0		5			224	2	104	24	359
	Gasoline	0					127	0		24	151
	Diesel	0		5			97	2	104		207
	Electricity										
PAESANA	**All fuels**						5.428		5.980	1.094	12.502
	Gasoline						3.081			1.094	4.175
	Diesel						2.347		5.980		8.327
	Electricity										
PAGNO	**All fuels**	49	36	191			1.540	36	670	144	2.666
	Gasoline	28	4				874	4		144	1.055
	Diesel	21	31	191			666	31	670		1.611
	Electricity										
REVELLO	**All fuels**	12		182		272	11.916	110	5.706	898	19.097
	Gasoline	7					6.763	13		898	7.681
	Diesel	5		182		272	5.153	97	5.706		11.416
	Electricity										
RIFREDDO	**All fuels**	6		69			2.511		1.962	336	4.884
	Gasoline	3					1.425			336	1.764
	Diesel	3		69			1.086		1.962		3.120
	Electricity										
SANFRONT	**All fuels**						6.178	13	3.565	594	10.351
	Gasoline						3.506	2		594	4.102
	Diesel						2.672	12	3.565		6.249
	Electricity										
GC AREA	**All fuels**	**214**	**117**	**1.348**	**4**	**435**	**71.810**	**343**	**48.990**	**6.719**	**129.980**
	Gasoline	122	14		4		40.756	41		6.719	47.655
	Diesel	93	103	1.348		435	31.054	302	48.990		82.325
	Electricity										

Table 24 Calculation of CO_2 emissions

Calculation of CO_2 emissions											
Em_{CO2}		Municipal fleet				Public transport	Private and commercial transport				Total
		Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	Buses	Passenger cars	Light duty vehicles	Heavy duty vehicles	Two wheelers	
		[tCO_2/year]	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*
BAGNOLO PIEMONTE	**All fuels**	**4**	**4**	**14**	**0**	**8**	**3.937**	**9**	**2.875**	**310**	**7.161**
	Gasoline	2	0		0		2.167	1		310	2.480
	Diesel	2	4	14		8	1.770	8	2.875		4.681
	Electricity										
BARGE	**All fuels**	**5**	**3**	**11**	**0**	**31**	**5.060**	**16**	**3.430**	**358**	**8.914**
	Gasoline	3	0		0		2.785	2		358	3.148
	Diesel	2	2	11		31	2.275	14	3.430		5.766
	Electricity										
BRONDELLO	**All fuels**	**0**	**0**	**0**	**0**	**1**	**210**	**1**	**142**	**15**	**370**
	Gasoline	0	0		0		115	0		15	130
	Diesel	0	0	0		1	94	1	142		239
	Electricity										
CRISSOLO	**All fuels**	**1**	**1**	**4**			**127**	**1**	**71**	**12**	**217**
	Gasoline	1	0				70	0		12	83
	Diesel	0	1	4			57	1	71		135
	Electricity										
ENVIE	**All fuels**	**28**	**14**	**189**			**1.130**	**14**	**1.245**	**140**	**2.759**
	Gasoline	15	2				622	2		140	780
	Diesel	12	12	189			508	12	1.245		1.979
	Electricity										
GAMBASCA	**All fuels**					**3**	**279**	**2**	**170**	**21**	**476**
	Gasoline						154	0		21	175
	Diesel					3	126	2	170		300
	Electricity										
MARTINIANA PO	**All fuels**			**19**			**489**	**5**	**301**	**42**	**856**
	Gasoline						269	1		42	312
	Diesel			19			220	4	301		545
	Electricity										

ONCINO	**All fuels**			**3**			**70**	**1**	**43**	**6**	**123**
	Gasoline						39	0		6	45
	Diesel			3			31	1	43		78
	Electricity										
OSTANA	**All fuels**	**0**		**1**			**58**	**0**	**28**	**6**	**93**
	Gasoline	0					32	0		6	38
	Diesel	0		1			26	0	28		55
	Electricity										
PAESANA	**All fuels**						**1.394**		**1.597**	**272**	**3.263**
	Gasoline						767			272	1.040
	Diesel						627		1.597		2.223
	Electricity										
PAGNO	**All fuels**	**13**	**9**	**51**			**395**	**9**	**179**	**36**	**693**
	Gasoline	7	1				218	1		36	263
	Diesel	6	8	51			178	8	179		430
	Electricity										
REVELLO	**All fuels**	**3**		**49**		**73**	**3.060**	**29**	**1.524**	**224**	**4.961**
	Gasoline	2					1.684	3		224	1.913
	Diesel	1		49		73	1.376	26	1.524		3.048
	Electricity										
RIFREDDO	**All fuels**	**2**		**18**			**645**		**524**	**84**	**1.272**
	Gasoline	1					355			84	439
	Diesel	1		18			290		524		833
	Electricity										
SANFRONT	**All fuels**						**1.586**	**4**	**952**	**148**	**2.690**
	Gasoline						873	0		148	1.021
	Diesel						713	3	952		1.668
	Electricity										
GC AREA	**All fuels**	**55**	**31**	**360**	**1**	**116**	**18.440**	**91**	**13.080**	**1.673**	**33.847**
	Gasoline	30	3		1		10.148	10		1.673	11.866
	Diesel	25	28	360		116	8.291	81	13.080		21.981
	Electricity										

2.6. FINAL GC AREA RESULTS AND ANALYSYS

The collection of all the data described in the previous chapters made it possible to obtain a final summary tables (Table 24) and graphs of all the data collected during task C3.1 relating to the project area. The table below collects all the final data of the analyses, divided by production and consumption. Consumption is in turn divided into electricity consumption, HVAC consumption and the transport sector. For each consumption, emissions were then identified as a function of the fuels used for HVAC.

Table 25 Final GCArea results

	Pop.	Electric RES Production	Thermal RES Production	Total electric energy consumption and emissions		Total HVAC consumption and emissions		Total emission building sector	Transport sector energy consumption and emissions		Total emissions
	[ab.°]	*[MWh_{el}/year]*	*[MWh_{th}/year]*	*[MWh_{el}/year]*	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[tCO_2/year]*	*[MWh/year]*	*[tCO_2/year]*	*[tCO_2/year]*
	D1	D19	D20	D67	D73	D65	D72		D74a	D74b	
BAP	5.953	1.994	6.104	16.973	5.295	34.685	7.059	12.355	27.491	7.161	19.516
BAR	7.616	8.769	15.250	40.524	12.644	48.029	9.005	21.648	34.239	8.914	30.563
BRO	282	5	426	417	130	1.399	265	395	1.419	370	764
CRI	165	196	293	798	249	1.091	229	478	836	217	695
ENV	1.989	1.554	3.008	7.956	2.482	8.998	1.703	4.186	10.546	2.759	6.945
GAM	350	46	197	590	184	1.490	301	485	1.829	476	960
MAP	747	128	852	1.130	352	4.305	849	1.202	3.292	856	2.058
ONC	78	3	190	139	43	413	71	115	471	123	237
OST	85	31	309	252	79	813	168	247	359	93	340
PAE	2.713	1.356	4.092	12.513	3.904	15.986	3.168	7.072	12.502	3.263	10.335
PAG	560	133	720	1.102	344	2.972	555	899	2.666	693	1.592
REV	4.273	5.741	4.264	14.814	4.622	23.910	4.839	9.461	19.097	4.961	14.422
RIF	1.044	498	698	4.176	1.303	4.138	838	2.141	4.884	1.272	3.413
SAN	2.354	1.012	1.231	6.386	1.992	11.100	2.347	4.339	10.351	2.690	7.029
TOTAL	28.209	21.465	37.635	107.768	33.624	159.328	31.399	65.023	129.980	33.847	98.870

Table 26 Share of consumption covered by RES (theoretical figure)

Sign	Electric energy consumption covered by RES	HVAC energy consumption covered by RES
	[%]	*[%]*
	Calculated data	*Calculated data*
BAP	12%	18%
BAR	22%	33%
BRO	1%	31%
CRI	25%	28%
ENV	20%	34%
GAM	8%	14%
MAP	11%	
ONC	2%	46%
OST	12%	45%
PAE	11%	27%
PAG	12%	25%
REV	39%	18%
RIF	12%	17%
SAN	16%	12%
TOTAL	20%	24%

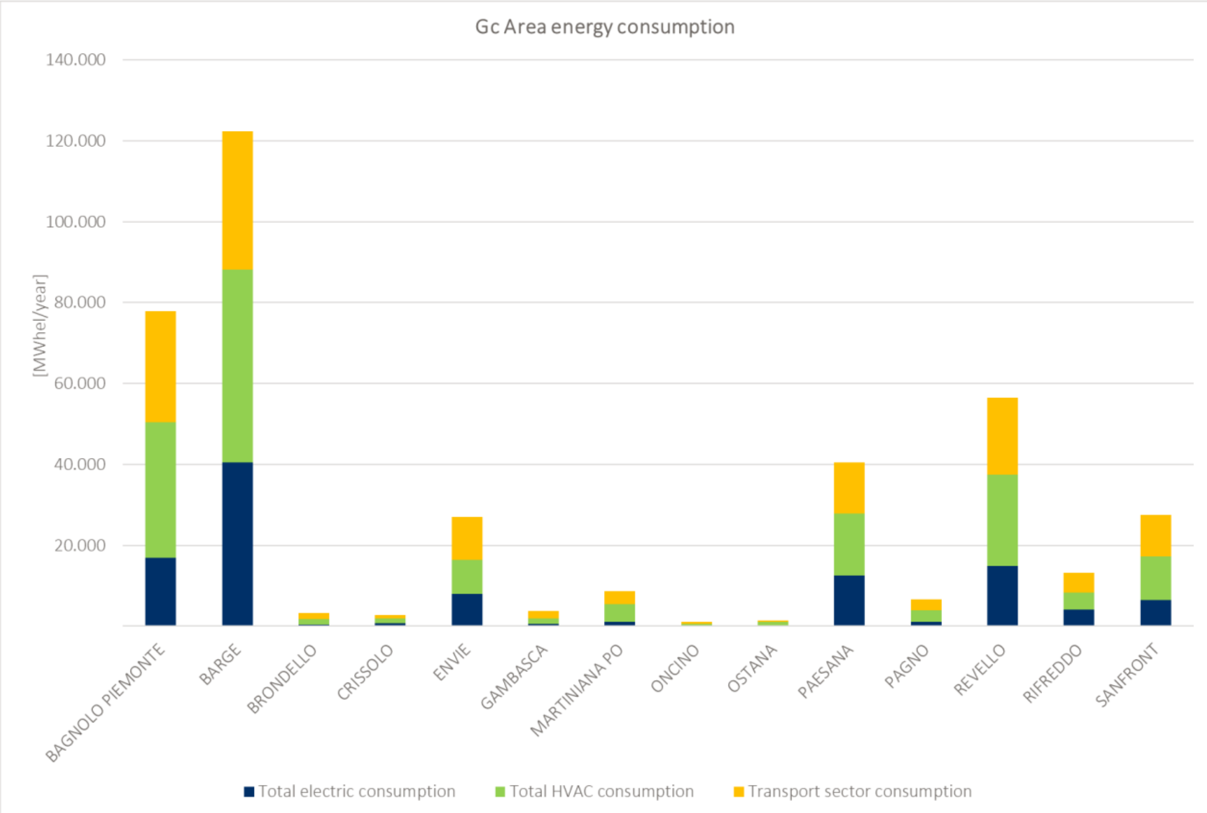


Figure 26 Distribution of energy consumption in each municipality

The percentage distribution of electricity consumption covered by RES (photovoltaic + hydroelectric) is only theoretical and does not consider actual self-consumption. This value could be real in the case of the establishment of an energy community with a self-consumption greater than 70% (Case study 03).

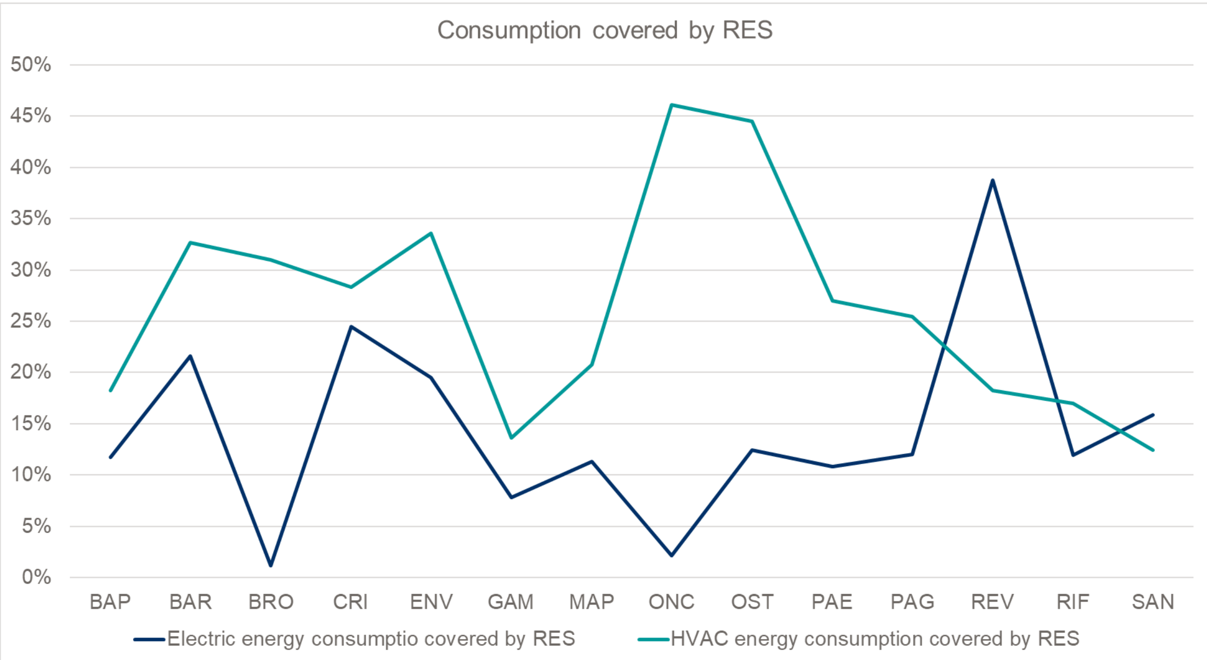


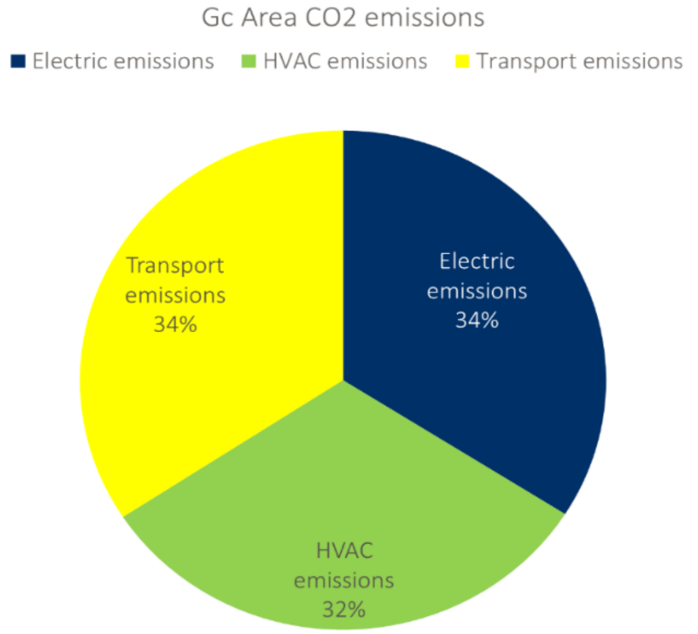
Figure 27 Consumption covered by RES.

The Energy consumption and related CO_2 emissions are shared almost equally:

- the transport sector 34% of the total,
- consumption of electricity 34%,
- consumption of HVAC systems 32%.

The building sector (residential and non-residential) therefore accounts for about 70% of total emissions in the territory.

Figure 28 Distribution of emissions by sector



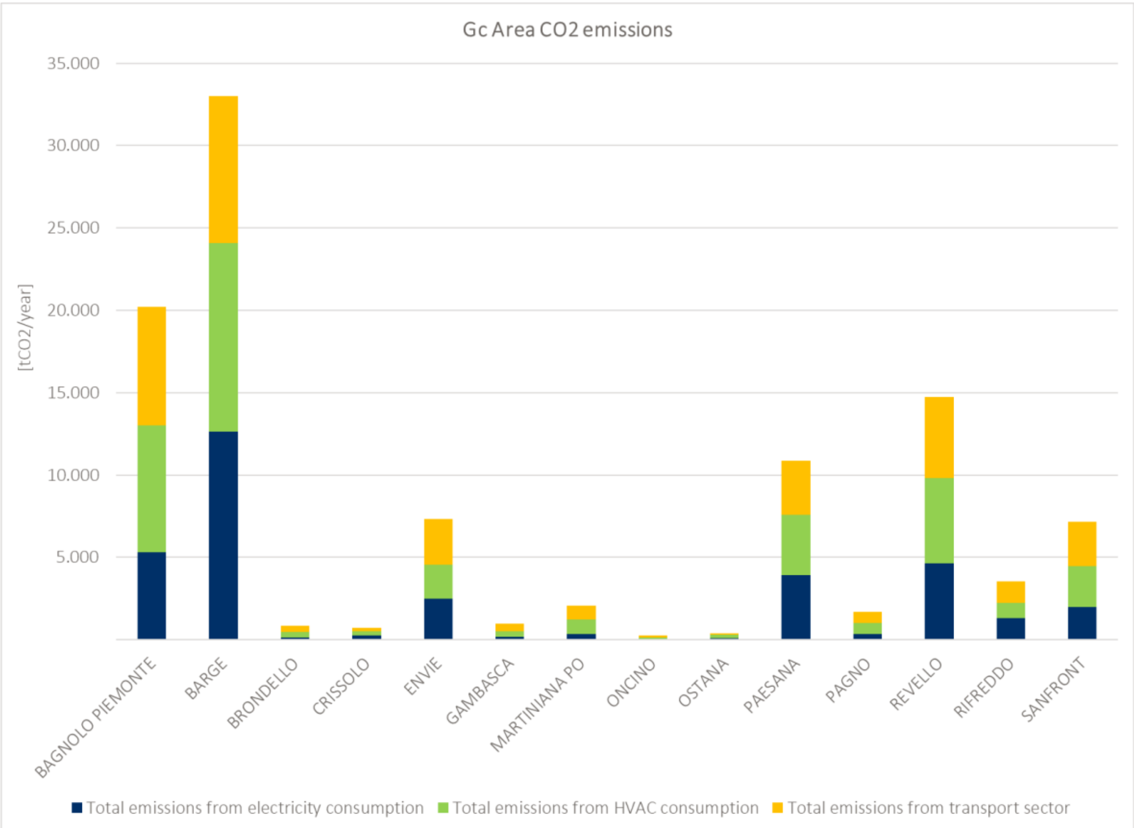


Figure 29 Distribution of CO2 emissions consumption in each municipality

Dividing the emissions by the number of inhabitants of each municipality determines an average value of CO_2 emissions per capita per year. This average value is higher in the municipalities with more industries (Barge and Bagnolo) and lower in the mountain municipalities where there are no large activities, and the buildings are mainly heated by local biomass.

Table 27 CO_2 emission per capita divider by sector

Sign	CO_2 emission per capita from electricity consumption	CO_2 emission per capita from HVAC consumption	CO_2 emission per capita (buildings + transport sector)	CO_2 emission per capita (buildings + transport sector)
	[tCO_2/year]	*[tCO_2/year]*	*[tCO_2/year]*	*[tCO_2/year]*
	D73	D73	D74b	D73
	Calculated data	*Calculated data*	*Calculated data*	*Calculated data*
BAP	0,89	1,19	1,20	3,28
BAR	1,66	1,18	1,17	4,01
BRO	0,46	0,94	1,31	2,71
CRI	1,51	1,39	1,32	4,21
ENV	1,25	0,86	1,39	3,49
GAM	0,53	0,86	1,36	2,74
MAP	0,47	1,14	1,15	2,75
ONC	0,56	0,91	1,57	3,04
OST	0,93	1,98	1,10	4,00
PAE	1,44	1,17	1,20	3,81
PAG	0,61	0,99	1,24	2,84
REV	1,08	1,13	1,16	3,38
RIF	1,25	0,80	1,22	3,27
SAN	0,85	1,00	1,14	2,99
TOTAL	1,19	1,11	1,20	3,50

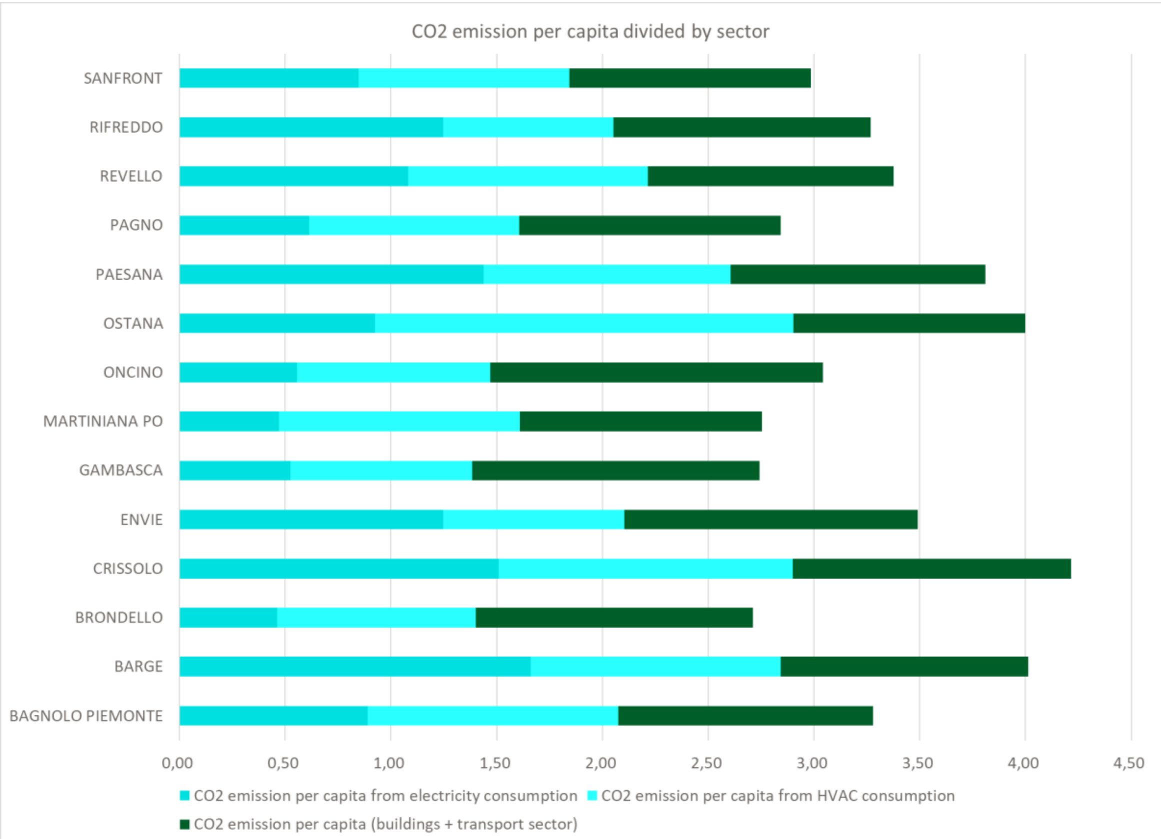


Figure 30 CO_2 emissions per capita divide by sector

3. FUNDING GUIDELINES (TASK 3.2)

3.1. METHODOLOGY AND SOURCES

The main objective of this chapter is to create a simple guide of all the incentives present at the regional and national level for the efficiency improvements of the plants. The first part describes the main national incentives on the installation of renewable sources to replace fossil sources.

The following incentives are analysed (Table 28):

- Superbonus 110% for private
- Ecobonus 50% and 65% for private
- Conto Termico for public
- Certificati bianchi for public with ESCO collaboration
- CAR Cogenerazione alto Rendimento

Every analysis is made on the incentives for the HVAC systems. The incentives for the building envelope interventions will be dealt with in the deliverable DL C3.

Ambito di intervento	PRIVATI CITTADINI	CONDOMINI	IMPRESE	PA
Involucri edilizi	Detrazioni 50% Ecobonus 65% Superbonus 110%	Detrazioni 50% Ecobonus 65% Superbonus 110%	CERTIFICATI BIANCHI	CONTO TERMICO PREPAC (PA Centrale)
Impianti climatizzazione	Detrazioni 50% Ecobonus 65% Superbonus 110% CONTO TERMICO CERTIFICATI BIANCHI CB - CAR	Detrazioni 50% Ecobonus 65% Superbonus 110% CONTO TERMICO CERTIFICATI BIANCHI CB - CAR	Ecobonus 65% CONTO TERMICO CERTIFICATI BIANCHI CB - CAR	CONTO TERMICO CERTIFICATI BIANCHI PREPAC (PA Centrale) CB - CAR
Sistemi di illuminazione e building automation	Detrazioni 50% Ecobonus 65% Superbonus 110%	Detrazioni 50% Ecobonus 65% Superbonus 110%	Ecobonus 65% CERTIFICATI BIANCHI	CONTO TERMICO PREPAC (PA Centrale)
Teleriscaldamento	CB - CAR	CB - CAR	CB - CAR	CB - CAR
Autoconsumo fotovoltaico e sistemi di accumulo	Detrazioni 50% Superbonus 110% SCAMBIO SUL POSTO RITIRO DEDICATO DM ISOLE MINORI AUTOCONSUMO AUTOCONSUMO COLLETTIVO	Detrazioni 50% Superbonus 110% DM ISOLE MINORI SCAMBIO SUL POSTO RITIRO DEDICATO AUTOCONSUMO AUTOCONSUMO COLLETTIVO	SCAMBIO SUL POSTO RITIRO DEDICATO DM 2019 (c.d. FER-1, solo per potenza > 20 KW) DM ISOLE MINORI AUTOCONSUMO AUTOCONSUMO COLLETTIVO COMUNITÀ ENERGETICHE Nuova Sabatini Credito d'Imposta	SCAMBIO SUL POSTO DM ISOLE MINORI AUTOCONSUMO AUTOCONSUMO COLLETTIVO COMUNITÀ ENERGETICHE RITIRO DEDICATO PREPAC (PA Centrale)

Figure 31 Table of currently funding for intervention of energy efficiency.

3.2. KNOWLEDGE OF INCENTIVES

Regarding the availability of incentives economic and the propensity to replace the old appliances, little more than the half (52%) said they were willing to change your system with a more efficient and less polluting one if economically incentivized.

Only the 30% of users are aware of it of the incentives provided for by the Conto Termico[13].

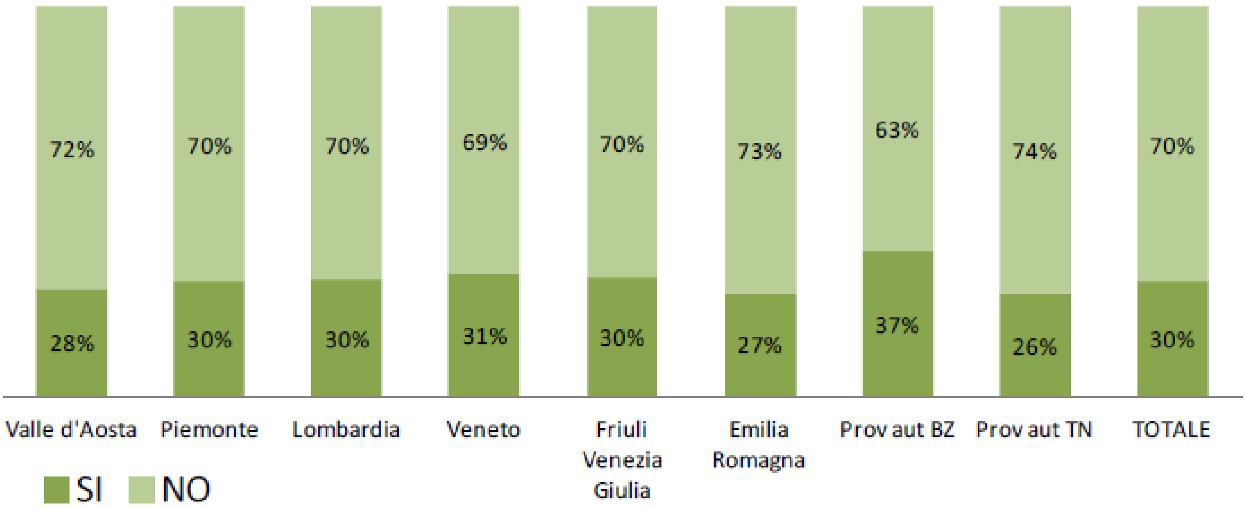


Figure 32 Average Knowledge of the available incentives [Source: AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Giugno 2020]

3.3. SUPERBONUS 110%

The Superbonus 110% is a benefit established by the "Decreto Rilancio" which raises to 110% the tax detraction rate for expenses sustained from July 1/2020 to December 31/2021, for specific interventions in the fields of energy efficiency, anti-seismic interventions, installation of photovoltaic systems or infrastructures for electric vehicle charging in buildings.

The detractions are a form of concessions consisting of the possibility of subtracting certain sums from the gross tax. In particular, detractions are due to taxpayers who have dependant family members or who possess income deriving from subordinate work or pension, self-employed or freelance work or small businesses[14].

The new measures come in addition to the detractions provided for interventions for the restoration of the building stock, including those for the reduction of seismic risk (so-called Sismabonus) and energy requalification of buildings (so-called Ecobonus, explained here in paragraph -).

13 Arpav 2018, Progetto Life+PrepAir

[14] Glossary - Agenzia delle Entrate. https://www.agenziaentrate.gov.it/portale/web/english/nse/glossary.

The detraction is granted in the amount of 110%, to be distributed among the entitled parties in 5 annual tranches of equal amount, within the limit of the beneficiary's earning capacity.

One of the new features introduced is the possibility, instead of using the detraction directly, of an early subsidy in the form of a discount from the goods or services suppliers. In this way, the supplier who applied the discount in the invoice can directly use the tax credit as compensation in F24 in five annual instalments, or it can transfer it, without limitations (as many times as desired) to any other entity (companies, banks, private citizens, etc.).

In other words, it is possible to transfer the credit corresponding to the detraction amount receivable.[9]

For completeness, the compensation is the possibility to make use of one's credits in order to reduce the amount of taxes, sanctions, contributions and sums due. Compensations are made effective by indicating them in the F24 form[15].

The beneficiaries of the Superbonus are:

- individuals, not involved in business activities, arts and professions;
- condominiums;
- third sector organisations and amateur sports associations;
- autonomous institutions of social housing (in Italian "Istituti Autonomi Case Popolari" - Iacp).

The leading interventions concern[16]:

- thermal insulation of opaque surfaces (>25% of the gross heat dissipating surface of the building);
- replacement of existing winter air conditioning systems with centralised systems for heating, cooling or domestic hot water supply with:
- condensing boilers;
- heat pumps;
- hybrid plants (heat pump integrated with condensing boiler, assembled in the factory and designed explicitly by the manufacturer to work in combination together);
- micro-cogeneration plants.

In order to access the detraction, the interventions must ensure the improvement of at least two energy classes or the achievement of the A4 class, to be proven by the energy performance certificate (APE - Attestato di Prestazione Energetica).

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[15] Schede - Riqualificazione energetica - Che cos'è - Agenzia delle Entrate. https://www.agenziaentrate.gov.it/portale/schede/agevolazioni/detrazione-riqualificazione-energetica-55-2016/cosa-riqualificazione-55-2016.

[16] Decreto Ecobonus 2020 come funziona incentivi e detrazioni 110 50 65 | ABB. https://new.abb.com/low-voltage/it/campagne/decreto-rilancio-2020-ecobonus.

There is also a list of interventions which can be financed if they are made in combination with the main ones:

- installation of grid-connected photovoltaic systems on buildings;
- installation of storage systems integrated with photovoltaic systems;
- installation of infrastructure for electric vehicles charging in the building.
- installation of thermodynamic solar panels;
- installation of condensing warm air heaters;
- connection to efficient district heating systems;
- installation of domestic hot water heat pumps;
- installation of biomass heat generators;
- installation of building automation systems for energy efficiency;
- installation of charging infrastructures for electric vehicles.

The access mode is described in the following list, with the procedure of data transmission on the ENEA website (to be done within 90 days after the intervention):

- register as an authenticator;
- access the system;
- fill in the authentication;
- print, sign and scan the generated document;
- reload and protocol the document;
- download the registered authentication[17].

It is necessary to apply for a conformity certificate for the documentation proving the fulfilment of the prerequisites for tax detraction. The party issuing the conformity certificate verifies the presence of the asseverations and certificates released by the responsible professionals.

The asseveration allows to demonstrate that the realised intervention meets the technical requirements and that the corresponding incurred expenses are appropriate. It has to be issued at the end of the works and for each working stage. All the data must be transmitted on the ENEA website within 90 days after the intervention.

If the realised intervention belongs to several eligible categories, the user can take advantage of only one of the existing incentives, respecting the specific requirements of each one.

If several interventions are carried out, which can be attributed to different eligible cases, the user can benefit from each grant, within each spending limit.

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17 Detrazioni fiscali ENEA - Asseverazioni. https://detrazionifiscali.enea.it/superecobonus.asp.

The conditions to be met are as follows:

- the expenses relating to the various interventions must be accounted for separately;
- the specific requirements for each detraction must be respected[18].

The expenditure limits put are taken from:

- table 4 of the guide on Superbonus 110% of Agenzia delle Entrate;
- general table of the course on Superbonus 110% held by ABB and Energy & Strategy Group of Politecnico di Milano.

3.4. ECOBONUS 50% & 65%

The "Decreto Rilancio" extends to December 31, 2020, the already existing (from 2006) tax detractions for the energy efficiency of buildings (Ecobonus), concerning expenses incurred from January 1 to December 31 2020.

For most interventions the detraction is 65%, for others, it is 50%.

The beneficiaries of the Ecobonus are:

- public and private entities not engaged in commercial activities;
- individuals;
- associations between professionals;
- professionals;
- taxpayers who earn business income (individuals, partnerships, corporations);
- autonomous institutions of social housing (only for 70% and 75% detraction).

The following list shows the interventions financed by the Ecobonus and Sismabonus (a version including seismic retrofitting actions).

Ecobonus:

- energy requalification interventions performed on the shared portions of buildings (since 2018 it has also been extended to those who carry out the actions of efficiency enhancement on the single property unit);
- energy requalification interventions that affect the building envelope with an incidence greater than 25% of the gross heat dispersion surface of the building itself;
- interventions aimed at improving the winter and summer energy performance.

18 Comunicazione, U. & Pubblicazioni, S. Le agevolazioni fiscali per il risparmio energetico. (2017)

Sismabonus:

- interventions concerning the adoption of anti-seismic measures;
- interventions related to the execution of structural safety works carried out on the shared parts of buildings;
- interventions aimed at the reduction in seismic risk on the individual property units.

The Ecobonus has the advantage of not requiring the improvement of at least two energy classes or the achievement of the A+ class. So, it's possible to make interventions on A+ buildings. It's an incentive focused on the single available technology and not the leap in the category.

The condensing boilers have the following technical requirements to be met:

- for Ecobonus 50%: average seasonal efficiency at least equal to class A of the product (Regulation EU no. 811/2013);
- for Ecobonus 65%: installation of advanced thermoregulation systems (classes V, VI or VIII of the Commission communication 2014/C 207/02);
- it is not possible to finance the installation of winter air conditioning systems in buildings that were not equipped with such systems. So, the intervention must replace totally or partially the old heat generator and shouldn't be a new installation;
- if the rated power is higher than 100 kW, there are three more requirements:
- installation of a modulating burner;
- climate regulation must operate directly on the burner;
- installation of a variable speed electronic pump or similar systems.

For the high-efficiency heat pumps, the technical requirements are as follows:

- the intervention must replace totally or partially the old HVAC system and shouldn't be a new installation;
- it's necessary the contextual realisation of a distribution system, balanced with the flow rates;
- the intervention has to ensure the minimum values (established in Annex I to the D.M. 06/08/2009) of Coefficient of Performance (COP/GUE) and Energy Efficiency Ratio (EER); if there is a variable speed drive (inverter), the relevant values in Annex I are reduced by 5%.
- the DHW heat pumps must guarantee a COP>2.6 measured according to EN 16147;

The hybrid systems are heat pumps integrated with condensing boilers (factory assembled and designed to work together). They have the following technical requirements:

- the intervention must replace totally or partially the old HVAC system and shouldn't be a new installation;
- the ratio between the nominal useful thermal power of the heat pump and the nominal useful thermal power of the boiler must be ≤ 0,5 (Annex I to the D.M. 16/02/2016);

- the intervention has to ensure the minimum values of the Coefficient of Performance (COP) established in Annex I to the D.M. 06/08/2009;
- the boiler must be a condensing one and its useful thermal efficiency, at full load, must be ≥ 93 + 2 log(P_n);
- installation of thermostatic valves with low thermal inertia;
- it's necessary the contextual realisation of a distribution system, balanced with the flow rates.

Regarding the micro-CHP plants, the requirements to be met are:

- primary energy savings (PES) equal to at least 20% (it has been defined in Annex III of the Decree of the Minister of Economic Development of August 2011);
- all the thermal energy produced must be used to satisfy the HVAC and DHW thermal demand;
- the construction, connection to the electricity grid and operation the plants must follow the guidelines provided by the Decree of the Minister of Economic Development of March 16, 2017.

The condensing warm air heaters must have a useful thermal efficiency (referred to the lower heating value at full load) at least equal to 93 + 2*log (P_n).

Regarding the biomass boilers, the requirements to be met are:

- a rated minimum useful efficiency of at least 85%;
- environmental certification as specified in D.M. 07/11/2017 no. 186;
- compliance with local regulations for generators and biomass;
- compliance with UNI EN ISO17225-2 for pellets, UNI EN ISO17225-4 for wood chips and UNI EN ISO 17225-5 for wood.

The photovoltaic plants can receive funding equal to 50% of the expenditure incurred, within the "Bonus Casa" incentive scheme. The expenditure limit is 96.000 € for each unit, and the maximum power of the plant is 20 kW.

To take advantage of the detraction is necessary that the system is fitted to provide support for the energy needs of the house (i.e., for domestic use, lighting, the power supply of electrical appliances, etc.) and, therefore, that the same is used directly at the house's disposal.

There isn't, anyway, the possibility to cumulate this "Bonus Casa" with the "Conto Energia" (an incentive on the energy produced by PV plants, which has been abandoned in Italy in 2013)[19].

Among the facilitated interventions, there is also the installation of individual temperature control and heat metering systems to measure the heat consumption in correspondence with each radiator located inside the building units.

Those devices have to:

[19] AE. Ristrutturazioni edilizie: le agevolazioni fiscali. Agenzia Entrate (2018)

- allow the switching on, off and weekly programming of the systems remotely;
- indicate, via digital channels, the energy consumption, through regular data transmission;
- show the current operating conditions and control temperature of the installations.

The documents that have to be transmitted to ENEA (within 90 days after the intervention) are:

- information report;
- Energy Performance Certificate (it is not required for the installation of solar panels, for the replacement of windows and winter air conditioning systems, the purchase and installation of solar shading).

Instead, no documents have to be transmitted to Agenzia delle Entrate: the Legislative Decree no. 175/2014 has deleted the obligation to communicate to the Agenzia delle Entrate the interventions that continue after the tax period.

The beneficiaries have to keep the following documents:

- asseveration certificate;
- receipt of transmission of documents;
- invoices or tax receipts;
- bank transfer receipt.

The payments can be made in the following ways:

- taxpayers without a vat number: bank transfer, postal transfer or through an account opened at a payment institution;
- other taxpayers: any form.

The tax detraction is not cumulative with other tax benefits provided for the same interventions by other laws (such as the detraction for the building stock regeneration).

If the realised interventions are included both in the energy-saving detractions and in the building regeneration ones, it is possible to benefit, for such expenses, only from one or the other tax benefit, in compliance with the chosen facilitation's requirements.

It is possible, instead, the cumulation with other regional, provincial, or local incentives (if the rules governing these incentives do not provide for the incompatibility).

If compatible, the detractions can still be requested for the part of the expenditure exceeding the incentives granted by the local authorities.

3.5. CONTO TERMICO

The Conto Termico is an incentive mechanism, established by the Ministerial Decree of 28/12/12, which aims to promote small interventions aimed at improving the energy efficiency of existing buildings and the production of thermal energy from renewable sources.

It's a stable incentive, i.e., without an expiration date, usable by private individuals and public administrations for small interventions for the production of thermal energy from renewable sources and increasing energy efficiency.

It is calculated based on the thermal energy produced and is paid in 2-5 years unless the total incentive does not exceed € 5.000: in this case, it is paid in a single tranche.

The Conto Termico is available to two typologies of beneficiaries:

- public administrations, which may request the incentive for both categories of intervention (energy efficiency and thermal energy production). The public administration involved can be the former "Istituti Autonomi Case Popolari", the cooperatives of inhabitants registered in the National Register of housing cooperatives and their consortia established at the Ministry of Economic Development, as well as companies with entirely public assets and social cooperatives registered in their respective regional registers.
- private subjects (individuals, condominiums and persons with business income or agricultural income), who can access the incentives only for small interventions related to thermal energy production plants from renewable sources and high-efficiency systems.

The interventions admitted to the incentives concern existing buildings equipped with air conditioning systems.

Also, the interventions admitted are divided into two categories:

- interventions to increase energy efficiency;
- small interventions related to thermal energy production plants from renewable sources and highly efficient systems.

Remarkably, the first category includes:

- insulation of buildings, replacement of windows and shutters, shading systems, lighting systems;
- replacement of existing air conditioning systems with systems using condensing boilers;
- transformation of existing buildings into nearly zero-energy buildings (nZEB buildings);
- installation of management and automatic control systems for the thermal and electrical plants of the building (Building Automation).

The second category, instead, concerns the following list of actions:

- replacement of existing winter air conditioning systems with winter air conditioning systems equipped with electrical or gas heat pumps, using aerothermal, geothermal or hydrothermal energy;
- replacement of existing winter air conditioning or heating systems in existing greenhouses and rural buildings with winter air conditioning systems equipped with biomass-powered heat generators;
- installation of solar thermal collectors for the production of domestic hot water and the integration of the winter air conditioning system, also combined with solar cooling systems;
- replacement of electric water heaters with heat pump water heaters;
- replacement of existing winter air-conditioning systems with hybrid heat pump systems.

The Decree defines two different ways to access the incentive mechanisms:

- Direct access: within 60 days after the conclusion of the interventions, the Responsible Party transmits to the GSE, through the appropriate section of the website "Portaltermico", the specific application for the incentives to be granted.
- Access by reservation: the Public Administrations and the ESCos that operate on the PA's behalf, except for Cooperatives of Inhabitants and Social Cooperatives, can submit to the GSE, for the reservation of the incentive, an application form with an estimated budget.

For the request for incentive, it is mandatory the preparation of the Energy Audit before the intervention and the subsequent Energy Performance Attestation (APE), under penalty of revocation of the incentive recognition.

The technical requirements for the condensing boilers are listed below:

- the installation must partially or entirely replace the winter air conditioning system already present in the building; partial replacement is allowed only in the case of a pre-existing system equipped with several heat generators;
- the rated thermal efficiency (measured according to UNI EN 15502), must be at least higher than $(93 + 2\log P_n)$, with P_n expressed in kW;
- the installation on every heating body of flow rate modulating control devices, such as low-inertia thermostatic valves, except:
    - when the installation of such devices is not technically feasible;
    - in rooms with a temperature control unit with modulating devices for the automatic adjustment of the room temperature;
    - in case of winter air conditioning systems designed and built with average heat transfer fluid temperatures below 45°C;
- the tuning and balancing of the distribution, monitoring and control systems;

- in case the intervention concerns a centralized plant at the service of multiple building units, it's necessary the installation of effective systems of individual metering of the thermal energy used for the consequent distribution of the expenses.

In the case of heating systems with a nominal firebox power higher or equal to 100 kW_{th}, there are the following additional technical requirements to be specified in the asseveration:

- a modulating type burner must be adopted;
- climate control must act directly on the burner;
- an electronic variable speed pump must be installed in the distribution system.

In case of installation of heat pumps, the minimum requirements for the access to the incentive are listed below:

- the installation must partially or entirely replace the winter air conditioning system already present in the property of any cadastral category (except F/3). Partial replacement is permitted only in the case of a pre-existing system equipped with several heat generators;
- the tuning and balancing of the distribution, monitoring and control systems;
- the installation on every heating body of flow rate modulating control devices, such as low-inertia thermostatic valves, except:
    - o when the installation of such devices is not technically feasible;
    - o in rooms with a temperature control unit with modulating devices for the automatic adjustment of the room temperature;
    - o in case of winter air conditioning systems designed and built with average heat transfer fluid temperatures below 45°C;
- in case the intervention concerns a centralised plant at the service of multiple building units, it's necessary the installation of effective systems of individual metering of the thermal energy used for the consequent distribution of the expenses;
- for interventions with a useful thermal power exceeding 200 kW, it is mandatory to install heat metering systems and to communicate to the GSE the measures of the yearly thermal energy produced by the plants and used to cover the thermal needs;
- minimum COP (Coefficient of performance, for electrical heat pumps): it's reported in Table 3 of Annex I of DM 16.02.16;
- minimum GUE (Gas Utilisation Efficiency, for natural gas heat pumps): it's reported in Table 4 of Annex I of DM 16.02.16;
- NO_2 emissions, due to the combustion system, must be calculated under current European regulations and must be less than 120 mg/kWh_{th} for gas absorption heat pumps and less than 240 mg/kWh_{th} for gas heat pumps with an internal combustion engine (these values refer to the thermal energy produced);

- in the case of electric or gas heat pumps equipped with variable speed drive (inverter or other types), the relevant COP and GUE values provided for in Tables 3 and 4 of the Decree must be reduced by 5%.

In case of installation of boilers fueled by biomass, the minimum requirements are the same of the ones listed for condensing boilers, with the addition of mandatory two-year maintenance for the entire duration of the incentive.

The technical requirements for the thermodynamic solar panels are the following ones:

- the solar collectors must comply with the Solar Keymark certification;
- specific productivity values, expressed in terms of annual thermal energy produced Q_L per unit of gross surface area A_G, or primary mirrors surface area for Fresnel linear collectors, for an average operating temperature of 50°C, higher than the following minimum values:
- in the case of flat collectors: more than 300 $kWh_{th}/(m^2$ year), with reference to Würzburg location;
- in the case of vacuum and evacuated tube collectors: more than 400 $kWh_{th}/(m^2$ year), with reference to Würzburg location;
- in the case of concentration collectors: more than 550 $kWh_{th}/(m^2$ year), with reference to Athens location;
- for prefabricated solar thermal plants of the "factory-made" type for which only UNI EN 12976 is appliable, the specific producibility, in terms of annual thermal energy produced Q_L per unit of aperture area Aa, must be more than 400 $kWh_{th}/(m^2$ year), with reference to Würzburg location;
- the warranty for solar collectors and boilers must be at least five years;
- warranty of accessories and electrical/electronic components must be at least two years;
- in the case of surfaces of the solar field exceeding 100 m^2, it is mandatory to install thermal energy metering systems and the reporting to the GSE of the measures of the thermal energy produced annually by the plants and used to satisfy the thermal needs;
- in case of partial coverage of the winter heating needs by the solar system, it is necessary to install flow control elements on all the heating bodies, such as thermostatic valves with low thermal inertia, with some exceptions listed in the Decree.

The incentive for solar panels is paid in 2 years when the gross installed area is less than 50 m^2 and in 5 years when the gross installed area is higher than 50 m^2.

The hybrid systems have the same requirements of the condensing boilers and the heat pumps, with the addition of the following ones:

- the ratio between the useful thermal power of the heat pump (heat pump functional group) and the useful thermal power of the boiler (condensing combustion functional group) must be less than or equal to 0.5;

- If the intervention is carried out on an entire building equipped with a heating system of total useful nominal power greater than or equal to 200 kW_{th}, there is the obligation to provide an energy diagnosis in advance and the postwork Energy Performance Attestation (EPA), under penalty of forfeiture of the incentives.

The identification of the minimum requirements for incentives in building automation interventions is regulated by the UNI EN 15232 standard that specifies:

- the design requirements (together with the guide CEI 205-18);
- the criteria and parameters for the identification of class B of efficiency, assignable to Building Automation systems;
- the categories of Building Automation devices that concern BACS /TBM systems for the services of:
    a. heating;
    b. cooling;
    c. ventilation and air conditioning;
    d. production of domestic hot water;
    e. lighting;
    f. integrated control of different applications;
    g. diagnostics and consumption detection.

The incentive can only be allocated to interventions that do not have access to other state incentives, except for guarantee funds, revolving funds and interest subsidies.

Specifically, there is the possibility of cumulation with PREPAC (up to 100% if the building is entirely owned and used by the public administration) and other regional or state bands[20].[15]

The Conto Termico also covers the following expenditures:

- For the PA (and ESCOs working on their behalf): 100% of the expenses for the Energy Diagnosis and the Energy Performance Attestation (APE).
- For private entities, with the Residents' Cooperatives and Social Cooperatives: 50% of those expenses.

[20] Sistemi, C. & Climatizzazione, D. I. Guida al nuovo Conto termico per le pompe di calore elettriche Incentivi per la sostituzione di impianti esistenti di climatizzazione invernale.

3.6. CERTIFICATI BIANCHI

The Public Administration can benefit from Certificati Bianchi (CB - White Certificates, also known as "Energy Efficiency Certificates" or "Titoli di Efficienza Energetica" - TEE) to upgrade energy-intensive public services: they are negotiable certificates that certify the achievement of energy savings in energy end-use through the implementation of energy efficiency improvement interventions.

The TEEs are released by the "Gestore dei Mercati Energetici" (GME) in favour of the beneficiaries, based on the achieved energy savings and communicated to the GME by the "Gestore dei Servizi Energetici - GSE S.p.A.". (GSE), following the requirements applied.

The beneficiaries can participate in this incentive program with the support of energy distribution service providers or certified ESCOs.

Alternatively, it is possible to designate a certified Energy Management Expert (EGE) or have an ISO 50001 certified energy management system and submit the requests for access to incentives for energy efficiency projects directly.

In this specific case, it is not possible to calculate in advance the amount of the contribution resulting from the adoption of Certificati Bianchi. This analysis should be carried out in collaboration with an ESCO in case of choosing this type of intervention.

The TEEs have a value equal to one TOE and are distinguished, based on the provisions of the D.M. 11/01/2017 in the following types:

- Type I titles, certifying the achievement of primary energy savings through interventions for the reduction of final energy consumption.
- Type II titles, attesting the achievement of primary energy savings through interventions for the reduction of natural gas consumption.
- Type III titles, attesting the achievement of primary energy savings other than electricity and natural gas not achieved in the transport sector.
- Type IV titles, attesting the achievement of savings of primary energy forms other than electricity and natural gas, achieved in the transport sector.

The subjects admitted to the realisation of energy efficiency projects are:

- the "obligated parties":
    - a) electricity distributors who, on December 31 of two years before the obligation year considered, have more than 50,000 final customers connected to their distribution grid;
    - b) natural gas distributors who, on December 31 of two years before the obligation year considered, have more than 50,000 final customers connected to their distribution grid;
- electricity and natural gas distribution companies not subject to the obligation;

- both public and private subjects that, for the whole duration of the lifetime of the submitted intervention, hold the UNI CEI 11352 certification, or have designated an energy management expert who is certified under UNI CEI 11339, or have a certified energy management system according to ISO 50001.

The CBs do not reward the overall energy savings, but rather the additional savings compared to a baseline equivalent to the standard technology consumption.[21]

The values are set according to the following equation: 1 CB = 1 TEE = 1 TOE (Tonne of oil equivalent) of additional savings.

For years the value of the CBs has been 100 - 110 €/TEP, while in 2018 (last officially registered year, according to a specific GSE report) the average price on the regulated market recorded a +14%, exceeding 303 €/TEP, as there had been fluctuations between 450 euro/TEP and 260 euro/TEP[22].

The summary table was not carried out for white certificates as the intervention is complex and depends on the variation of the certificates on the market. It must therefore be assessed on a case-by-case basis in collaboration with an ESCO.

3.7. CAR = COGENERAZIONE AD ALTO RENDIMENTO

The cogeneration units, which simultaneously generate electrical and thermal energy, increase the efficiency of fossil fuel use up to over 80% and can replace traditional thermal power plants, producing significant energy and current expenditure savings for local authorities.

Furthermore, the Public Administration can benefit from the TEEs by installing cogeneration plants in public structures and buildings, such as schools and universities, municipal sports centres, hospitals, municipal offices, etc. Many municipalities are equipping themselves with cogeneration units combined with district heating networks, for which, in the event of the construction of new networks, an increased incentive period is envisaged. District heating networks, exploiting the heat produced at a relatively low temperature, are particularly interesting for municipalities belonging to colder climatic zones.

Access to the support mechanism can be requested by the owner of the cogeneration unit or by the operator.

The cogeneration units entered into operation after 31/12/2010 are awarded with White Certificates if they are recognized:

- as "new cogeneration units" or as "refurbishments" of existing units;
- CAR pursuant to the Ministerial Decree of 4 August 2011 for each year of access to the incentives.

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[21] Titoli di Efficienza Energetica (TEE) - Certificati Bianchi Energia. http://www.energysaving.it/energy-management/certificati-bianchi/.

[22] Certificati bianchi: cosa sono, quanto valgono, i risultati raggiunti - Energyup. https://www.energyup.tech/sostenibilita/certificati-bianchi-cosa-sono-quanto-valgono-i-risultati-raggiunti/.

3.8. TABLE OF THE INCENTIVES

Table 28 SUPERBONUS 110%

<table>
<tr><th colspan="2" rowspan="2">ACTIONS</th><th colspan="8">SUPERBONUS 110%</th></tr>
<tr><th>BONUS FOR MAIN ACTIONS (LEADING)</th><th>BONUS FOR ACTIONS IN COMBINATION WITH THE MAIN ONES</th><th>EXPENDITURE LIMITS [€]</th><th>PUBLIC / PRIVATE</th><th>TYPOLOGY OF INCENTIVE</th><th>ACCESS MODE</th><th>TECHNICAL REQUIREMENTS</th><th>CUMULATION</th></tr>
<tr><td rowspan="7">HVAC & DHW SYSTEMS</td><td>CONDENSING BOILERS</td><td>✓</td><td></td><td rowspan="6">30.000 € FOR AN INDEPENDENT BUILDING UNIT, 20.000 € FOR EACH UNIT IN CONSOMINIUMS OF 2-8 UNITS, 15.000 € FOR EACH UNIT IF THERE ARE MORE THAN 8 UNITS</td><td rowspan="11">• INDIVIDUALS (NOT INVOLVED IN BUSINESS ACTIVITIES, ARTS AND PROFESSIONS);

• CONDOMINIUMS;

• THIRD SECTOR ORGANIZATIONS AND AMATEUR SPORTS ASSOCIATIONS;

• AUTONOMOUS INSTITUTIONS OF SOCIAL HOUSING (PUBLIC AND PRIVATE).</td><td rowspan="11">• INSTALMENT PAYMENT IN THE FORM OF TAX DETRACTIONS IN 5 YEARS WITHIN THE LIMIT OF THE BENEFICIARY'S EARNING CAPACITY.
• AS AN ALTERNATIVE, IT IS POSSIBLE TO CHOOSE FOR AN EARLY SUBSIDY IN THE FORM OF A DISCOUNT FROM THE GOODS OR SERVICES SUPPLIERS, WHICH CAN THEN DECIDE EITHER TO:
a) DIRECTLY USE THE TAX CREDIT AS COMPENSATION IN F24 IN FIVE ANNUAL INSTALMENTS;
b) TRANSFER THE TAX CREDIT, WITHOUT LIMITATIONS (AS MANY TIMES AS DESIRED) TO ANY OTHER ENTITY (E.G. COMPANIES, BANKS, PRIVATE CITIZENS).</td><td rowspan="11">IT IS NECESSARY TO APPLY FOR A CONFORMITY CERTIFICATE FOR THE DOCUMENTATION PROVING THE FULFILMENT OF THE PREREQUISITES FOR TAX DETRACTION.

THE PARTY ISSUING THE CONFORMITY CERTIFICATE VERIFIES THE PRESENCE OF THE ASSEVERATIONS AND CERTIFICATES RELEASED BY THE RESPONSIBLE PROFESSIONALS.

THE ASSEVERATION ALLOWS TO DEMONSTRATE THAT THE REALIZED INTERVENTION MEETS THE TECHNICAL REQUIREMENTS HAS TO BE ISSUED AT THE END OF THE WORKS AND FOR EACH WORKING STAGE.

ALL THE DATA HAVE TO BE TRANSMITTED ON ENEA WEBSITE WITHIN 90 DAYS AFTER THE INTERVENTION.</td><td rowspan="11">REQUIREMENTS ON THE ENERGY CLASS (TO BE PROVEN BY THE ENERGY PERFORMANCE CERTIFICATE - APE: “ATTESTATO DI PRESTAZIONE ENERGETICA”):
• IMPROVEMENT OF AT LEAST TWO ENERGY CLASSES
• ACHIEVEMENT OF THE A4 CLASS

EXPENSES SUSTAINED FROM 1 JULY 2020 TO 31 DECEMBER 2021</td><td rowspan="11">IF THE REALIZED INTERVENTION BELONGS TO SEVERAL ELIGIBLE CATEGORIES, THE USER CAN TAKE ADVANTAGE OF ONLY ONE OF THE EXISTING INCENTIVES, RESPECTING THE SPECIFIC REQUIREMENTS OF EACH ONE.
THE CONDITIONS TO BE MET FOR SEVERAL INTERVENTIONSARE AS FOLLOWS:
• THE EXPENSES RELATING TO THE VARIOUS INTERVENTIONS MUST BE ACCOUNTED FOR SEPARATELY;
• THE SPECIFIC REQUIREMENTS FOR EACH DETRACTION MUST BE RESPECTED.</td></tr>
<tr><td>HIGH EFFICIENCY HEAT PUMPS</td><td>✓</td><td></td></tr>
<tr><td>HYBRID PLANTS</td><td>✓</td><td></td></tr>
<tr><td>MICRO-CHP</td><td>✓</td><td></td></tr>
<tr><td>CONDENSING WARM AIR HEATERS</td><td></td><td>✓</td></tr>
<tr><td>BIOMASS HEAT GENERATORS</td><td></td><td>✓</td></tr>
<tr><td>THERMODYNAMIC SOLAR PANELS</td><td></td><td>✓</td><td>100.000 €</td></tr>
<tr><td rowspan="2">POWER GENERATION</td><td>PHOTOVOLTAIC PLANTS + STORAGE SYSTEM</td><td></td><td>✓</td><td>48.000 € FOR PV, 1.000 €/kWh FOR STORAGE</td></tr>
<tr><td>PHOTOVOLTAIC PLANTS CONNECTED TO THE GRID</td><td></td><td>✓</td><td>48.000 € OR 2.400 €/kW FOR PV</td></tr>
<tr><td rowspan="2">OTHER</td><td>BUILDING AUTOMATION FOR ENERGY EFFICIENCY</td><td></td><td>✓</td><td>15.000 €</td></tr>
<tr><td>CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES</td><td></td><td>✓</td><td>3.000 €</td></tr>
</table>

Table 29 Ecobonus 50% & 65% limits and technical requirements

ACTIONS		ECOBONUS 50% & 65%			
		ACTIONS INCLUDED IN ECOBONUS 65%	ACTIONS INCLUDED IN ECOBONUS 50%	EXPENDITURE LIMITS *[€]*	TECHNICAL REQUIREMENTS
HVAC & DHW SYSTEMS	CONDENSING BOILERS	✓	✓	30.000 € FOR EACH UNIT	• FOR ECOBONUS 50%: AVERAGE SEASONAL EFFICIENCY AT LEAST EQUAL TO CLASS A OF PRODUCT (REGULATION EU NO. 811/2013); • FOR ECOBONUS 65%: INSTALLATION OF ADVANCED THERMOREGULATION SYSTEMS (CLASSES V, VI OR VIII OF THE COMMISSION COMMUNICATION 2014/C 207/02); • IT IS NOT POSSIBLE TO FINANCE THE INSTALLATION OF WINTER AIR CONDITIONING SYSTEMS IN BUILDINGS THAT WERE NOT EQUIPPED WITH SUCH SYSTEMS. SO, THE INTERVENTION MUST REPLACE TOTALLY OR PARTIALLY THE OLD HEAT GENERATOR AND SHOULDN'T BE A NEW INSTALLATION; IF THE RATED POWER IS HIGHER THAN 100 kW: • INSTALLATION OF A MODULATING BURNER; • CLIMATE REGULATION MUST OPERATE DIRECTLY ON THE BURNER; • INSTALLATION OF A VARIABLE SPEED ELECTRONIC PUMP OR SIMILAR SYSTEMS.
	HIGH EFFICIENCY HEAT PUMPS	✓	✗	30.000 € FOR EACH UNIT	• TOTAL OR PARTIAL REPLACEMENT OF OLD HVAC SYSTEM, NO NEW INSTALLATION; • IT'S NECESSARY THE CONTEXTUAL REALIZATION OF A DISTRIBUTION SYSTEM; • THE INTERVENTION MUST ENSURE THE MINIMUM VALUES (ESTABLISHED IN ANNEX I TO THE D.M. 06/08/2009) OF COEFFICIENT OF PERFORMANCE (COP/GUE) AND ENERGY EFFICIENCY RATIO (EER); • DHW HEAT PUMPS MUST GUARANTEE A COP>2.6.
	HYBRID PLANTS	✓	✗	30.000 € FOR EACH UNIT	• HEAT PUMP MUST BE INTEGRATED AND FACTORY ASSEMBLED WITH THE CONDENSING BOILER AND DESIGNED TO WORK TOGETHER; • TOTAL OR PARTIAL REPLACEMENT OF OLD HVAC SYSTEM, NO NEW INSTALLATION; • THE RATIO BETWEEN THE NOMINAL USEFUL THERMAL POWER OF THE HEAT PUMP AND THE NOMINAL USEFUL THERMAL POWER OF THE BOILER MUST BE ≤ 0,5 (ANNEX I TO THE D.M. 16/02/2016); • THE INTERVENTION HAS TO ENSURE THE MINIMUM VALUES OF COEFFICIENT OF PERFORMANCE (COP) ESTABLISHED IN THE ANNEX I TO THE D.M. 06/08/2009; • THE BOILER MUST BE A CONDENSING ONE AND ITS USEFUL THERMAL EFFICIENCY, AT FULL LOAD, MUST BE ≥ 93 + 2 LOG(Pn); • INSTALLATION OF THERMOSTATIC VALVES WITH LOW THERMAL INERTIA; • IT'S NECESSARY THE CONTEXTUAL REALIZATION OF A DISTRIBUTION SYSTEM, BALANCED IN RELATION TO THE FLOW RATES.
	MICRO-CHP	✓	✗	100.000 €	• PRIMARY ENERGY SAVINGS (PES) EQUAL TO AT LEAST 20%; • ALL THE THERMAL ENERGY PRODUCED MUST BE USED TO SATISFY THE HVAC AND DHW THERMAL DEMAND; • THE CONSTRUCTION, CONNECTION TO THE ELECTRICITY GRID AND OPERATION THE PLANTS MUST FOLLOW THE GUIDELINES PROVIDED BY THE DECREE OF THE MINISTER OF ECONOMIC DEVELOPMENT OF MARCH 16, 2017.
	CONDENSING WARM AIR HEATERS	✓	✗	30.000 € FOR EACH UNIT	• THE USEFUL THERMAL EFFICIENCY REFERRED TO THE LOWER HEATING VALUE AT FULL LOAD MUST BE ≥ 93 + 2*log (Pn); • IT IS NOT POSSIBLE TO FINANCE THE INSTALLATION OF WINTER AIR CONDITIONING SYSTEMS IN BUILDINGS THAT WERE NOT EQUIPPED WITH SUCH SYSTEMS. SO, THE INTERVENTION MUST REPLACE TOTALLY OR PARTIALLY THE OLD HEAT GENERATOR AND SHOULDN'T BE A NEW INSTALLATION.
	BIOMASS HEAT GENERATORS	✗	✓	30.000 € FOR EACH UNIT	• A RATED MINIMUM USEFUL EFFICIENCY OF AT LEAST 85%; • ENVIRONMENTAL CERTIFICATION AS SPECIFIED IN D.M. 07/11/2017 NO. 186; • COMPLIANCE WITH LOCAL REGULATIONS FOR GENERATORS AND BIOMASS;

					• COMPLIANCE WITH UNI EN ISO17225-2 FOR PELLETS, UNI EN ISO17225-4 FOR WOOD CHIPS AND UNI EN ISO 17225-5 FOR WOOD.
	THERMODYNAMIC SOLAR PANELS	✓	✗	60.000 € FOR ECOBONUS 65%	• MINIMUM WARRANTY PERIOD (FIXED IN 5 YEARS FOR PANELS AND BOILERS AND IN 2 YEARS FOR ACCESSORIES AND TECHNICAL COMPONENTS); • CONFORMITY WITH UNI EN 12975 OR UNI EN 12976 STANDARDS, CERTIFIED BY A BODY OF A EUROPEAN UNION COUNTRY OR SWITZERLAND; • INSTALLATION OF THE SOLAR PANELS REALIZED ON EXISTING BUILDINGS.
POWER GENERATION	PHOTOVOLTAIC PLANTS + STORAGE SYSTEM	✗	✓	96.000 € FOR EACH UNIT	
	PHOTOVOLTAIC PLANTS CONNECTED TO THE GRID				• SYSTEM USED DIRECTLY AT THE HOUSE'S DISPOSAL: FITTED TO PROVIDE SUPPORT FOR THE ENERGY NEEDS OF THE HOUSE (I.E. FOR DOMESTIC USE, LIGHTING, POWER SUPPLY OF ELECTRICAL APPLIANCES, ETC.); • NO POSSIBILITY OF CUMULATION WITH THE “CONTO ENERGIA” (INCENTIVE ON THE ENERGY PRODUCED BY PV PLANTS; • OUTPUT POWER <20 kW.
OTHER	BUILDING AUTOMATION FOR ENERGY EFFICIENCY	✓	✗	15.000 € FOR EACH UNIT	THE DEVICES MUST: • SHOW ENERGY CONSUMPTION THROUGH MULTIMEDIA CHANNELS, BY PERIODICALLY PROVIDING DATA; • SHOW THE CURRENT OPERATING CONDITIONS AND THE REGULATION TEMPERATURE OF THE SYSTEMS; • ALLOW REMOTE SWITCHING ON, SWITCHING OFF AND WEEKLY PROGRAMMING OF THE SYSTEMS.
	CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES	✗	✗		THE TEMPERATURE CONTROL AND HEAT METERING SYSTEMS HAVE TO: • ALLOW THE SWITCHING ON, OFF AND WEEKLY PROGRAMMING OF THE SYSTEMS REMOTELY; • INDICATE, VIA DIGITAL CHANNELS, THE ENERGY CONSUMPTION, THROUGH REGULAR DATA TRANSMISSION; • SHOW THE CURRENT OPERATING CONDITIONS AND CONTROL TEMPERATURE OF THE INSTALLATIONS.

Table 30 Ecobonus 50% & 65% access mode

PUBLIC / PRIVATE	TYPOLOGY OF INCENTIVE	ACCESS MODE	CUMULATION
• INDIVIDUALS (NOT INVOLVED IN BUSINESS ACTIVITIES, ARTS AND PROFESSIONS); • CONDOMINIUMS; • THIRD SECTOR ORGANIZATIONS AND AMATEUR SPORTS ASSOCIATIONS; • AUTONOMOUS INSTITUTIONS OF SOCIAL HOUSING (PUBLIC AND PRIVATE).	INSTALMENT PAYMENT IN THE FORM OF TAX DETRACTIONS IN 10 YEARS WITHIN THE LIMIT OF THE BENEFICIARY'S EARNING CAPACITY. AS AN ALTERNATIVE, IT IS POSSIBLE TO CHOOSE FOR AN EARLY SUBSIDY IN THE FORM OF A DISCOUNT FROM THE GOODS OR SERVICES SUPPLIERS, WHICH CAN THEN DECIDE EITHER TO: • DIRECTLY USE THE TAX CREDIT AS COMPENSATION IN F24 IN FIVE ANNUAL INSTALMENTS; • TRANSFER THE TAX CREDIT, WITHOUT LIMITATIONS (AS MANY TIMES AS DESIRED) TO ANY OTHER ENTITY (E.G. COMPANIES, BANKS, PRIVATE CITIZENS).	DOCUMENTS TO BE TRANSMITTED TO ENEA (WITHIN 90 DAYS AFTER THE INTERVENTION): • INFORMATION REPORT; • ENERGY PERFORMANCE CERTIFICATE (IT IS NOT REQUIRED FOR THE INSTALLATION OF SOLAR PANELS, FOR THE REPLACEMENT OF WINDOWS AND WINTER AIR CONDITIONING SYSTEMS, FOR THE PURCHASE AND INSTALLATION OF SOLAR SHADING). DOCUMENTS TO BE TRANSMITTED TO AGENZIA DELLE ENTRATE: NO DOCUMENT: THE LEGISLATIVE DECREE NO. 175/2014 HAS IN FACT DELETED THE OBLIGATION TO COMMUNICATE TO THE AGENZIA DELLE ENTRATE THE INTERVENTIONS THAT CONTINUE AFTER THE TAX PERIOD. WHAT TO KEEP: • ASSEVERATION CERTIFICATE; • RECEIPT OF TRANSMISSION OF DOCUMENTS; • INVOICES OR TAX RECEIPTS; • BANK TRANSFER RECEIPT. PAYMENTS: • TAXPAYERS WITHOUT A VAT NUMBER: BANK TRANSFER, POSTAL TRANSFER OR THROUGH AN ACCOUNT OPENED AT A PAYMENT INSTITUTION; • OTHER TAXPAYERS: ANY FORM.	IT ISN'T POSSIBLE THE CUMULATION WITH OTHER TAX BENEFITS PROVIDED FOR THE SAME INTERVENTIONS BY OTHER LAWS (SUCH AS, FOR EXAMPLE, THE DETRACTION FOR THE BUILDING STOCK REGENERATION). IF THE REALIZED INTERVENTIONS ARE INCLUDED BOTH IN THE ENERGY SAVING DETRACTION AND IN THE BUILDING REGENERATION ONES, IT IS POSSIBLE TO BENEFIT, FOR SUCH EXPENSES, ONLY FROM ONE OR THE OTHER TAX BENEFIT, IN COMPLIANCE WITH THE CHOSEN FACILITATION'S REQUIREMENTS. IT'S POSSIBLE THE CUMULATION WITH OTHER REGIONAL, PROVINCIAL OR LOCAL INCENTIVES (IF THE RULES GOVERNING THESE INCENTIVES DO NOT PROVIDE FOR THE INCOMPATIBILITY BETWEEN THE TWO FACILITIES). IF COMPATIBLE, THE DETRACTIONS CAN STILL BE REQUESTED FOR THE PART OF THE EXPENDITURE EXCEEDING THE INCENTIVES GRANTED BY THE LOCAL AUTHORITIES.

Table 31 CONTO TERMICO – GSE limits and technical requirements

ACTIONS		CONTO TERMICO - GSE		
		ACTIONS INCLUDED	TECHNICAL REQUIREMENTS	EXPENDITURE LIMITS *[€]*
HVAC & DHW SYSTEMS	CONDENSING BOILERS	✓	• THE INSTALLATION MUST PARTIALLY OR COMPLETELY REPLACE THE WINTER AIR CONDITIONING SYSTEM ALREADY PRESENT IN THE BUILDING; • THE RATED THERMAL EFFICIENCY (MEASURED ACCORDING TO UNI EN 15502), MUST BE AT LEAST HIGHER THAN (93 + 2log(P_n)), WITH P_n EXPRESSED IN kW; • INSTALLATION ON EVERY HEATING BODY OF FLOW RATE MODULATING CONTROL DEVICES, SUCH AS LOW-INERTIA THERMOSTATIC VALVES (EXEPTIONS EXPLAINED IN THE TEXT); • TUNING AND BALANCING OF THE DISTRIBUTION, MONITORING AND CONTROL SYSTEMS; • INSTALLATION OF EFFECTIVE SYSTEMS OF INDIVIDUAL METERING OF THE THERMAL ENERGY USED; • IN THE TEXT THERE ARE ADDITIONAL REQUIREMENTS FOR BOILERS WITH NOMINAL FIREBOX POWER HIGHER OR EQUAL TO 100 kW_{th}.	• UNTIL 65% OF THE EXPENSES INCURRED • FOR THE PA (AND ESCOS WORKING ON THEIR BEHALF): 100% OF THE EXPENSES FOR THE ENERGY DIAGNOSIS AND THE ENERGY PERFORMANCE ATTESTATION (APE). • FOR PRIVATE ENTITIES, WITH THE RESIDENTS' COOPERATIVES AND SOCIAL COOPERATIVES: UP TO 50% OF THOSE EXPENSES.
	HIGH EFFICIENCY HEAT PUMPS	✓	• THE INSTALLATION MUST PARTIALLY OR COMPLETELY REPLACE THE WINTER AIR CONDITIONING SYSTEM ALREADY PRESENT IN THE BUILDING; • TUNING AND BALANCING OF THE DISTRIBUTION, MONITORING AND CONTROL SYSTEMS; • INSTALLATION ON EVERY HEATING BODY OF FLOW RATE MODULATING CONTROL DEVICES, SUCH AS LOW-INERTIA THERMOSTATIC VALVES (EXEPTIONS EXPLAINED IN THE TEXT); • INSTALLATION OF EFFECTIVE SYSTEMS OF INDIVIDUAL METERING OF THE THERMAL ENERGY USED; • INSTALLATION OF HEAT METERING SYSTEMS AND COMMUNICATION TO THE GSE OF THE YEARLY THERMAL ENERGY PRODUCED BY THE PLANTS AND USED TO COVER THE THERMAL NEEDS (FOR POWER > 200 kW); • MINIMUM COP (COEFFICENT OF PERFORMANCE, FOR ELECTRICAL HEAT PUMPS): IT'S REPORTED ON TABLE 3 OF ANNEX I OF DM 16.02.16; • MINIMUM GUE (GAS UTILIZATION EFFICIENCY, FOR NATURAL GAS HEAT PUMPS): IT'S REPORTED ON TABLE 4 OF ANNEX I OF DM 16.02.16; • NO_2 EMISSIONS: - GAS ABSORPTION HEAT PUMPS: 120 mg/kWh_{th}; - GAS HEAT PUMPS WITH INTERNAL COMBUSTION ENGINE 240 mg/kWh_{th}; • WHEN THERE ARE VARIABLE SPEED DRIVE (INVERTER OR OTHER TYPE), THE COP AND GUE MINIMUM VALUES MUST BE REDUCED BY 5%.	
	HYBRID PLANTS	✓	SAME REQUIREMENTS OF THE CONDENSING BOILERS AND THE HEAT PUMPS, WITH THE ADDITION OF THE FOLLOWING ONES: • THE RATIO BETWEEN THE USEFUL THERMAL POWER OF THE HEAT PUMP (HEAT PUMP FUNCTIONAL GROUP) AND THE USEFUL THERMAL POWER OF THE BOILER (CONDENSING COMBUSTION FUNCTIONAL GROUP) MUST BE LESS THAN OR EQUAL TO 0.5; • IF THE INTERVENTION IS CARRIED OUT ON AN ENTIRE BUILDING EQUIPPED WITH A HEATING SYSTEM OF TOTAL USEFUL NOMINAL POWER GREATER THAN OR EQUAL TO 200 kW_{th}, THERE IS THE OBLIGATION TO PROVIDE AN ENERGY DIAGNOSIS IN ADVANCE AND THE POSTWORKS ENERGY PERFORMANCE ATTESTATION (EPA), UNDER PENALTY OF FORFEITURE OF THE INCENTIVES.	
	MICRO-CHP	✗		
	CONDENSING WARM AIR HEATERS	✗		
	BIOMASS HEAT GENERATORS	✓	THE SAME OF THE ONES LISTED FOR CONDENSING BOILERS, WITH THE ADDITION OF A MANDATORY TWO-YEAR MAINTENANCE FOR THE ENTIRE DURATION OF THE INCENTIVE.	• UNTIL 65% OF THE EXPENSES INCURRED • FOR THE PA (AND ESCOS WORKING ON

				THEIR BEHALF): 100% OF THE EXPENSES FOR THE ENERGY DIAGNOSIS AND THE ENERGY PERFORMANCE ATTESTATION (APE). • FOR PRIVATE ENTITIES, WITH THE RESIDENTS' COOPERATIVES AND SOCIAL COOPERATIVES: 50% OF THOSE EXPENSES.
	THERMODYNAMIC SOLAR PANELS	✓	• COMPLIANCE WITH SOLAR KEYMARK CERTIFICATION; • SPECIFIC PRODUCTIVITY VALUES, EXPRESSED IN TERMS OF ANNUAL THERMAL ENERGY PRODUCED QL PER UNIT OF GROSS SURFACE AREA AG, OR PRIMARY MIRRORS SURFACE AREA FOR FRESNEL LINEAR COLLECTORS, FOR AN AVERAGE OPERATING TEMPERATURE OF 50°C, HIGHER THAN: • FLAT COLLECTORS: > 300 kWhth/(m² year); • VACUUM AND EVACUATED TUBE COLLECTORS: > 400 kWhth/(m² year); • CONCENTRATION COLLECTORS: > 550 kWhth/(m² years); • "FACTORY MADE" TYPE: THE SPECIFIC PRODUCIBILITY, IN TERMS OF ANNUAL THERMAL ENERGY PRODUCED QL PER UNIT OF APERTURE AREA Aa, MUST BE MORE THAN 400 kWhth/(m² year); • WARRANTY FOR SOLAR COLLECTORS AND BOILERS: > 5 YEARS; • WARRANTY FOR ACCESSORIES AND ELECTRICAL/ELECTRONIC COMPONENTS: > 2 YEARS; • IF SOLAR FIELD SURFACE > 100 m2, IT IS MANDATORY TO INSTALL THERMAL ENERGY METERING SYSTEMS AND THE REPORTING TO THE GSE OF THE MEASURES OF THE THERMAL ENERGY PRODUCED ANNUALLY BY THE PLANTS AND USED TO SATISFY THE THERMAL NEEDS; • INSTALLATION OF FLOW CONTROL ELEMENTS ON ALL THE HEATING BODIES IF THE WINTER THERMAL NEEDS ARE PARTIALLY COVERED.	UNTIL 0,43 €/kWh$_{th}$
POWER GENERATION	PHOTOVOLTAIC PLANTS + STORAGE SYSTEM	✗		
	PHOTOVOLTAIC PLANTS CONNECTED TO THE GRID	✗		
OTHER	BUILDING AUTOMATION FOR ENERGY EFFICIENCY	✓	THE UNI EN 15232 STANDARD SPECIFIES: • DESIGN REQUIREMENTS; • CRITERIA AND PARAMETERS FOR THE IDENTIFICATION OF CLASS B OF EFFICIENCY; • CATEGORIES OF BUILDING AUTOMATION DEVICES THAT CONCERN BACS /TBM SYSTEMS FOR THE SERVICES OF: HEATING, COOLING, VENTILATION AND AIR CONDITIONING, PRODUCTION OF DOMESTIC HOT WATER, LIGHTING, INTEGRATED CONTROL OF DIFFERENT APPLICATIONS, DIAGNOSTICS AND CONSUMPTION DETECTION.	• 40% OF THE EXPENDITURES (UP TO 25 €/m2 AND 50.000 € OVERALL); • 100% OF THE ENERGY DIAGNOSIS COSTS.
	CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES	✗		

Table 32 CONTO TERMICO access mode

PUBLIC / PRIVATE	TYPOLOGY OF INCENTIVE	ACCESS MODE	CUMULATION
PUBLIC ADMINISTRATIONS: • FORMER "ISTITUTI AUTONOMI CASE POPOLARI"; • THE COOPERATIVES OF INHABITANTS REGISTERED IN THE NATIONAL REGISTER OF HOUSING COOPERATIVES AND THEIR CONSORTIA ESTABLISHED AT THE MINISTRY OF ECONOMIC DEVELOPMENT; • COMPANIES WITH ENTIRELY PUBLIC ASSETS AND SOCIAL COOPERATIVES REGISTERED IN THEIR RESPECTIVE REGIONAL REGISTERS. PRIVATE SUBJECTS • INDIVIDUALS; • CONDOMINIUMS AND PERSONS WITH BUSINESS INCOME OR AGRICULTURAL INCOME.	• STABLE INCENTIVE; • CALCULATED ON THE BASIS OF THE THERMAL ENERGY PRODUCED; • PAID IN 2-5 YEARS; • IF THE TOTAL INCENTIVE DOES NOT EXCEED € 5,000: IT IS PAID IN A SINGLE TRANCHE.	2 DOCUMENTS REQUIRED: • ENERGY AUDIT BEFORE THE INTERVENTION; • ENERGY PERFORMANCE ATTESTATION (APE) AFTER THE INTERVENTION. 2 ACCESS MODES: • DIRECT ACCESS: WITHIN 60 DAYS AFTER THE CONCLUSION OF THE INTERVENTIONS, THE RESPONSIBLE PARTY TRANSMITS TO THE GSE, THROUGH THE APPROPRIATE SECTION OF THE WEBSITE "PORTALTERMICO", THE SPECIFIC APPLICATION FOR THE INCENTIVES TO BE GRANTED; • ACCESS BY RESERVATION: THE PUBLIC ADMINISTRATIONS AND THE ESCOS THAT OPERATE ON THE PA'S BEHALF, CAN SUBMIT TO THE GSE, FOR THE RESERVATION OF THE INCENTIVE, AN APPLICATION FORM WITH AN ESTIMATED BUDGET.	NO POSSIBILITY OF CUMULATION WITH OTHER STATE INCENTIVES. EXCEPTIONS: • GUARANTEE FUNDS; • REVOLVING FUNDS; • INTEREST SUBSIDIES; • PREPAC (UP TO 100% IF THE BUILDING IS ENTIRELY OWNED AND USED BY THE PUBLIC ADMINISTRATION); • OTHER REGIONAL OR STATE BANDS.

4. BUSINESS CASES ANALYSIS OF RENEWABLE ENERGY PRODUCTION TECHNOLOGIES (TASK 3.2)

4.1. METHODOLOGY AND SOURCES

The main objective of the task 3.2 is evaluation financial sustainability of the use of wooden biomass renewable energy plants for the generation of thermal and electric energy in buildings.

In detail, the following activities were carried out:

- RENEWABLE ENERGY PRODUCTION TECHNOLOGIES: identification of the commercial technology solutions for small scale energy production and/or cogeneration (electric + thermal) from forest biomass;
- BUSINESS CASE TECHNICAL-SOCIO-ECONOMIC ANALYSIS: identification of three case studies, divided into three main power size (nano, micro, small), whose consumption was determined in task 3.1. energy simulation on the three case studies relating to energy efficiency interventions to replace existing fossil technologies with wooden biomass renewable energy plants. The technical-economic analysis is focused on the evaluation of the feasibility and convenience of efficiency interventions with the presence of incentives and without incentives. The analysis was focused on the presence of the incentives for the diffusion of renewable energies that can be implemented as well on rural areas, classifying them by financial instrument, type of funding and eligible actions.
- RESULTS AND FINAL EVALUATION: Determination of the preliminary best solution for each size.

In the deliverable DL C3.1 the solutions were supposed to be categorised into three different target sizes:

- NANO, with a peak power of 7-15 kW_{el} and 20-40 kW_{th};
- MICRO, with a peak power of 45 kW_{el} and 200 kW_{th};
- SMALL, with a peak power of 200-250 kW_{el} and 600-800 kW_{th}.

In this work, those three categories of final user have been updated for better compliance with real conditions:

- NANO, with a potential less than 60 kW_{th}
- MICRO, with a potential in the range of 60 - 200 kW_{th}
- SMALL, integration between different RES systems (thermal, electric and storage) in a micro-energy community composed by a series of public building and public lighting with total potential greater than 200 kW.

IRIS has conducted a study regarding the financial sustainability of the use of renewable energy fuelled plants and equipment for the generation of energy with wooden biomass.

For each size, IRIS has identified a business case (building and community) and related best technological solution for small-scale energy production (thermal), or cogeneration (electrical + thermal) fuelled by residual biomass from sustainable forestry management, with a focus on equipment calibrated on the quality and availability of local biomass (Preliminary analysis of available biomass from Task C2.2);
One of the technologic solutions be the IRIS Green Plasma: an energy efficient, affordable device to treat secondary biomass and waste from industrial processes. The treatment is based on the use of plasma and induction technology than at high temperature are able to convert organic matter into syngas, electricity, and a recyclable slag using plasma. Green Plasma was be tested also to treat the ashes deriving from the biomass plants to facilitate their disposal and reduce treatment costs and transport costs and emissions: after treatment, through treatment, the ashes will be converted into a vitreous and inert material that could be used for streets pavements or building in mixtures with traditional materials.

The main analysed parameters are:

- energy consumption;
- system efficiency;
- CO_2 emissions;
- investment costs;
- payback period;

The economic analysis for energy efficiency investments has been focused on two scenarios:

- I scenario: without incentives;
- II scenario: with incentives.

The II scenario has been further elaborated to obtain:

- a proposal to modify the incentives to achieve a payback period of 10 years;
- the optimal value of the biomass flow rate to achieve economic sustainability.

4.2. RENEWABLE ENERGY PRODUCTION TECHNOLOGIES

4.2.1. CURRENT DISTRIBUTION OF BIOMASS TECHNOLOGIES

The first step was to determine the current biomass HVAC technologies present in the homes and their distribution trend. This figure derives from a survey carried out by the "Report statistico AIEL 2019 - Diego Rossi e Valter Francescato – AIEL".

The results show a group of technologies that in the last ten years has been stably maintained just over 9 million sets, the 76% with wood and 24% with pellets in 2018.

In the face of some technologies that remain substantially stable in numerical terms, yes observes a consistent percentage change of some technologies. The turnover most significant technology concerns the open fireplace which rose from 42% to 34%. This reduction has affected all the wood-burning appliances that have been reduced overall from 92% to 77%. At the same time, pellet appliances are increased from 8 to 23%.

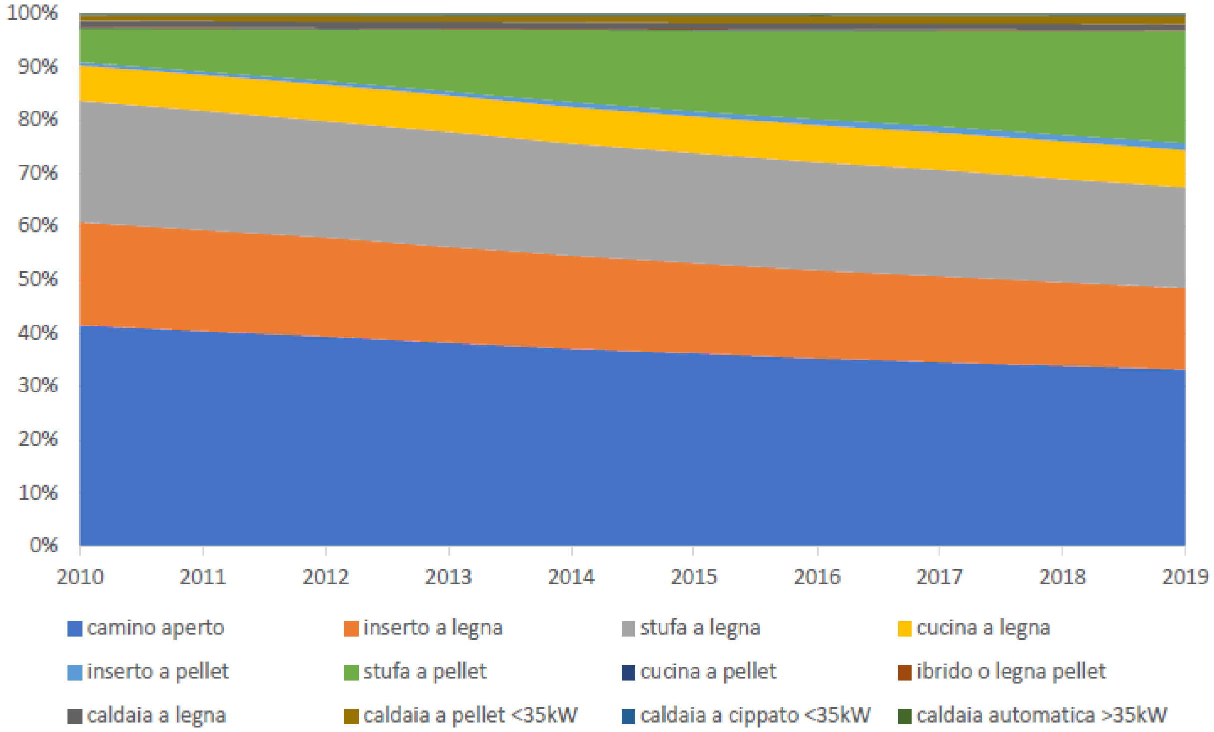
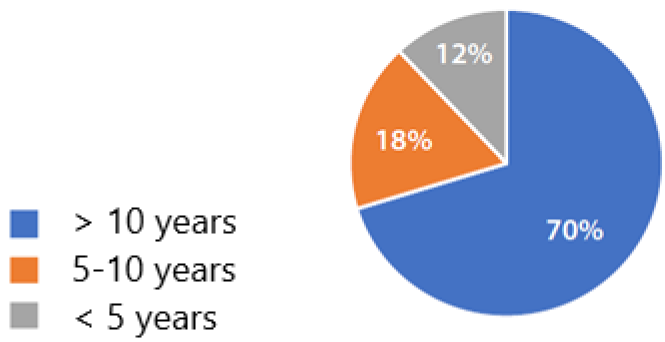


Figure 33 Evolution and distribution of the numerical percentage of technologies that make up the installed [Source: AGRIFORENERGY, Valter Francescato e Diego Rossi – AIEL, Giugno 2020]

70% of the installed biomass HVAC systems are over 10 years old, while the most efficient ones, installed in the last ones five years, still represent only the 12% of the total.



4.2.2. TECHNOLOGY ANALYSIS SUMMARY

The analysis of biomass technologies available on the market has made it possible to identify some categories of systems. Of these, only the most promising ones in terms of energy efficiency, emissions, reliability, and level of automation have been described in detail. Wood-stoves, traditional non-condensing pellet boilers, and log-fed biomass boiler with yields of less than 90% were excluded from the survey as they do not bring improvements compared to the state of the art.
The other 4 technologies were analysed with a brief description and a table with market analysis among the existing solutions.

Table 33 Technology summary

TECHNOLOGY	TYPE	RANGE SIZE	Efficiency	Best application	Percentage of appliances installed
Wood stove	Only thermal energy production	< 20 kW_{th}	Thermic < 80%	Small houses without a heating system	80%
Wood pellet boiler	Only thermal energy production	30 - 200 kW_{th}	Thermic < 85%	Small houses	<5%
Log-fed biomass boiler	Only thermal energy production	10 - 150 kW_{th}	Thermic < 80%	Small houses, farms	<5%
Wood pellet condensation boiler + chips storage	Only thermal energy production	10 - 200 kW_{th}	Thermic > 100 %	Small villas, hotels, offices, swimming pools	<1%
Wood chips boiler + chips storage	Only thermal energy production	> 30 kW_{th}	Thermic > 95 %	Medium-large sized villas, schools, buildings with high consumption, gyms, hotels, farms	<1%
Wood chips cogeneration system + chips storage	Thermal and electric energy production	> 20 kW_{el} > 40 kW_{th}	Thermic > 55 % Electric > 25%	Energy communities, swimming pools, biomass processing plants	<1%
Omnivorous GreenPlasma pyrolyser	Thermal and electric energy production	61 kW_{el} 38 kW_{th}	Thermic > 40 % Electric > 27%	Energy communities, self-sufficient buildings	-

4.2.3. WOOD PELLET CONDENSATION BOILER

The condensing pellet boilers allow to be installed in relatively small rooms (3x3 m) and connected to commercial prefabricated pellet tanks. Through closed pipes, the pellets are automatically transferred from the tank to the boiler, without any external intervention. The boilers are self-cleaning and require little maintenance (3-4 times during the entire heating season). The boiler can be connected directly to the heating and domestic hot water system (high and low temperature) or connected to a storage puffer> 500 litres to optimize consumption and yield.

The highly efficient combustion-technology and the high-quality components resulted in an efficiency-improvement of the pellet boiler, to over 106%, as well as a reduction of emissions. The steam in the flue gas is cooled down so far that liquid condensate is formed in the heat exchanger. With this cooling process condensing heat is released and can be used for heating purposes, thereby efficiencies over 106 percent are achieved.

The path which flue gas must walk is up to three times longer than in conventional boilers, being the flow spontaneously turbulent without the help of additional devices.

The heat distribution can be done via a low temperature system such as subfloor heating or a traditional high temperature radiator system. Depending on requirement the boiler can supply the correct temperature even without a buffer tank.

A market analysis made it possible to determine various commercial models of condensing pellet boilers that can currently be purchased.

Table 34 Technical-economic comparative analysis of the systems available on the market

Producer and model	Electric Power [kW]	Thermal Power [kW]	Overall dimensions	Wood chip consumption	Annual maintenance cost	Costs (only device without installation)
HERZ Pellestar condensation 60	0	60kW	Local > 3mx3m	10 - 15 kg/h	< 500 €	30.000€
LOHE BIOCOM 75	0	75 kW		10 - 15 kg/h	< 500 €	26.500 €
Oekofen Pellematic maxi condensing	0	64 kW		10 - 15 kg/h	< 500 €	22.000 €
Froling P4 PELLET	0	58,5 kW		10 - 15 kg/h	< 500 €	22.500 €

4.2.4. WOOD CHIPS BOILER

The wood chip boilers are powered by wood chips having a humidity between 10% and 35% and a size normally less than 35mm. Unlike condensing pellet boilers, they normally have lower yields (95%). These systems work at high temperatures and always require a puffer sized considering between 25 and 50 litres of storage water per kW of boiler power.

Wood chip boilers in the order of 150 kW allow installations in relatively small rooms (> 4x4 m). There must be a deposit (> 3m x3m) for the wood chips, larger than that of the pellets as the wood chips are not sold in transport bags in larger quantities. The wood chips are automatically transferred from the storage to the boiler by means of augers or belts combined with augers.

The cost of the single boiler is lower than the pellet ones (equipped with electronics and automation) but due to the loading systems, the puffer, and the wood chip storage, the final costs will be higher for the same power.

Although these systems are now very automated, they require more maintenance than pellet systems. The cleaning operations and emptying of the ash containers must in fact be carried out about 8-10 times for each season.

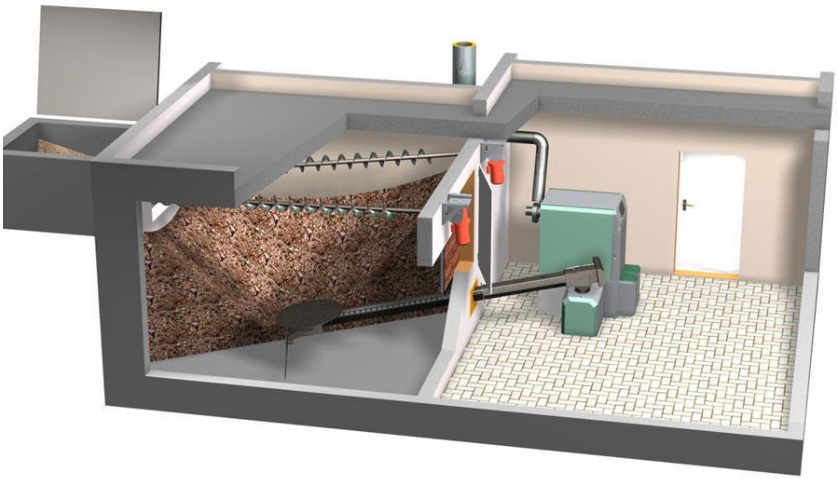


Figure 34 Wood chip boiler and relative storage with auger

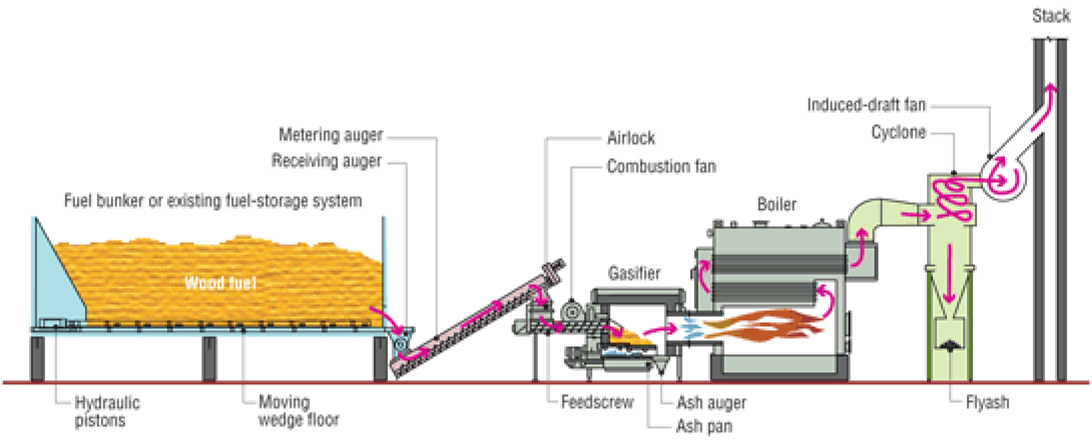


Figure 35 Connection diagram between wood chip storage and boiler

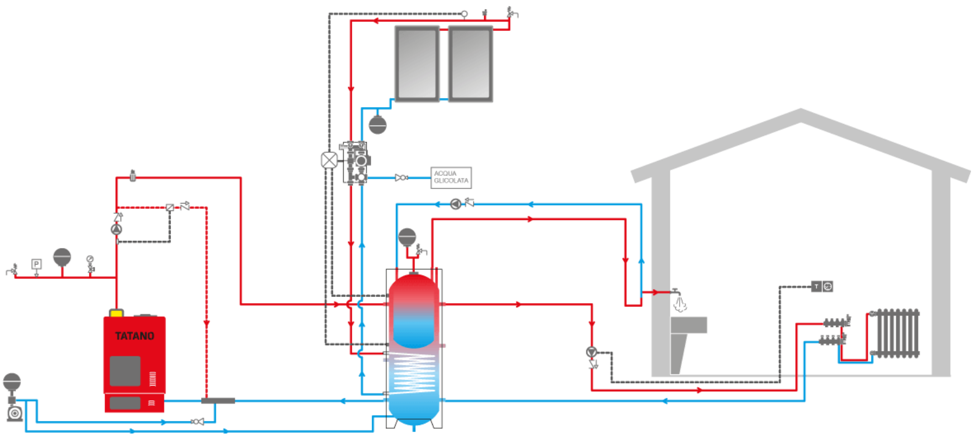


Figure 36 Single-line diagram of a possible installation of a wood chip boiler combined with a puffer and solar thermal panels.

Table 35 Technical-economic comparative analysis of the systems available on the market

Producer and model	Electric Power [kW]	Thermal Power [kW]	Overall dimensions	Wood chip consumption	Annual maintenance cost	Total costs
HARGASSNER ECO HK	0	120-150kW	Local for boiler > 3mx3m Local for biomass > 3x3 m 60-80 m3	45 kg/h	800 €	35.000 €
ETA HACK 130	0	38 - 133 kW		40 kg/h	800 €	32.500 €
FROLIG T4 150	0	45-150 kW		45 kg/h	800 €	30.000 €
HERZ Firematic149	0	35 – 149 kW		45 kg/h	800 €	45.000 €

4.2.5. WOOD CHIPS COGENERATION SYSTEM

The cogeneration system (CHP) generates electricity and heat according to the principle of combining heat and energy. The biomass system consists of a wood chip gasifier that produces syngas. The syngas after being cooled (recovery of thermal energy) powers an internal combustion engine for the combined production of electricity. The generated electricity can be consumed directly (self-consumption) or stored in a battery pack or fed into the grid. The heat generated during the process is stored in a suitably sized puffer and can subsequently be used for heating buildings, for drying cereals and biomass or in district heating systems.

The analysis of the products on the market made it possible to determine that on average for each kg of biomass input the plant is capable of producing 1 kW_e and 2 kW_{th}.

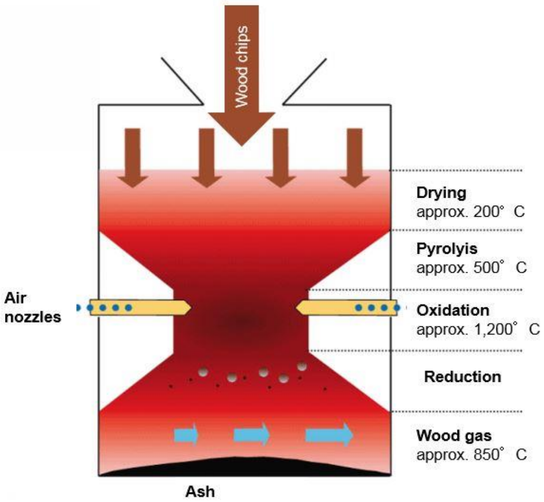


Table 36 Technical-economic comparative analysis of the systems available on the market

Producer and model	Electric Power [kW]	Thermal Power [kW]	Overall dimensions	Wood chip consumption	Annual maintenance cost	Total costs	Unitary costs for each electric kW of production
Spanner Re² GmbH HKA	35	73 - 111	2 x20' standard container = 2x (6x2,45x2,6)	50 kg/h	15500	200.000	5714
FROELING CHP	50	95 - 105	2 x20' standard container = 2x (6x2,45x2,6)	40 kg/h	25000	225.000	4500
CMD Engine ECO20X	20	40	20' standard container = (6x2,45x2,6)	22 kg/h	7000	155.000	7750
RESET s.r.l. SyngaSmart	35	45 - 75	20' standard container = (6x2,45x2,6)	35 kg/h	12000	235.000	6714

4.2.6. OMNIVOROUS GREENPLASMA PYROLYSER

The GreenPlasma pyrolysis thermal conversion unit (TCU) is an innovative evolution of the Plasma Pyrolyser (EP3023693), owned by IRIS. The technology was successfully demonstrated for the energy recovery from marine litter in the H2020 project CLAIM (GA number 774586), reaching TRL7.

Figure 37 IRIS GreenPlasma during the TRL6 and TRL7 tests campaign

GreenPlasma is composed with an induction assisted pyrolyser reactor with residual collection tank integrated in a plug and play and complete skid in steel (AISI316L) with high mechanical resistance, with walls both thermally and acoustically with high-performance fibres materials and different masses (reduction of a wide range of acoustic frequencies). The skid is complete with a pre-treatment system, induction pyrolyser, syngas conditioning station, and energy conversion system. There is also a general electric panel (GEP) capable of connecting all the devices and auxiliaries of the station. The induction heating furnace is composed by a cylindrical steel reactor insulated with a 1,5 cm of high-performance rock wool and with outside a heating coil. The thermocouples measure the temperature trend (a) inside the reactor, (b) in the expansion chamber, (c, d,e) in the output syngas, sending the data to the GEP. An automatic intelligence consequently modulates current and voltage (0V-48V; 0A/100A) and manage the ON/OFF of the power supply to the inductor. This system allows to have a temperature in the reactor of 750° (hysteresis < 50°C managed automatically), reducing electricity consumption to a minimum. The system is also supported by a partial air inlet (<10% in volume - pyro-gasification). The plant is always be kept in depression with a syngas blower capable of sending the syngas to the engine with a pressure between 3 and 5 kPa. The Lower heating value (LHV) of syngas is higher when the pyrolyser operates at higher temperature. This is due to the fact that the LHV syngas is calculated from mole fraction of CO, CH_4 and H_2 and thus, it has a similar trend of CO and H_2 mole fraction profile. Since only H_2, CO and CH_4 are combustible, the LHV of syngas is the calorific value of these three gases.

Instantaneous pressure fluctuation measurements (dominant frequency, standard deviation) allow to identify the insurgence of agglomeration and sintering phenomena within the bed promoted by ash melting. The Syngas conditioning box-station reduce the residual compounds content in the gas exiting the pyrolysis problematic for the longevity of the power generator: tars, particulate, sulphur, halogens, and alkali metals. The conditioning system is designed to allow the use of syngas on both Power Generator Unit (f-PGU) and SOFC. The quantity of tar will be kept low thanks to pyrolisation at temperatures above 600°C. In fact, when the temperature increases beyond 600°C, the tar yield will generally decrease due to tar cracking at higher temperature. For the TAR and particulate removal is used a cyclone separator combined a carbon/ceramic barrier filter after the induction pyrolyser. Tar condensation during this particulate removal is avoided by maintaining the synthesis gas temperature above the tar dew point (375-400°C). For the reduction of H2S and HCl is used two type of adsorbent materials: ZnO able to react with hydrogen sulphide in a wide range of temperatures and pressures, CaO or K2CO3 for the reduction of HCl. The beneficial effect of HCl on desulphurisation using a calcium-based sorbent involves the formation of CaCl2.

According to the studies the breakthrough time of the commercial sorbent in the industrial condition has been estimated around 215 days. A final Tar reformer (with Ni-based catalysts) allows almost full conversion of tar (98,8%-99,9%) and considerably low amount of coke deposited in the form of amorphous and filamentous carbon (15,9-178,5 mg gcat-1). The combination of hot syngas conditioning system with Induction assisted pyrolizer allows to have a high-quality syngas (LHV > 2,5 kWh/Nm3).

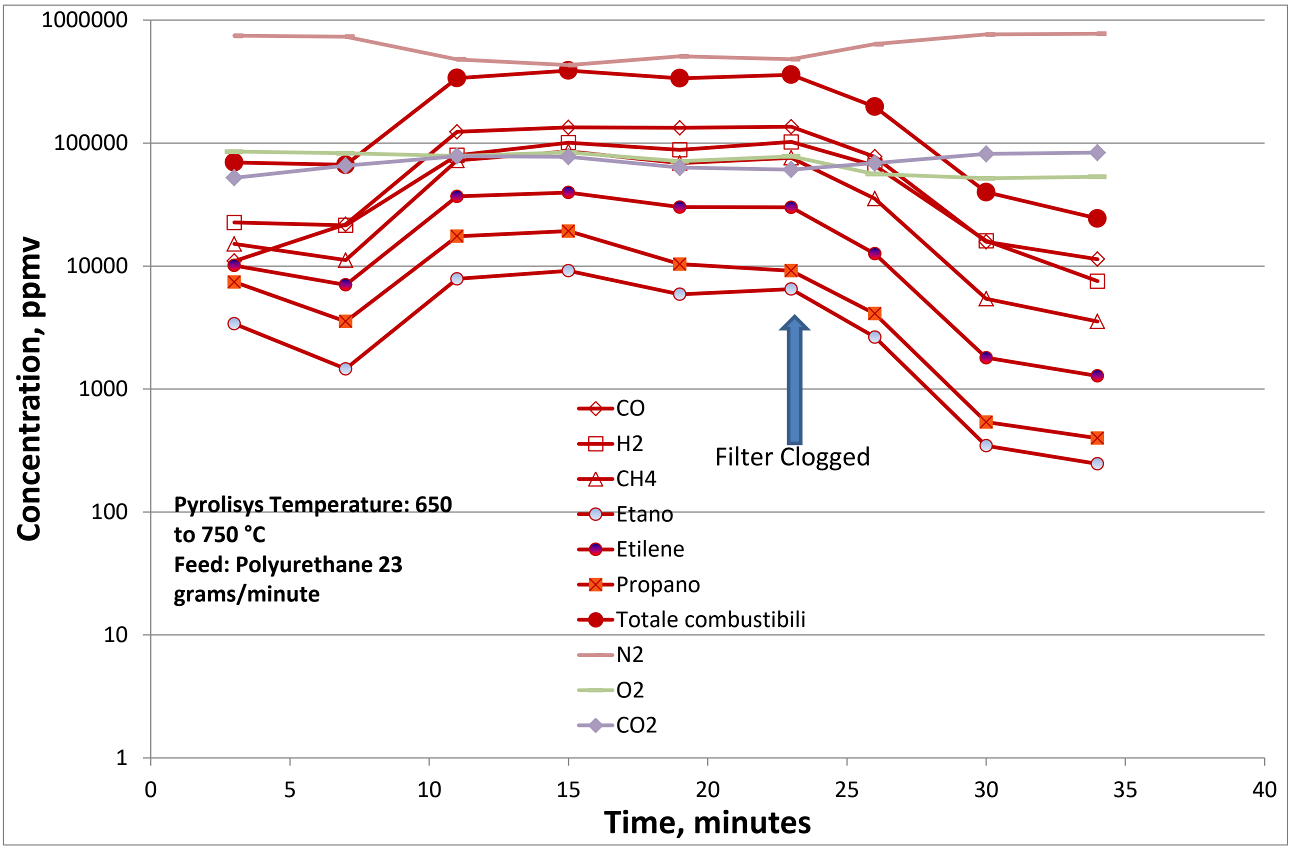


Figure 38 Composition of the syngas. Concentrations are reported in parts per million by volume (ppmV). To obtain the percentages by volume, divide by 10000.

The cleaned syngas supplies a flexi-Power Generator Unit (f-PGU). This is believed to have benefits like low capital cost, reliability, good part-load performance, high operating efficiency, and modularity and are quite safe to use. Thanks to a regulating valve placed before entering f-PGU, the syngas pressure is monitored, and its modulation allows the engine rpm to be modulated. The f-GPU condition are engine heat value ≥ 4MJ/Nm3; Syngas temperature ≤ 40°C; Gas pressure 3~5kpa, pressure change rate ≤ 1kPa/min. he f-GPU is open-cooled.

Figure 39 GreenPlasma off-grid installation in micro energy communities

The TCU is composed of three heat exchangers: (i) water-water, (ii) syngas-air, and (iii) exhaust fumes-air) that allow the maintenance of the right temperatures of the system by recovering the excess heat to dry the waste thanks to an air fan. The water-water exchanger is used to cool the inductor temperature (from 80° to 60°C), the syngas-air exchanger is used to cool the syngas temperature (from 400° to 40°C), the third exchanger allows the cooling of the engine exhaust fumes. The hot air (40 ° C) deriving from the exchangers ii and iii is conveyed to the shredded waste tank to allow their drying. An automotive commercial catalytic converter is integrated to treat exhaust in order to minimize NOx and CO. The exhaust will also pass through the pre-chambers of the induction reactor, increasing the temperature and drying the waste.

Table 37 GreenPlasma technical dataset

Data	Unit	Max Value	Min Value
Treatable material	kg/h	70	30
Pyrolysis set point	°C	750	750
Syngas Flow	Nm^3/h x kg of marine litter	2	2
Syngas calorific value	kWh/Nm^3	2,5	2,5
Solid residues quantity	%	10	3
Liquid residues quantity	%	3	5
Peak energy consumption	kW_p	51,5	32,5
Energy consumption	kWh_e	33,5	21,1
Syngas energy production	kWh	350	150
Electric energy production	kWh_e	94,5	40,5
Thermal energy production	kWh_{th}	38,5	27
Electric energy balance	kWh_e	61,0	19,4

4.2.7. TECHNOLOGY ANALYSIS EVALUATION

The analysis of the results made it possible in the first instance to define the best suited technological solution for each intervention size.

Table 38 Renewable energy production technologies final evaluation

Application Size	RES Technologies	Evaluation	Best solution
Nano	Wood chips boiler	System efficiency below 95%, costs are 10% lower than condensing solutions, require on average frequent cleaning and maintenance, the system requires a large storage and transport space for the wood chips, which is not convenient on small sizes.	For this size the best solutions in terms of efficiency, ROI and emission are the **Wood pellet condensation boiler**
	Wood pellet condensation boiler	System efficiency greater than 95%, costs are 10% higher than condensing solutions, the high automation allows semi-automatic maintenance and therefore little intervention by personnel	
	Wood chips cogeneration system	The system produces continuous electricity and thermal energy over 24 hours. The system is oversized for small sizes for a single building.	
	Omnivorous GreenPlasma pyrolyser	The system produces continuous electricity and thermal energy over 24 hours. The system is oversized for small sizes for a single building.	
Micro	Wood chips traditional boiler	The commercial products currently on the market have a thermal power on average below 60 thermal kW. For higher powers, more systems should be installed in series, with an increase in costs that would exceed the costs of a traditional or wood chip system.	For this size the best solutions in terms of efficiency, ROI and emission are the **Wood chips boiler**
	Wood pellet condensation boiler	The system produces only thermal energy. The initial cost is lower than other technologies, but on higher sizes and consumption the cost of local pellets is double the cost of local wood chips. This leads to the inconvenience compared to other solutions.	

	Wood chips cogeneration system	The optimal size for the use of the cogeneration system as the electricity and heat production are used at 100%, justifying the high initial expense and the personnel required for maintenance operations.	
	Omnivorous GreenPlasma pyrolyser	The installation of this system is convenient only in the case of continuous consumption of thermal and electrical energy (in the case of hotels with spas and swimming pools). The system is also convenient in farms with the production of non-recoverable organic waste (branches, animal bedding) and constant electrical and thermal consumption.	
Small	Wood chips traditional boiler	The system produces only thermal energy. The initial cost is lower than other technologies, but on higher sizes and consumption the cost of local pellets is double the cost of local wood chips. This leads to the inconvenience compared to other solutions.	For this size the best solutions in terms of efficiency, ROI and emission are the **Biomass CHP combined with a biomass drying system**
	Wood pellet condensation boiler	The system produces only thermal energy. The initial cost is lower than other technologies, but on higher sizes and consumption the cost of local pellets is double the cost of local wood chips. This leads to the inconvenience compared to other solutions.	
	Wood chips cogeneration system	The system is convenient in an energy community where electricity production is used almost entirely (during the day in buildings and at night in public lighting) and thermal energy is used in the winter for buildings and the drying of biomass and d summer to dry biomass for sale.	
	Omnivorous GreenPlasma pyrolyser	The system is convenient in an energy community where electricity production is used almost entirely (during the day in buildings and at night in public lighting) and thermal energy is used in the winter for buildings and the drying of biomass and d summer to inert the ash residues produced during the winter season.	

4.3. BUSINESS CASES TECHNICAL-ECONOMIC ANALYSIS

4.3.1. BUSINESS CASES SELECTION

After an analysis of consumption data and after having discussed with the municipal administrations and technicians, 1 building was chosen for each type of size (Nano, Micro, Small).

Table 39 Business cases summary

Size	Business case	Potential and consumption	Consumption	Main Interventions simulated
Nano	9.1 - Single building in Ostana municipality destinated at office (city hall) and museum.	Electric:3 kW HVAC:60kW	Electric:7.243 kWh HVAC: 110.438 kWh	Replacement of the existing Diesel boiler with a new Biomass condensation boiler fuelled with Local pellet
Micro	10.19 - Single building in Paesana municipality destinated at services related to tourism, accommodation, and related services.	Electric: 15kW HVAC:150kW	Electric:120.175 kWh HVAC: 317.303 kWh	6 scenarios of intervention simulated: insulation of walls and floors with bio-materials, renovation of the thermal power plant with wood chip boiler, building automation, global intervention.
Small	1.1 - 1.2 - 1.3 - 1.4 - 1.5 - 1.6 Renewable Energy Community between 6 public buildings with different destinations and public lighting.	Electric: 146kW HVAC:899kW	Electric: 169.927 kWh HVAC: 824.888 kWh	13 scenarios for creating of Renewable Energy Community with installation of photovoltaic panels + lithium battery + micro-CHP 20 kWe-40kWt

4.3.2. WORKPHASES

The work was divided into the following phases:

- Business cases selection: after a comparison with the technicians of the various municipalities, with the public administration and the strategic plans, the most energy-intensive buildings powered by fossil fuels for each size were analysed and 3 most representative case studies were chosen, located in 3 different municipalities.
- Analysis of all municipal projects and consumption bills provided by the administrator and found in the municipal archive.
- Inspection in the accessible parts of the building and visual inspection.
- Brief interview with users in order to determine problems and times and methods of use of the system.
- Analysis of fuel and electricity consumption bills provided.
- Simulation with Termus ACCA software and EdilClima of the state of the art (before intervention) both in Asset Rating (A2) and Tailored Rating (A3) modes.
- definition of the efficiency measures to be simulated on the building based on the experience of the IRIS staff and on the preliminary data deriving from the technical-economic comparison of the technologies existing on the market.
- Asset rating (A3) simulations of energy efficiency measures.
- Research and calculation of the incentives present and applicable to the chosen intervention.
- Analysis of technical-economic results and identification of simple return times.
- Determination of KPI GreenChainSAW4Life.
- Applications of the KPIs to the entire territory of the project on a forecast basis.

This deliverable summarizes the simulation activities and the main results.
The official documents delivered to the municipalities (in Italian) containing all the calculation data and technical specifications are attached to the deliverable.

4.4. NANOSCALE: OSTANA

4.4.1. GENERAL DESCRIPTION

The building has a centralized heating system and is currently serving:

- NEW MUNICIPIO GROUND FLOOR BUILDING: area intended to house the town hall offices.
- OLD TOWN HALL GROUND FLOOR BUILDING: The ground floor of the old town hall building is not heated and will therefore not undergo interventions aimed at its heating.
- MULTI-PURPOSE AREA - FIRST FLOOR: area intended for projection room and laboratory.
- BUILDING B FIRST FLOOR: area used as a museum.
- BUILDING B SECOND FLOOR: area used as a museum.

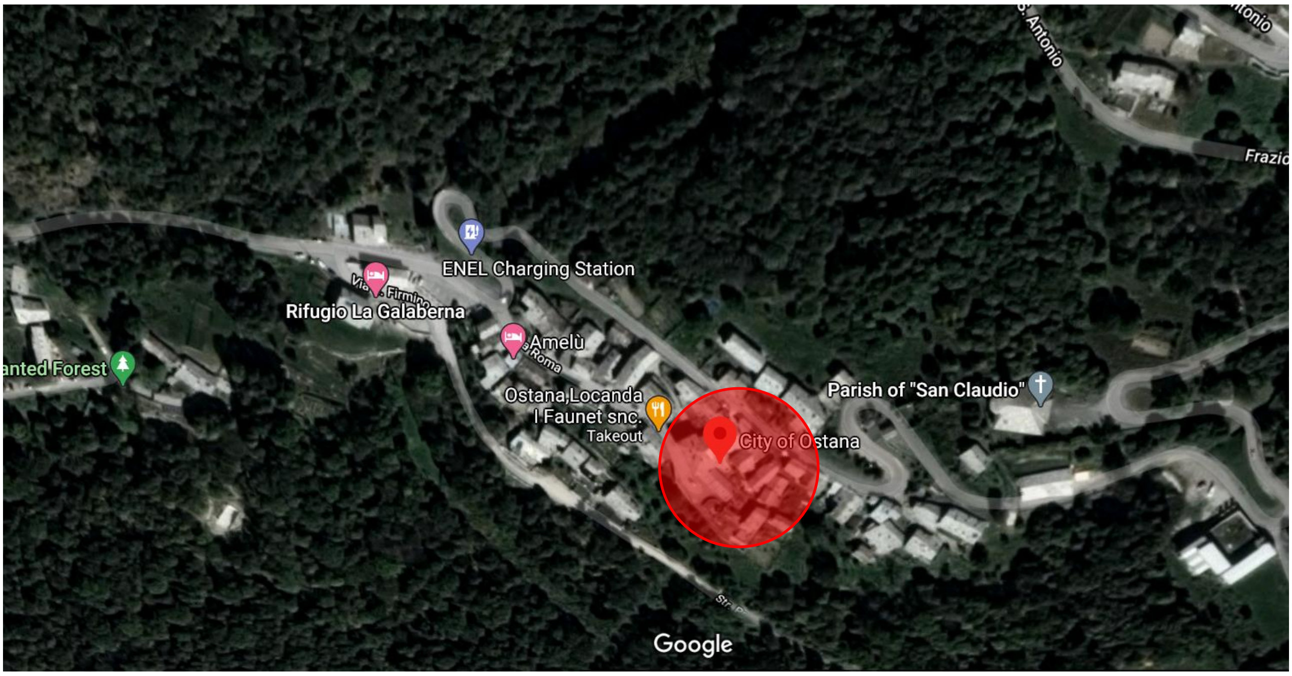


Figure 42 Aerial view of the building

Figure 41 Ostana museum

Figure 40 Ostana city Hall

4.4.2. SITE AUDIT

The first step was to carry out a survey of the state of buildings and HVAC plants.

The HVAC generation subsystem consists of a RIELLO TREGI 7 diesel fuelled boiler with the following technical characteristics:

- Nominal heat output to the hearth: 62 kW
- Efficiency <90%

The heat generator is coupled to an air-blown diesel burner. The existing flue has an external inlet diameter of 160 mm. The boiler is fed by an underground diesel oil tank with a presumed capacity of 5000 litres (impossibility of measurement and absence of supporting technical documentation). There are pipes for transporting the fuel from the tank to the burner, also underground. The fuel supply system is completed by the group of level control and safety devices (pull lever).

The distribution subsystem of the heating system is of the collector type with horizontal distribution. Each high temperature radiator is connected either to a manifold placed on the floor or directly to the general manifold placed in thermal power room. The secondary distribution currently consists of 6 circuits that branch off from the delivery manifold located inside the central heating room.

On each circuit, after each circulation pump, a two-way zone valve is installed with a servomotor (reversible synchronous motor) powered at 230 V. Both the circulators and the servomotors are activated by the signals coming from the chrono thermostats of the various zones or by zone relays placed in thermal power room.

The emission subsystem serving the different rooms of the building consists of:

- BIASI LBT column cast iron radiators.
- BIASI PRG cast iron plate radiators.

The regulation system serving the different rooms of the building is made up as follows:

- climatic regulation probe with external probe. The control unit is located in the boiler room.

- n° 2 Room thermostats installed in the old town hall building and N. 2 in the new building that manage the related zone valves and the related circulation pumps;
- n° 10 electronic thermostatic valves present on some communicating radiators with relative N ° 2 zone relays placed in thermal power room acting on the 2-way valves;
- n° 15 manual radiator valves.

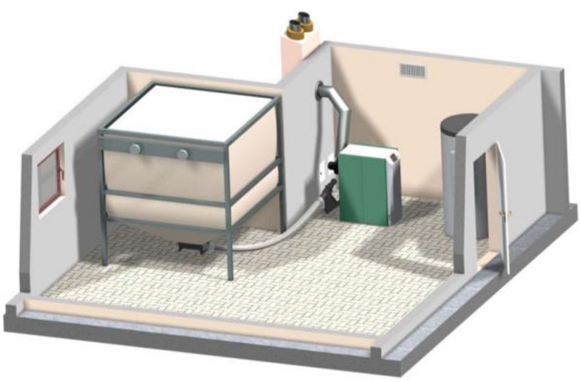
The systems do not communicate with each other and therefore do not allow the management of room temperatures and operating times by means of a single supervision system.

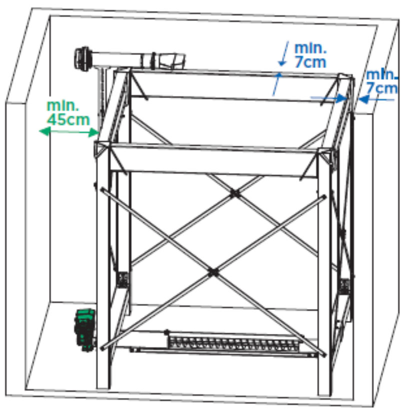
4.4.3. INTERVENTION FOR ENERGY EFFICIENCY

Due to the type of existing system, only one intervention was simulated relating to HVAC systems which are obsolete and running on diesel. The small spaces of the boiler room led to the choice of a pellet condensing boiler with automatic pellet loading system from an ad hoc tank located in a room on the first floor. The new generation subsystem will consist of a floor standing condensing boiler fuelled by wood pellets, with a power of 60 kW capable of satisfying the real thermal needs and is in line with the power of the replaced generator. The boiler must have integrated a small pellet storage deposit and allow manual loading with bags (in place of the automatic loading system in case of maintenance or non-functioning of the automatic system). The boiler will store the technical water produced inside a puffer with a capacity of 800 litres.

Table 40

INTERV.	SIMULATED INTERVENTION	DESCRIPTION	EXPENSE
9.1.1	HEATING CENTRAL REFURBISHMENT WITH WOOD CHIP BOILER AND BUILDING AUTOMATION	• installation of a pellet storage tank with relative automatic boiler supply piping, to be placed inside a special room • installation of a new floor standing condensing pellet generator with relative safety devices • installation of a puffer with a capacity of 800 litres of primary water storage with relative primary filling system • creation of a room regulation system consisting of a general control unit, relays for grouping zones and electronic wi-fi thermostatic valves to be positioned on each radiant terminal	72.000 €





4.4.4. ENERGY SIMULATION

It was drawn up:

- an asset rating simulation (A2) considering real climate, standard conditions of use;
- a Tailored Rating simulation (A3) was then performed starting from simulation A2 and the data of possible opening and operation of the building. The A3 simulation made it possible to obtain the results shown in the table below.

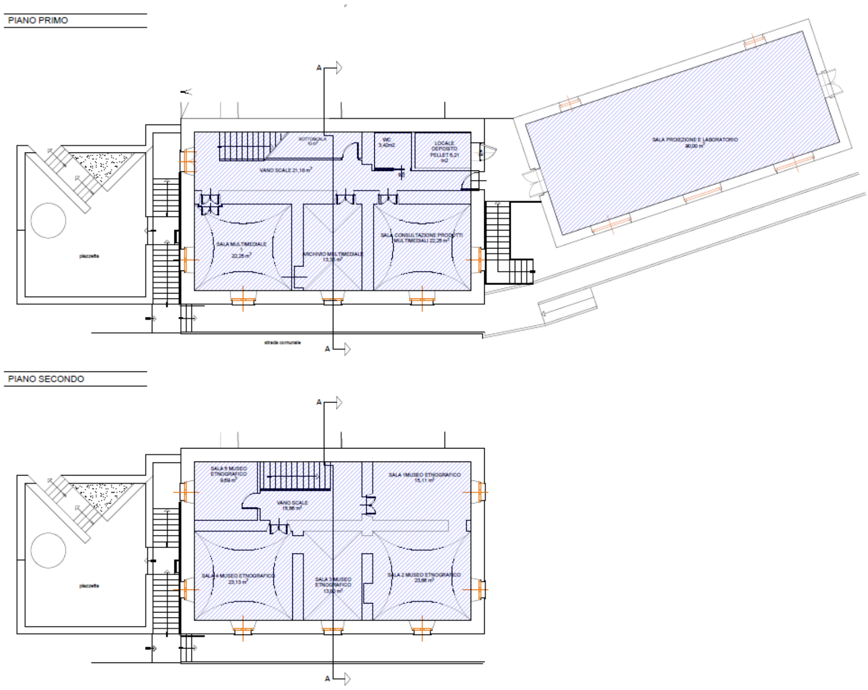


Table 41 State of the art: energy consumption and emissions data

STATE OF THE ART								
HVAC Total primary energy consumption	Fuel type	HVAC fuels consumption	HVAC RES Primary energy consumption	HVAC primary energy covered by RES	HVAC primary energy covered by Local biomass	HVAC Global Efficiency	HVAC CO_2 emissions	Expenses for HVAC fuels
[kWh]	[type]	[m3, kg]	[kWh]	[%]	[%]	[%]	[$kgCO_2$]	[€]
110438	DIESEL	8872	88	0,08%	0,00%	65,70%	29487	10043

Table 42 Results of energy simulation before intervention

INTERVENTION								
HVAC Total primary energy consumption	Fuel type	HVAC fuels consumption	HVAC RES Primary energy consumption	HVAC primary energy covered by RES	HVAC primary energy covered by Local biomass	HVAC Global Efficiency	HVAC CO2 emissions	Expenses for HVAC fuels
[kWh]	[type]	[m3, kg]	[kWh]	[%]	[%]	[%]	[$kgCO_2$]	[€]
98988	LOCAL PELLET	20307	76616	77,40%	100,00%	76,70%	4739	6137

Table 43 Energy performance certificate after intervention – State of the art

REGIONE PIEMONTE

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE IDENTIFICATIVO:

VALIDO FINO AL: *28/11/2029*

APE 2015

DATI GENERALI

Destinazione d'uso

- [ ] Residenziale
- [x] Non residenziale

Classificazione D.P.R. 412/93: ***E.4 (2)***

Oggetto dell'attestato

- [x] Intero edificio
- [ ] Unità immobiliare
- [ ] Gruppo di unità immobiliari

Numero di unità immobiliari di cui è composto l'edificio: ***2***

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [x] Altro: ______

Dati identificativi

FOTO EDIFICIO

Regione : ***PIEMONTE***
Comune : ***Ostana***
Indirizzo : ***Borgata Villa***
Piano :
Interno :
Coordinate GIS :

Zona climatica : ***F***
Anno di costruzione : ***1940***
Superficie utile riscaldata (m²) : ***288,71***
Superficie utile raffrescata (m²) :
Volume lordo riscaldato (m³) : ***1475,78***
Volume lordo raffrescato (m³) :

Comune catastale	*G183*							Sezione			Foglio			Particella		
Subalterni	da		a			da		a			da		a			da		a		
Altri subalterni																

Servizi energetici presenti

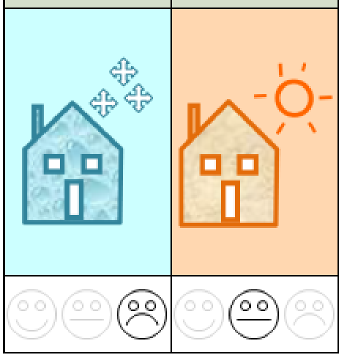
- [x] Climatizzazione invernale
- [ ] Climatizzazione estiva
- [ ] Ventilazione meccanica
- [ ] Prod. acqua calda sanitaria
- [ ] Illuminazione
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

La sezione riporta l'indice di prestazione energetica globale non rinnovabile in funzione del fabbricato e dei servizi energetici presenti, nonché la prestazione energetica del fabbricato, al netto del rendimento degli impianti presenti.

Prestazione energetica del fabbricato

INVERNO	ESTATE



Prestazione energetica globale

Più efficiente

A4
A3
A2
A1
B
C
D
E
F
G

Meno efficiente

EDIFICIO A ENERGIA QUASI ZERO ☐

CLASSE ENERGETICA

G

389,63 kWh/m²anno

Riferimenti

Gli immobili simili avrebbero in media la seguente classificazione:

Se nuovi: **D (94,22)**

Se esistenti: -

Table 44 Energy performance certificate before intervention

REGIONE PIEMONTE

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE IDENTIFICATIVO: VALIDO FINO AL: *18/12/2029*

APE 2015

DATI GENERALI

Destinazione d'uso

- [ ] Residenziale
- [x] Non residenziale

Classificazione D.P.R. 412/93: *E.4 (2)*

Oggetto dell'attestato

- [x] Intero edificio
- [ ] Unità immobiliare
- [ ] Gruppo di unità immobiliari

Numero di unità immobiliari di cui è composto l'edificio: *2*

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [x] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

FOTO EDIFICIO

Regione : *PIEMONTE*
Comune : *Ostana*
Indirizzo : *Borgata Villa*
Piano :
Interno :
Coordinate GIS : *0,000000 N - 0,000000 E*

Zona climatica : *F*
Anno di costruzione : *1940*
Superficie utile riscaldata (m^2) : *288,71*
Superficie utile raffrescata (m^2) : *0,00*
Volume lordo riscaldato (m^3) : *1475,78*
Volume lordo raffrescato (m^3) :

Comune catastale	G183	Sezione		Foglio		Particella	
Subalterni	da / a	da / a	da / a	da / a			
Altri subalterni							

Servizi energetici presenti

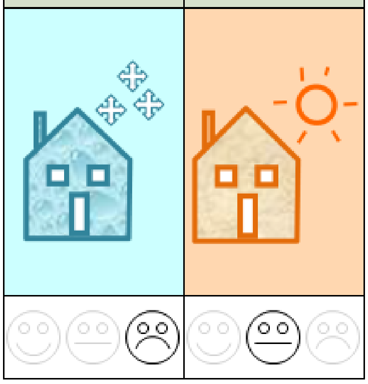
- [x] Climatizzazione invernale
- [ ] Climatizzazione estiva
- [ ] Ventilazione meccanica
- [ ] Prod. acqua calda sanitaria
- [ ] Illuminazione
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

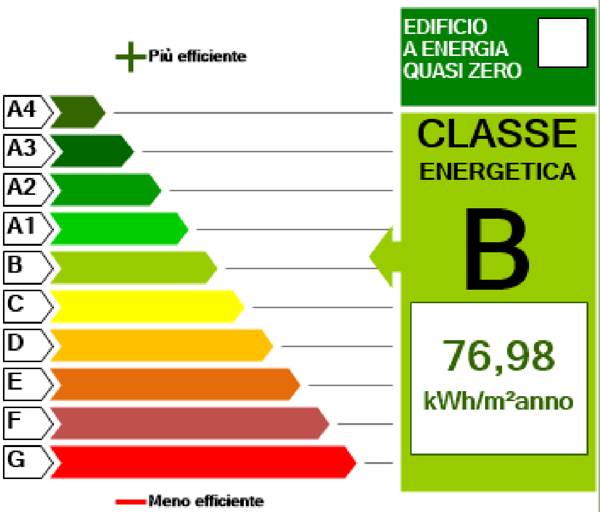
La sezione riporta l'indice di prestazione energetica globale non rinnovabile in funzione del fabbricato e dei servizi energetici presenti, nonché la prestazione energetica del fabbricato, al netto del rendimento degli impianti presenti.

Prestazione energetica del fabbricato

INVERNO	ESTATE



Prestazione energetica globale



Riferimenti

Gli immobili simili avrebbero in media la seguente classificazione:

Se nuovi: A4 (16,75)

Se esistenti: -

Pag. 1

4.4.5. FUNDING ANALYSIS AND SOCIO-ECONOMIC EVALUATION

An analysis was carried out on the incentives currently in force envisaged for energy efficiency measures. The main opportunities related to the energy requalification of real estate assets derive from the CONTO TERMICO GSE, which offers a non-repayable loan for efficiency interventions, single or combined. The incentive is credited directly to the current account of the organization that requalifies, at the end of the works. The Administration can also request an advance, which is obtained already at the start of the works.

At the same time there is another type of Regional incentives which would finance part of the intervention calculated only on the museum part. The amount of this incentive is in any case higher than that provided by the GSE.

Table 45 Summary of incentives

FOUNDING			
ECOBONUS 50%-65%	**CONTO TERMICO GSE**	**CERTIFICATI BIANCHI**	**OTHER [€]**
Not possible	Possible	Possible to evaluate with an ESCO	REGIONAL Incentives – 80% of the intervention in the museum
-	15.840 €	-	44.868 €

The economic analysis made it possible to identify the simple payback time of the investment calculated on the basis of A3 simulation.

The simple investment payback time is the payback time or investment payback period that considers the initial investment and the savings forecast over the years, considering taking advantage of the thermal account incentives described in the table. This payback time does not take into account the discounting and the change in the cost of purchasing the energy carrier. The calculation was drawn up on the basis of the costs of fuels obtained from the AIEL (2020).

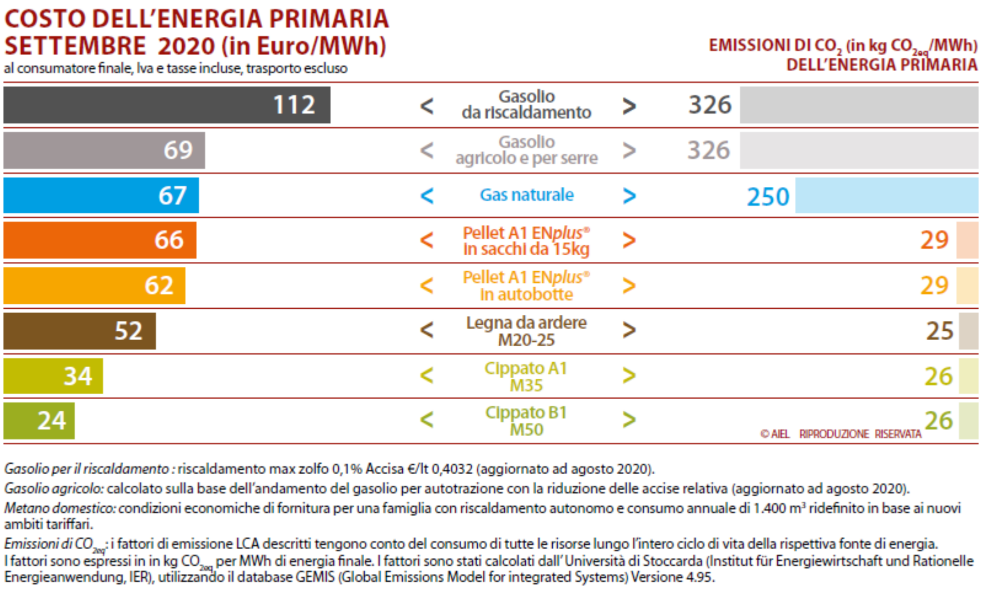


Figure 43 Energy costs divider by Fuel – Source AIEL

The calculations made it possible to determine how the replacement of the fossil fuel boiler with a pellet condensing one leads to a reduction in fuel costs of 38% per year. This savings combined with the regional incentives for intervention allow to have a payback time of less than 10 years.

Table 46 Results of economic simulations

				STATE OF THE ART	INTERVENTION	ECONOMICS	
n°	**Description**	**Total Costs**	**Incentives**	**Expenses for HVAC fuels**	**Expenses for HVAC fuels**	**Return of investment (ROI)**	**Return of investment (ROI) with incentives**
		[€]	[€]	[€]	[€]	[year]	[year]
9.1.	Replacement of the existing Diesel boiler with a new Biomass condensation boiler fuelled with pellet	72000	44868	10.043	6.137	**18**	**7**

The social, economic and environmental advantages of the proposed intervention on the territory of the intervention are the following:

- Support for the local economy - in fact, it is estimated that the intervention can generate approximately € 415,000 in annual turnover in the area and that 2 equivalent jobs (Direct + indirect, temporary + permanent);
- Territory maintenance and climate change mitigation - Considering the amount of biomass required annually and the average supply of local forests, the intervention can finance the sustainable maintenance of about 0,5 ha of forest;
- Reduction of CO_2 emissions - if coming from woods used according to sustainable forest management rules, where therefore the quantity of biomass withdrawn is always lower than the annual regrowth of the territory. The pellets will in fact be purchased locally by companies that guarantee a certified product.

Table 47 Impact on the GCArea

Increase in the number of jobs (Direct + indirect, temporary + permanent)	[n]	2
Investments in energy efficiency measures	[€]	72.000
Increase in local economic impact generated	[€]	414.720

4.5. MICROSCALE: PAESANA

4.5.1. GENERAL DESCRIPTION

The building is an existing building rebuilt in the 1960s which is spread over 3 floors. Currently it is partly unused and partly used for various activities related to BIM (Bacino Imbrifero del Monviso) and other associations in the country.

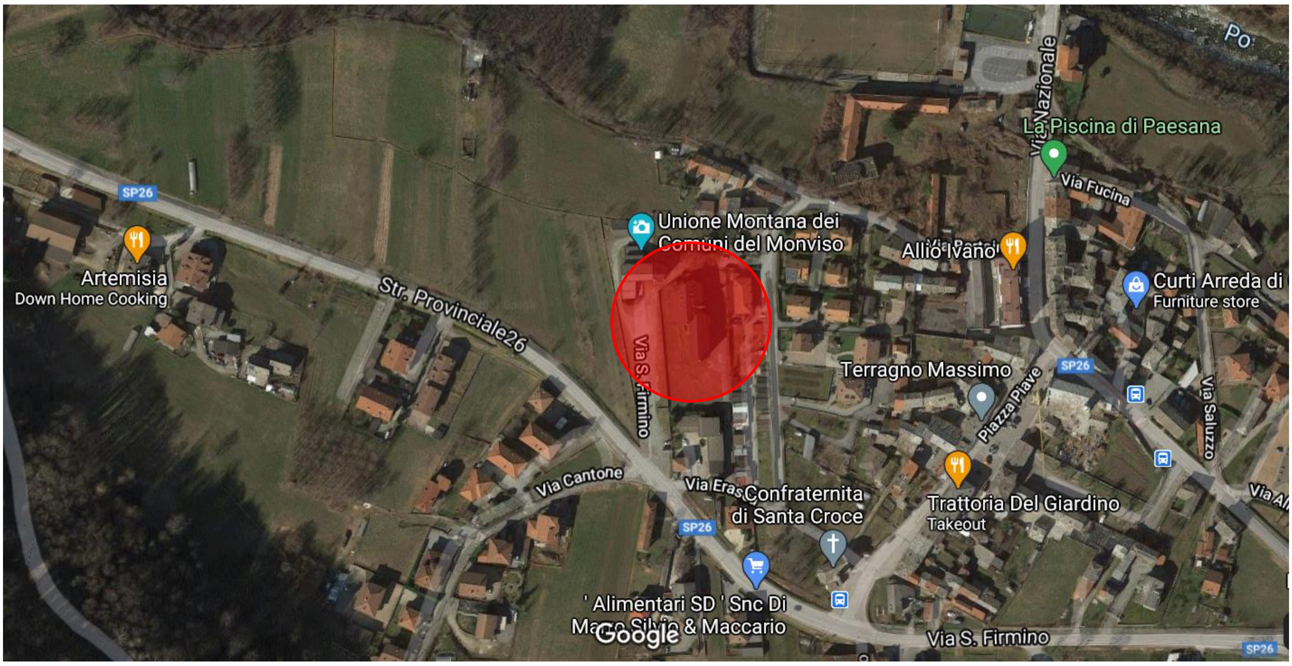


Figure 44 Aerial view of the building

The building is the subject of a project that provides for the energy requalification of the building in order to transform it into a building with the function of Porta di Valle, within which there will be services related to tourism, accommodation and related services.

4.5.2. SITE AUDIT

The building is currently equipped with a central heating system consisting of a low-efficiency basement natural gas boiler model RIELLO 3500 S190 with a power of 230 kW with ring distribution and emission by means of high-temperature radiators. The distribution in the boiler room is not isolated.
There is also a 24 kW natural gas boiler for heating the attic floor, the only room currently used.
Some rooms (kitchen, bedrooms bathrooms) are equipped with an autonomous system for the production of domestic hot water (methane boilers for the kitchen, electric boilers for the bedrooms). The DHW system was not included in the calculations as a more in-depth evaluation is required according to the type of architectural intervention to be carried out (refurbishment of floors, floors, etc.). Depending on the type of architectural intervention that will be carried out, the convenience with respect to the adoption of a centralized or autonomous DHW system will be evaluated.

4.5.3. INTERVENTION FOR ENERGY EFFICIENCY

In this building various efficiency improvements were simulated. In addition to that required in the deliverable (intervention 10.19.4), possible improvements on the envelope and a global intervention were identified. This analysis had the purpose of comparing the payback times and the incentives present between insulation interventions and interventions on HVAC systems and the possibility of accumulating incentives.

Table 48 Summary of simulated interventions

	SIMULATED INTERVENTION	DESCRIPTION	EXPENSE
10.19.1	**EXTERNAL WALL INSULATION**	External wall insulation with bio-materials (TR < 0,22 W/M2K)	210.000
10.19.2	**EXTERNAL FLOOR INSULATION**	External floor insulation with bio-materials (TR < 0,2 W/M2K)	15.500
10.19.3	**ROOF INSULATION**	External wall insulation with bio-materials (TR < 0,2 W/M2K)	18.000
10.19.4	**HEATING CENTRAL REFURBISHMENT WITH WOOD CHIP BOILER**	Complete deconstruction of the old thermal power plant, installation of a wood chip boiler with a useful power of 150 kW (to be verified according to the insulation interventions that will actually be carried out), complete reconstruction of the CT distribution system with puffer for technical water storage (5000 litres) , regulatory compliance with CT and flue, construction of an underground wood chip storage deposit with a capacity of 50 cubic meters equipped with an automatic system for transporting and loading the chips into the boiler	130.000

10.19.5	**BUILDING AUTOMATION**	Installation of automated technologies equipped with artificial intelligence for the management and automatic control (Building Automation - BA) of the thermal and electrical systems and lighting of buildings (excluding light points), including the installation of thermoregulation and heat metering systems	33.000
10.19.6	**GLOBAL INTERVENTION**	Integration of all the described interventions	406.500

In particular for this deliverable the main intervention considered are the HEATING CENTRAL REFURBISHMENT WITH WOOD CHIP BOILER. The intervention involves the complete refurbishment of the thermal power plant for heating the entire building. In particular:

- Complete decommissioning of the old natural gas power plant (basement boiler and wall boiler, distribution, electrical system, flue);
- Possible dimensional adjustment of the thermal plant to accommodate the new systems;
- Installation of a high-efficiency wood chip boiler with a useful power of 150 kW;
- Installation of a puffer for technical water storage to have a capacity of 5000 litres;
- Complete refurbishment of the distribution system with electronic circulators;
- Construction of a waterproofed underground reinforced concrete tank with a capacity of 50 cubic meters, with screw system for the transport and automatic loading of the wood chips into the boiler. The reinforced concrete structure must be built in an area that is currently not asphalted and be equipped with a closed loading mouth with a pneumatic opening system for unloading by vehicle.

4.5.4. ENERGY SIMULATION

It was drawn up:

- an asset rating simulation (A2) considering real climate, standard conditions of use
- a Tailored Rating simulation (A3) was then performed starting from simulation A2 and the data of possible opening and operation of the building.

The A3 simulation made it possible to obtain the results shown in the table below.

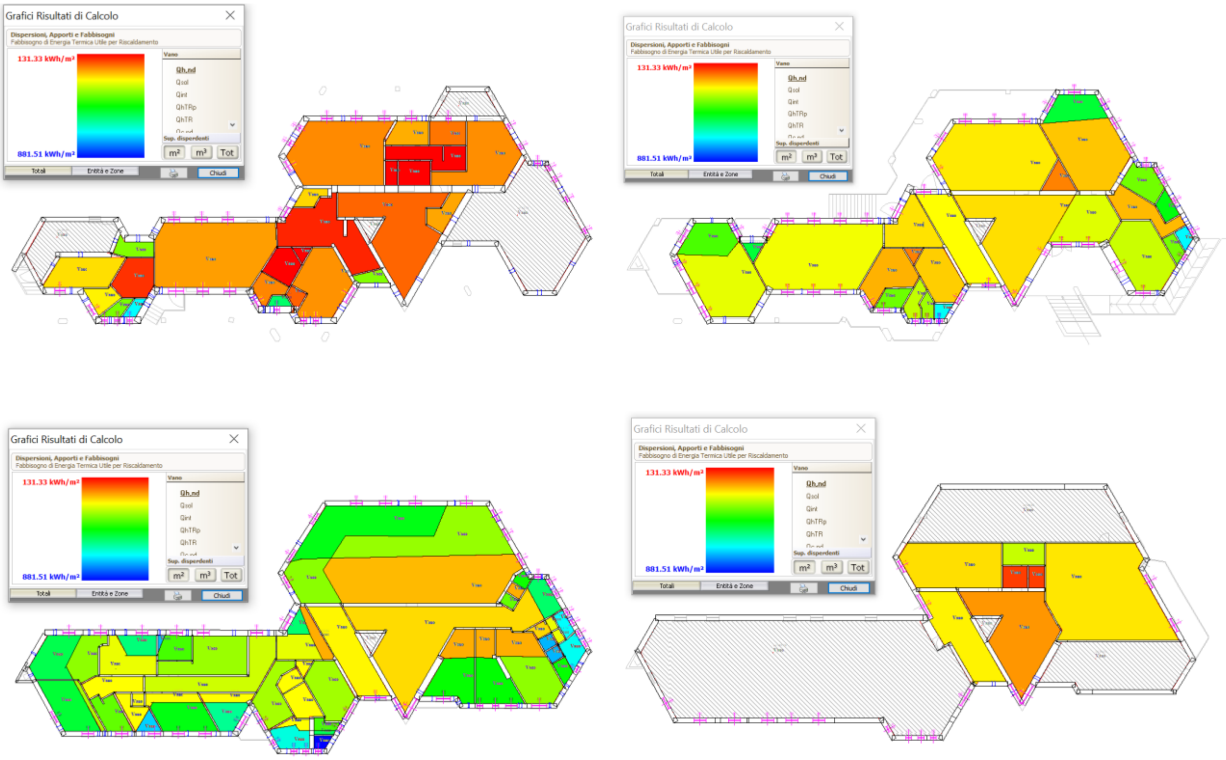


Figure 45 Energy needs of each area

Table 49 State of the art: energy consumption and emissions data

STATE OF THE ART									
n°	HVAC Total primary energy consumption	Fuel type	HVAC fuels consumption	HVAC RES Primary energy consumption	Percentage of HVAC primary energy covered by RES	Percentage of HVAC primary energy covered by Local biomass	HVAC Global Efficiency	HVAC CO_2 emissions	Expenses for HVAC fuels
	[kWh]	[type]	[m^3,kg]	[kWh]	[%]	[%]	[%]	[$kgCO_2$]	[€]
10.19	317593	Natural gas	33608	1048	0,33%	0,00%	69,00%	62534	21279

Table 50 Results of energy simulation before intervention

INTERVENTION									
n°	HVAC Total primary energy consumption	Fuel type	HVAC fuels consumption	HVAC RES Primary energy consumption	Percentage of HVAC primary energy covered by RES	Percentage of HVAC primary energy covered by Local biomass	HVAC Global Efficiency	HVAC CO_2 emissions	Expenses for HVAC fuels
	[kWh]	[type]	[m^3,kg]	[kWh]	[%]	[%]	[%]	[$kgCO_2$]	[€]
10.19.1	246047	Natural gas	26036	959,5833	0,39%	0,00%	74,00%	48447	16485
10.19.2	302543	Natural gas	32015	1028,6462	0,34%	0,00%	69,00%	59571	20270
10.19.3	291376	Natural gas	30833	990,6784	0,34%	0,00%	69,00%	57372	19522
10.19.4	287819	Wood chip	71954	228298,0308	79,32%	100,00%	78,00%	11858	9786
10.19.5	289067	Natural gas	30589	549,2273	0,19%	0,00%	76,20%	56917	19367
10.19.6	121930	Wood chip	34837	97117,245	79,65%	100,00%	89,41%	5024	4146

4.5.5. FUNDING ANALYSIS AND SOCIO-ECONOMIC EVALUATION

An analysis was carried out on the incentives currently in force envisaged for energy efficiency measures. The main opportunities related to the energy requalification of the buildings derive from the CONTO TERMICO GSE, which offers a non-repayable loan for efficiency interventions, single or combined. The incentive is credited directly to the current account of the organization that requalifies, at the end of the works. The Administration can also request an advance, which is obtained already at the start of the works. At the same time there is another type of National incentives which would finance part of the global intervention (50.000 €) and it is cumulable with the GSE founds.

Table 51 Summary of incentives

FOUNDING				
	ECOBONUS 50%-65%	**CONTO TERMICO GSE**	**CERTIFICATI BIANCHI**	**OTHER [€]**
10.19.1	Not possible	Possible 66.700€	Possible to evaluate with an ESCO	-
10.19.2	Not possible	Possible 9.300€	Possible to evaluate with an ESCO	-
10.19.3	Not possible	Possible 15.000€	Possible to evaluate with an ESCO	-
10.19.4	Not possible	Not possible	Possible to evaluate with an ESCO	-
10.19.5	Not possible	Possible 12.650€	Possible to evaluate with an ESCO	-
10.19.6	Not possible	Possible 96.100€	Possible to evaluate with an ESCO	National found 50.000€

The economic analysis made it possible to identify the simple payback time of the investment calculated on the basis of A3 simulation. The simple investment payback time is the payback time or investment payback period that considers the initial investment and the savings forecast over the years, considering taking advantage of the thermal account incentives described in the table. This payback time does not take into account the discounting and the change in the cost of purchasing the energy carrier. The calculation was drawn up on the basis of the costs of fuels obtained from the AIEL (2020).

Table 52 Results of economic simulations

			STATE OF THE ART	INTERVENTION	ECONOMICS	
n°	Total Costs	Incentives	Expenses for HVAC fuels	Expenses for HVAC fuels	Return of investment (ROI)	Return of investment (ROI) with incentives
	[€]	[€]	[€]	[€]	[year]	[year]
10.19.1	210000	66700	21279	16485	44	30
10.19.2	15500	7750	21279	20270	15	8
10.19.3	18000	9000	21279	19522	10	5
10.19.4	130000		21279	9786	11	11
10.19.5	33000	12650	21279	19367	17	11
10.19.6	406500	96100	21279	4146	24	18

The social, economic and environmental advantages of the proposed intervention on the territory of the intervention are the following:

- Support for the local economy - in fact, it is estimated that the intervention can generate approximately € 750.000 in annual turnover in the area and that 2 equivalent jobs (Direct + indirect, temporary + permanent);
- Territory maintenance and climate change mitigation - Considering the amount of biomass required annually and the average supply of local forests, the intervention can finance the sustainable maintenance of about 2 ha of forest;
- Reduction of CO_2 emissions - if coming from woods used according to sustainable forest management rules, where therefore the quantity of biomass withdrawn is always lower than the annual regrowth of the territory. The wood chips will in fact be purchased locally by companies that guarantee a certified product.

Table 53 Impact on the GCArea

Increase in the number of jobs (Direct + indirect, temporary + permanent)	[n]	2
Investments in energy efficiency measures	[€]	130.000
Increase in local economic impact generated	[€]	748.800

4.6. SMALL SCALE: BAGNOLO PIEMONTE RENEWABLE ENERGY COMMUNITY

4.6.1. ENERGY COMMUNITY

In article 22, the RED II Directive introduces the Renewable Energy Community (REC), a collective entity of citizens based on the open, voluntary and autonomous participation of members who are located in the vicinity of energy production plants. The primary objective of a REC is to provide environmental, economic or social benefits to its shareholders, rather than financial profits. The main activities of a REC include the production, consumption, storage and sale of energy from renewable sources, the sharing among its members of the energy produced and the participation in all energy markets.

Between the end of 2019 and the beginning of 2020, the Decreto Legge 162/19, later converted into Legge 8/2020, with article 42-bis started the early and partial transposition of the RED II Directive into Italian legislation on collective autonomy and introduction of REC.

The Decree aims to encourage the construction of new plants from renewable sources (at the moment the existing plants cannot enter into experimentation) aimed at satisfying the requests of the communities that host them. Therefore, those who participate in collective self-consumption schemes or energy communities must produce energy for their own consumption with these RES plants with a single power not exceeding 200 kWp. However, it is important to note that the benefits for the energy system deriving from self-consumption are not strictly linked to the source, therefore any incentives may not be limited to RES plants only.

In this first phase, the Decree aims to promote the balance between the demand and the supply of energy from renewable sources at the local level: the participants in collective self-consumption schemes must be in the same building; REC components must be on the same low voltage network below the same Medium Voltage (“Media tensione”)/ Low Voltage (“Bassa tensione”) substation.

The Decree provides that shared energy, also with the support of storage systems, will be rewarded through the recognition of an explicit incentive that will be given by the GSE. It will be cumulative with tax detractions but will not be compatible with the incentive scheme envisaged by the Decree of 4 July 2019 - “FER 1”, based on auctions for large generators and register for minor plants.

The GreenChainSaw4Life project made it possible to successfully participate in a tender set up by the Piedmont Region for the establishment of a large-scale energy community (AT/MT). 10 municipalities that are part of the Life project have joined the group in order to establish the Monviso energy community within which there will be individual RECs with the requisites envisaged by the National Decree. Among these communities we have carried out a feasibility study on the REC of Bagnolo Piemonte. The Life project allowed a student of the Polytechnic of Turin to draw up a preliminary energy balance of the community in collaboration with IRIS. This budget was the basis of the business case described in the following paragraphs, aimed at determining the best biomass technological solution to be installed in the community and at determining the related project KPIs.

4.6.2. GENERAL DESCRIPTION - RENEWABLE ENERGY COMMUNITY

As a case study in the Small scale, it was decided to take into consideration not 1 single building and 1 single technology but the energy community of Bagnolo Piemonte. In fact, the GreenChainSaw4Life project has favoured the drafting of an energy balance of the large area energy community among the municipalities that are part of the project. Within the large area community, as required by current legislation, individual communities will be established with buildings underneath the same medium-low voltage transformer substation.

Among these communities, the most representative and energy-intensive case is represented by 6 buildings in the municipality of Bagnolo Piemonte and a part of the town's public lighting.

Table 54 Bagnolo Business case summary

CODE	BUILDINGS	ELECTRIC POWER	THERMAL POWER	ADDRESS	DESTINATION
		[kW]	[kW]		
1.1	City hall	15	115	Piazza Divisione Alpina Cuneense 5	E2 - Office
1.2	Nursery school	10	160	Via De Gasperi 5	E7 - School
1.3	Public gym	15	400	Via Roma 2	E6.2 - School
1.4	Primary school	50	60	Via Don Milani 9	E7 - School
1.5	Secondary school	50	300	Via Confraternita	E7 - School
1.6	Public Library	6	24	Corso Malingri 22	E4.2 - Library
1.A	Public lighting	10	0	Energy community area	Public lighting

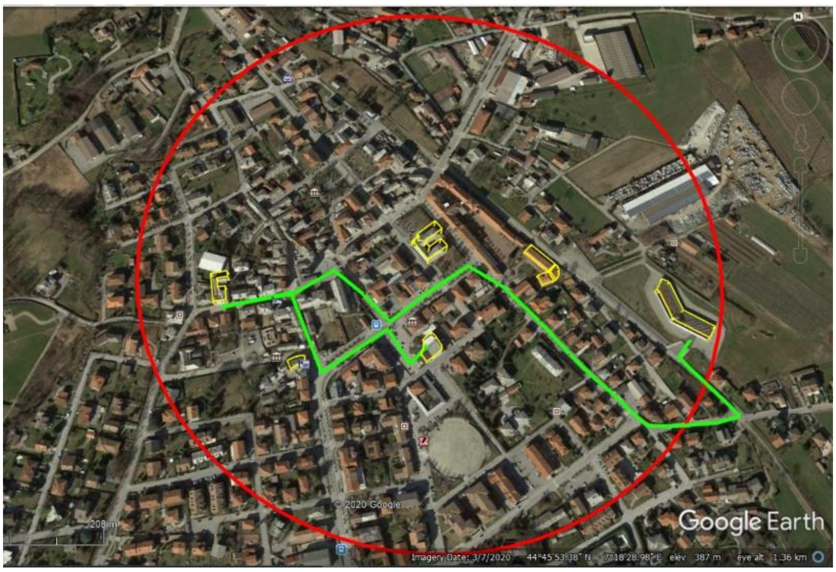


Figure 46 Micro energy community aerial view

4.6.3. SITE AUDIT

The energy audit made it possible to determine a total real monthly consumption in the case study is MWh (data deriving from real bills).

Table 55 REC Electric and Thermal energy consumption

CODE	BUILDINGS	Electric energy consumption [kWh]	Thermal energy consumption [kWh]
1.1	City hall	37976	98240
1.2	Nursery school	6761	348156
1.3	Public gym	17061	
1.4	Primary school	30386	5079
1.5	Secondary school	39623	349894
1.6	Public Library	6464	23519
1.A	Public lighting	31509	0
TOTAL	REC	169.927	824.888

After determining the real average monthly consumption, hourly consumption for weekdays, holidays, winter and summer days was simulated. The hourly study uses a mixed methodology between forecasting and definition. the following pages show the distribution graphs of a typical weekday for each building.

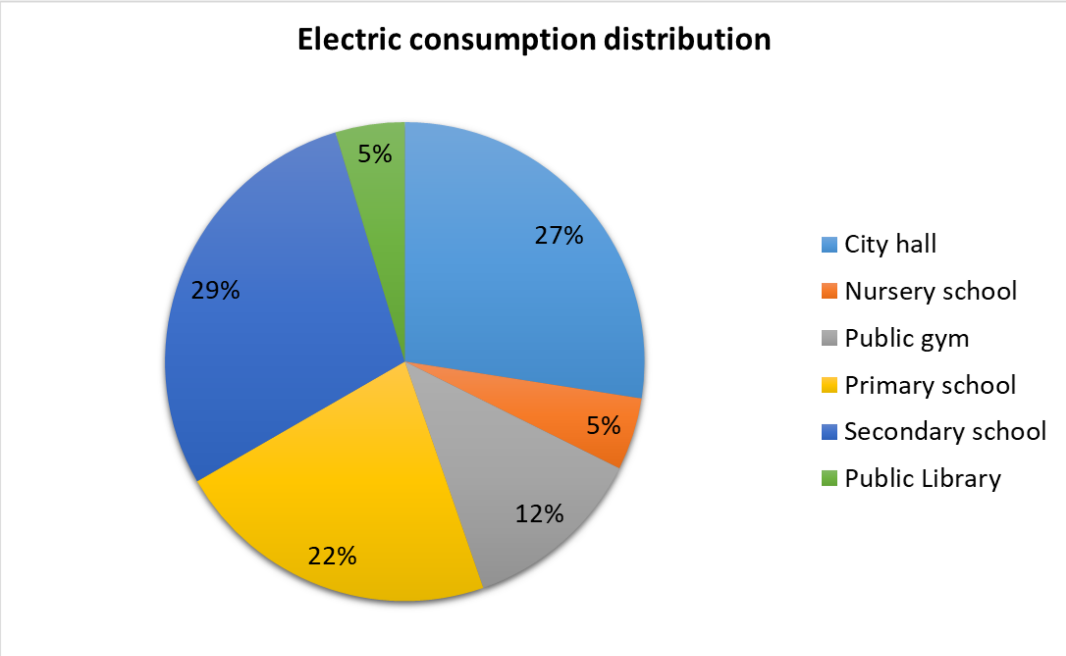


Figure 47 Micro energy community - Electric consumption distribution

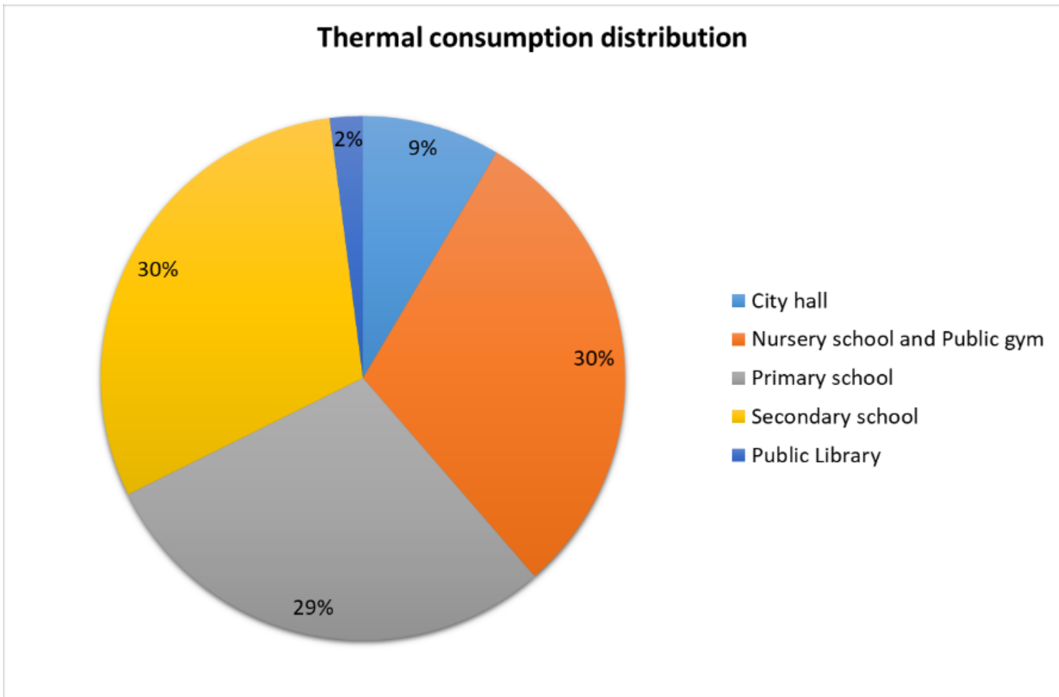


Figure 48 Micro energy community - Thermal consumption distribution

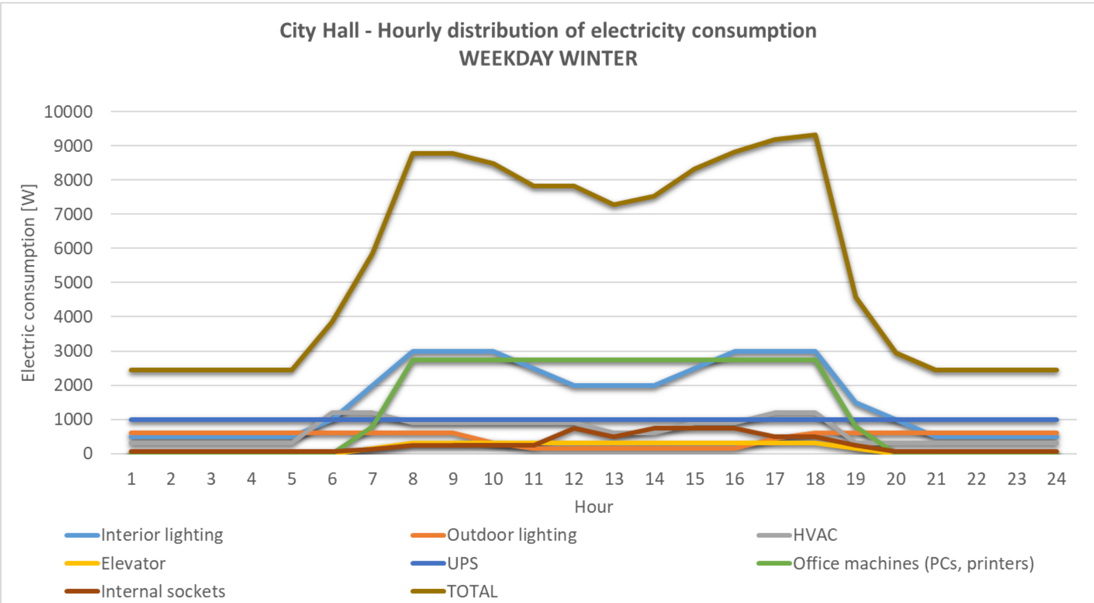


Figure 49 City Hall - Hourly distribution of electricity consumption - WEEKDAY WINTER

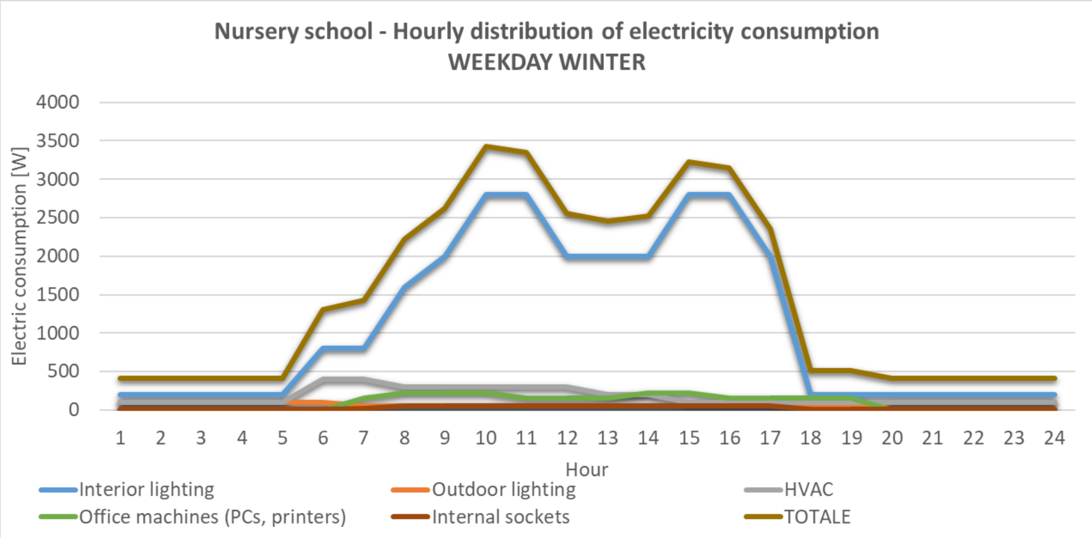


Figure 50 Nursery School - Hourly distribution of electricity consumption - WEEKDAY WINTER

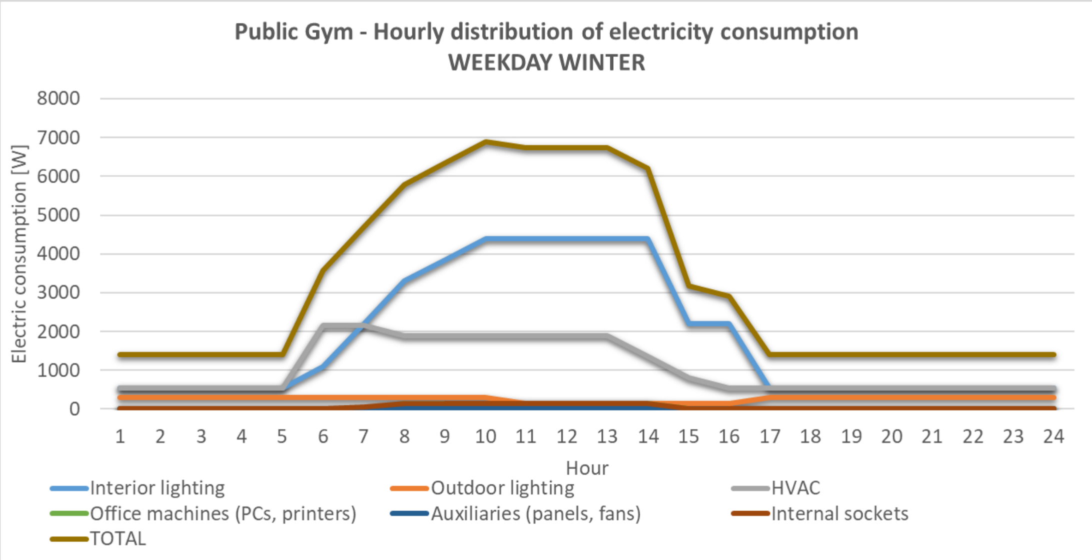


Figure 51 Public Gym - Hourly distribution of electricity consumption - WEEKDAY WINTER

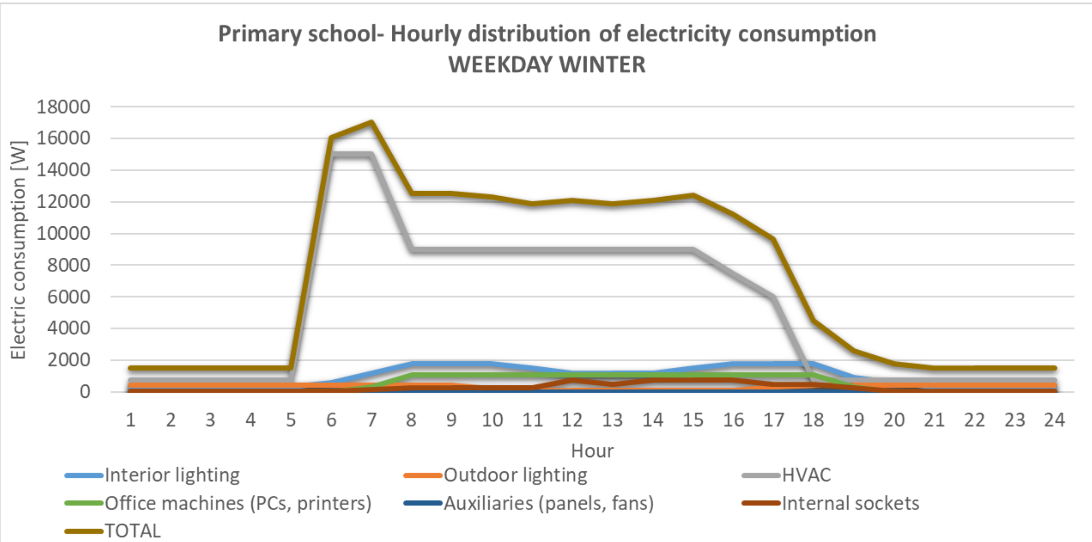


Figure 52 Primary school - Hourly distribution of electricity consumption - WEEKDAY WINTER

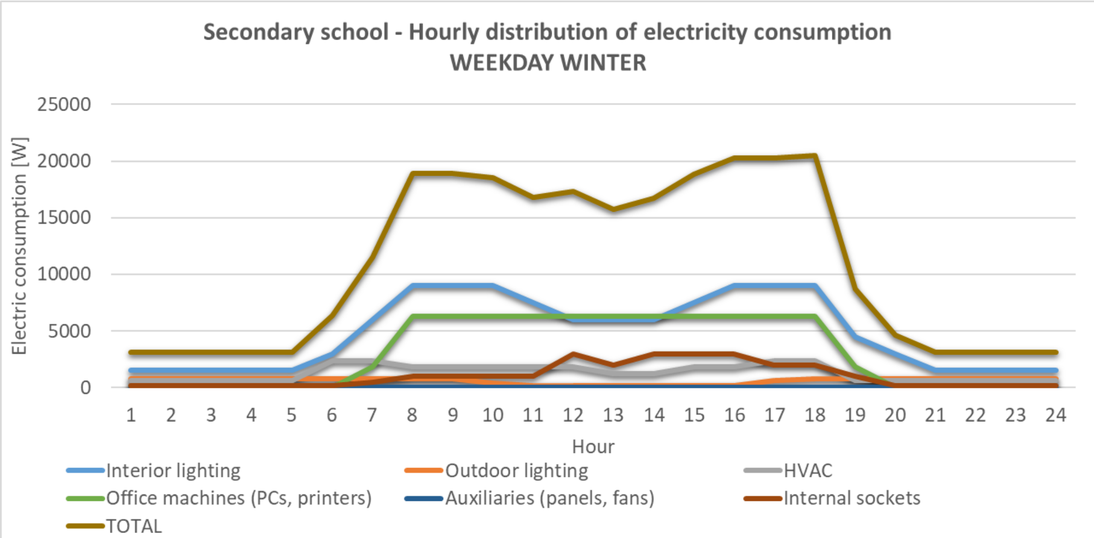


Figure 53 Secondary school - Hourly distribution of electricity consumption - WEEKDAY WINTER

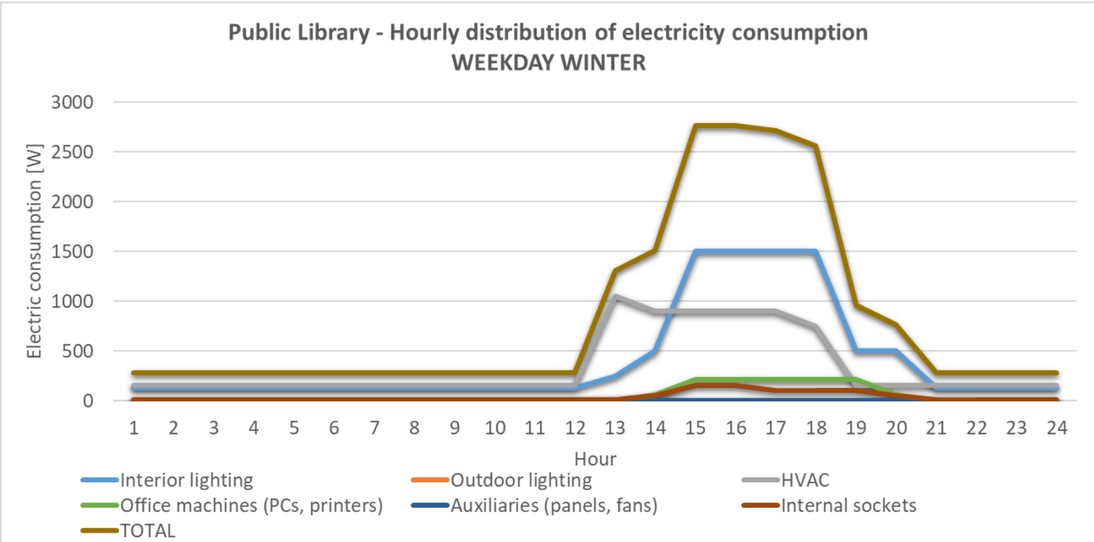


Figure 54 Public library - Hourly distribution of electricity consumption - WEEKDAY WINTER

4.6.4. INTERVENTION FOR ENERGY EFFICIENCY

In order to determine the best solution, 13 scenarios were simulated in which the type and size of the interventions varied. All the scenarios studied are listed below, but only those chosen to determine the KPIs are reported. The detailed results of all the scenarios are present in Annex 04.
Before describing the scenarios, some technical indicators are described that were used to compare the solutions.

SCI (Self Consumption Index)

It is an index introduced by the legislation on energy communities. Indicates the ratio between the energy produced by RES and immediately consumed or stored in the REC without being fed into the national grid. Its threshold must be at least 70% and is necessary to classify an EC as Renewable. The energy production consumed instantly on site is defined as self-consumption.

$$\boldsymbol{SCI = \frac{Selfconsumption\ [kWh]}{RES\ energy\ production\ [kWh]}}$$

SSI (Self Sufficiency Index)

It is an index that indicates the energy independence of a REC, the higher its value, the more "independent" the community is. It is the result of the relationship between energy produced by RES and self-consumed by users and the total energy consumed.

$$\boldsymbol{SSI = \frac{Selfconsumption\ [kWh]}{Total\ energy\ consumption\ [kWh]}}$$

Table 56 Summary of simulated scenarios

Intervention	Description	Battery capacity	CHP power installed	PV power installed
		[kWh]	Kw_p	Kw_p
SoTA	0% FV	0	0	0
SCENARIO 1	100% FV - NO battery	0	131	0
SCENARIO 2	41% FV - NO battery	0	54	0
SCENARIO 3	29% FV - NO battery	0	38	0
SCENARIO 4	19% FV - NO battery	0	25	0
SCENARIO 5	29% FV + 210 kWh battery	210	38	0
SCENARIO 6	41% FV + 30 kWh battery	30	54	0
SCENARIO 7	100% FV - NO battery + CHP da 20 kWel	0	131	20
SCENARIO 8	50% FV - NO battery + CHP da 20 kWel	0	66	20
SCENARIO 9	25% FV - NO battery + CHP da 20 kWel	0	35	20
SCENARIO 10	18% FV - NO battery + CHP da 20 kWel	0	24	20
SCENARIO 11	50% FV + 45 kWh battery + CHP da 20 kWel	45	66	20
SCENARIO 12	25% FV + 45 kWh battery + CHP da 20 kWel	45	35	20
SCENARIO 13	41% FV + 30 kWh battery + CHP da 20 kWel	30	54	20

CONCEPTUAL SCHEME - Scenario 1,2,3,4

These scenarios provide for the installation of variable quotas of monocrystalline photovoltaic panels for the production of electricity without the presence of accumulation.

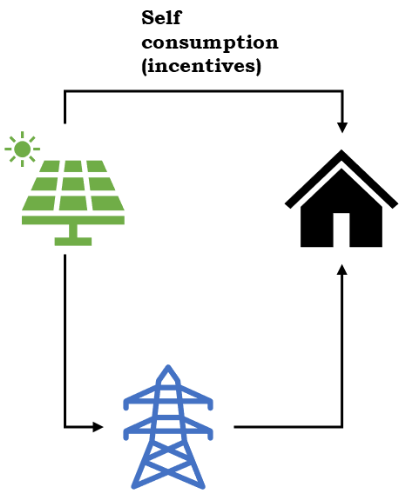


Figure 55 Scenario 1 to 4

CONCEPTUAL SCHEME - Scenario 5,6

These scenarios provide for the installation of variable quotas of monocrystalline photovoltaic panels for the production of electricity with the addition of highly efficient lithium-ion storage systems.

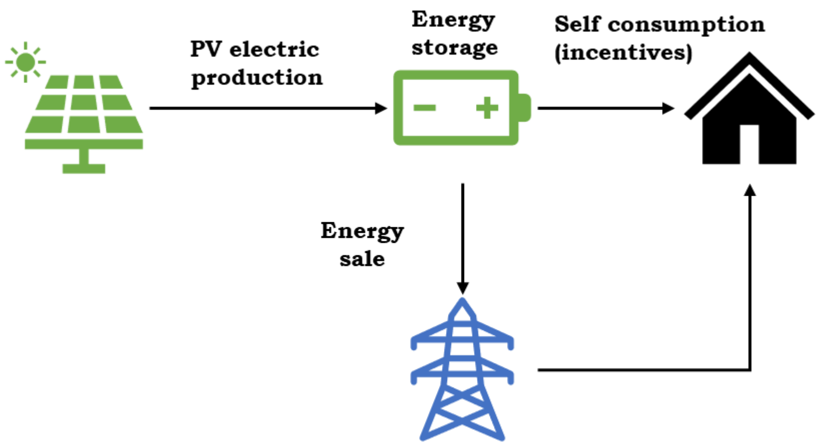


Figure 56 Scenario 5 and 6

CONCEPTUAL SCHEME - Scenario 7,8,9,10,11,12,13 These scenarios provide for the installation of variable quotas of monocrystalline photovoltaic panels for the production of electricity with the addition of highly efficient lithium-ion storage systems. It is also installed in a biomass cogeneration system for the production of electrical and thermal energy.

Table 57 CHP technical data

Electric power	20 kWp
Thermal power	40 kWp
Frequency	Three-phase 50Hz
Biomass flow kg/h)	22-26 kg/h
Height	256 cm
Width	243 cm
Length	605 cm
Weight	5500 kg

CONCEPTUAL SCHEME – Sub Scenario 11.a, 11.b, 11.c, 11.d, 11.e

In addition, 5 sub-scenarios of solution 11 were identified with different ways of using thermal energy. The thermal energy is partly used for drying the biomass that feeds the CHP (humidity <10%) and partly used to heat a building and / or dry biomass for sale.

Table 58 Sub-scenario with thermal energy valorisation

Intervention	Description	Thermal energy for drying biomass self-consumption	Thermal energy for drying biomass self-consumption	Thermal energy for District heating
		[kW]	[kW]	[kW]
11.a	Dissipation of thermal energy	3,76		
11.b	Sale of excess wood chips dried with thermal energy	3,76	36,24	
11.c	Sale of excess wood chips dried with thermal energy, heating of primary school near the cogeneration plant.	3,76	26,24	10
11.d	Creation of a public cooperative for forest management and sale of excess wood chips dried with thermal energy	3,76	36,24	
11.e	Heating of 3 buildings (primary school, public gym, Nursery school) with district heating plant	3,76		36,24

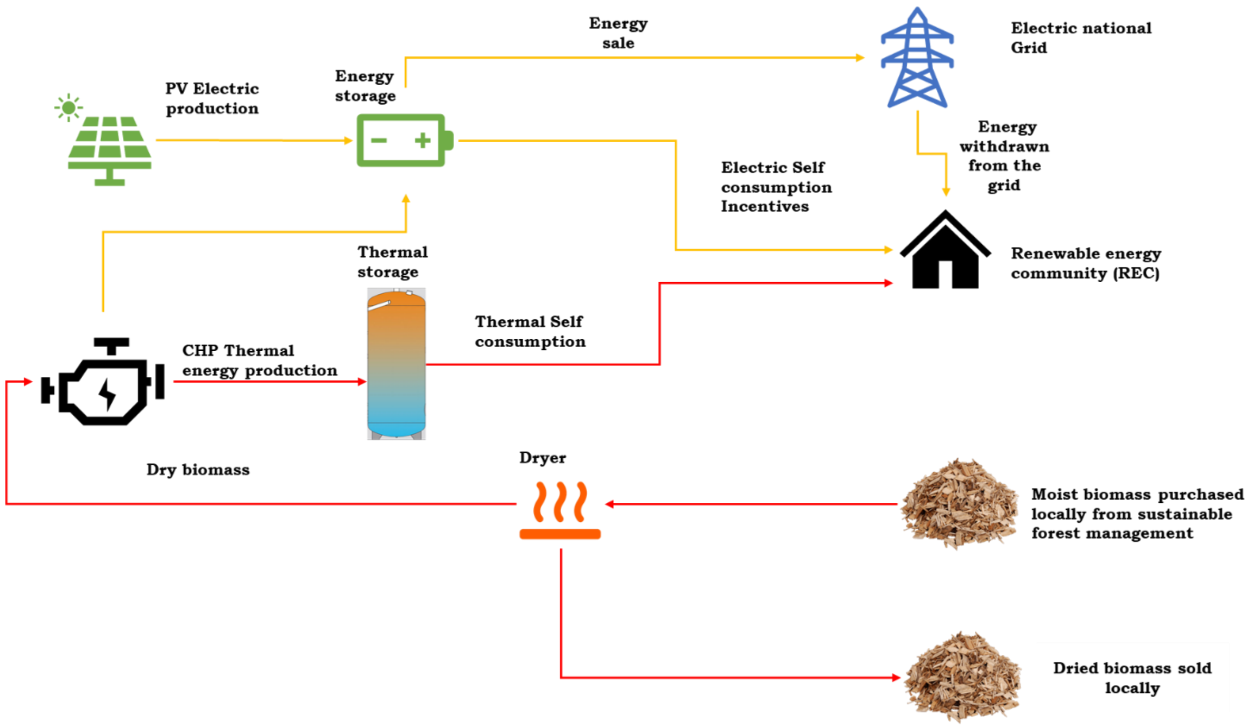


Figure 57 Scenario 11.d

The final scenario 11.e is the one whose KPIs will be used as a tool for replicating the intervention, as it offers the greatest thermal independence and the best results in terms of emission reduction and social contribution to the area.

It was therefore considered to create a district heating network capable of connecting 3 buildings: Elementary School, Kindergarten and Gymnasium. The district heating network extends for 831 m and the cost of the delivery and return pipes of the TLR is considered equal to 400 €/ m. The final investment, only for the district heating plant was estimated at € 332.400.

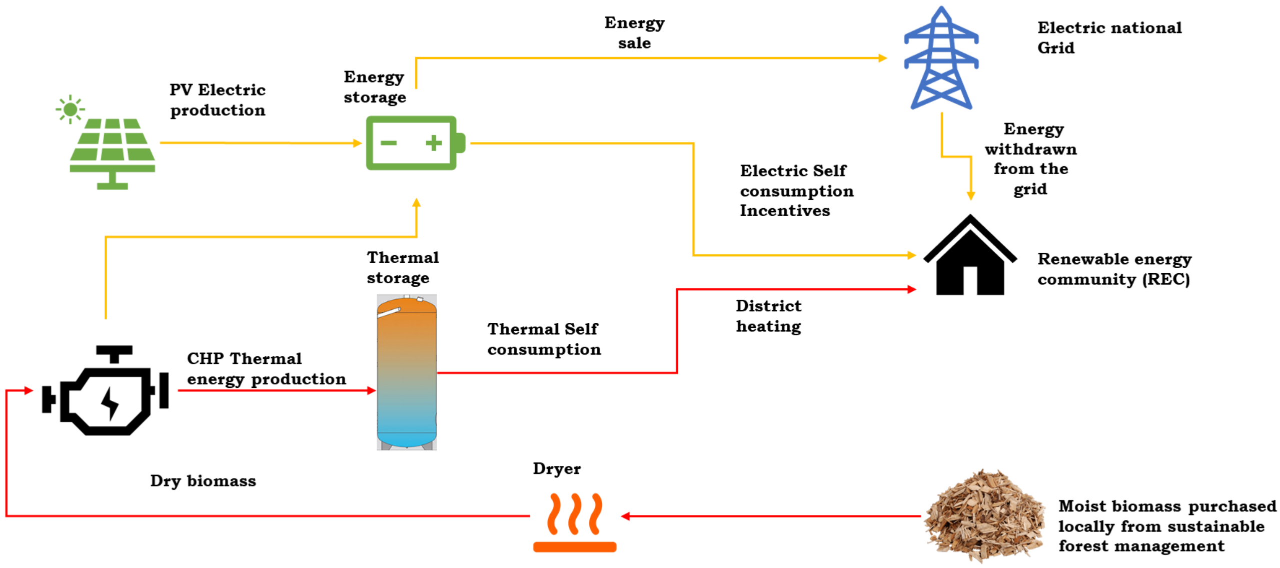


Figure 58 Scenario 11.e

4.6.5. ENERGY SIMULATION

First a simulation of consumption and electricity production was carried out among the 13 scenarios. Electricity consumption is not reduced with the installation of solar panels, battery and CHP but are covered with renewable sources (sun and biomass). This allows us to be independent quads (80%) from the national network and therefore from ditch fuels. The scenarios make it possible to reach a level of coverage with RES for electricity up to 84%.

Table 59 Electric energy simulated intervention results

SCENARIO	Electric energy consumption	PV electric energy production	CHP electric production	Self-consumption	Excess electric energy	Energy withdrawn from the grid	SCI	SSI
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]	[%]	[%]
SoTA	138418	0	0	0	0	138522	0	0%
1	138418	146479	0	62947	83532	75472	43%	45%
2	138418	60056	0	41938	18118	96480	70%	30%
3	138418	42479	0	33955	8524	104463	80%	25%
4	138418	27831	0	24944	2887	113474	90%	18%
5	138418	50977	0	42683	0	95726	100%	31%
6	138418	63518	0	47659	14598	90750	79%	34%
7	169927	146479	114723	136637	41032	32014	52%	80%
8	169927	73239	114723	129748	31784	38903	69%	76%
9	169927	39549	114723	121576	25500	47075	79%	72%
10	169927	26366	114723	116626	22003	52025	83%	69%
11	169927	73239	114723	137149	10650	35284	73%	81%
12	169927	39549	114723	127228	2437	45564	75%	84%
13	169927	63518	114723	114723	9895	39233	76%	79%

Subsequently, a simulation was carried out for the energy consumption of each building for HVAC and related thermal energy production of the CHP (scenario 11.a to 11.e)

Table 60 Energy consumption for HVAC

Month	City hall	Nursery school and Public Gym	Primary school	Secondary school	Public Library
	[kWh]	[kWh]	[kWh]	[kWh]	[kWh]
01	24304	83518	1302	80089	2922
02	16612	48465	1176	62318	2606
03	12262	41395	713	34593	2558
04	2951	8526	420	5049	6457
05	1265	4234	155	10500	1619
06	10	0	0	0	134
07	0	0	0	182	134
08	0	0	0	182	125
09	0	0	0	182	134
10	536	8047	0	18579	1015
11	7472	60028	11	47593	2443
12	32827	93941	1302	90627	3372
TOTAL	**98240**	**348156**	**5079**	**349894**	**23519**

Table 61 CHP production for HVAC and biomass drying.

Month	CHP thermal production for HVAC (SSI)	CHP Production of thermal energy for biomass drying (fuel)	Local Biomass used
	[kWh]	[kWh]	[kg]
01	29760	2797,44	17856
02	26880	2526,72	17856
03	29760	2797,44	17856
04	8946,2	2707,2	17856
05	4389,36	2797,44	17856
06	0	1353,6	17856
07	0	0	0
08	0	0	0
09	0	2707,2	17856
10	8047,2	2797,44	17856
11	28800	2707,2	17856
12	29760	2797,44	17856
TOTAL	166342,76	25989,12	178650

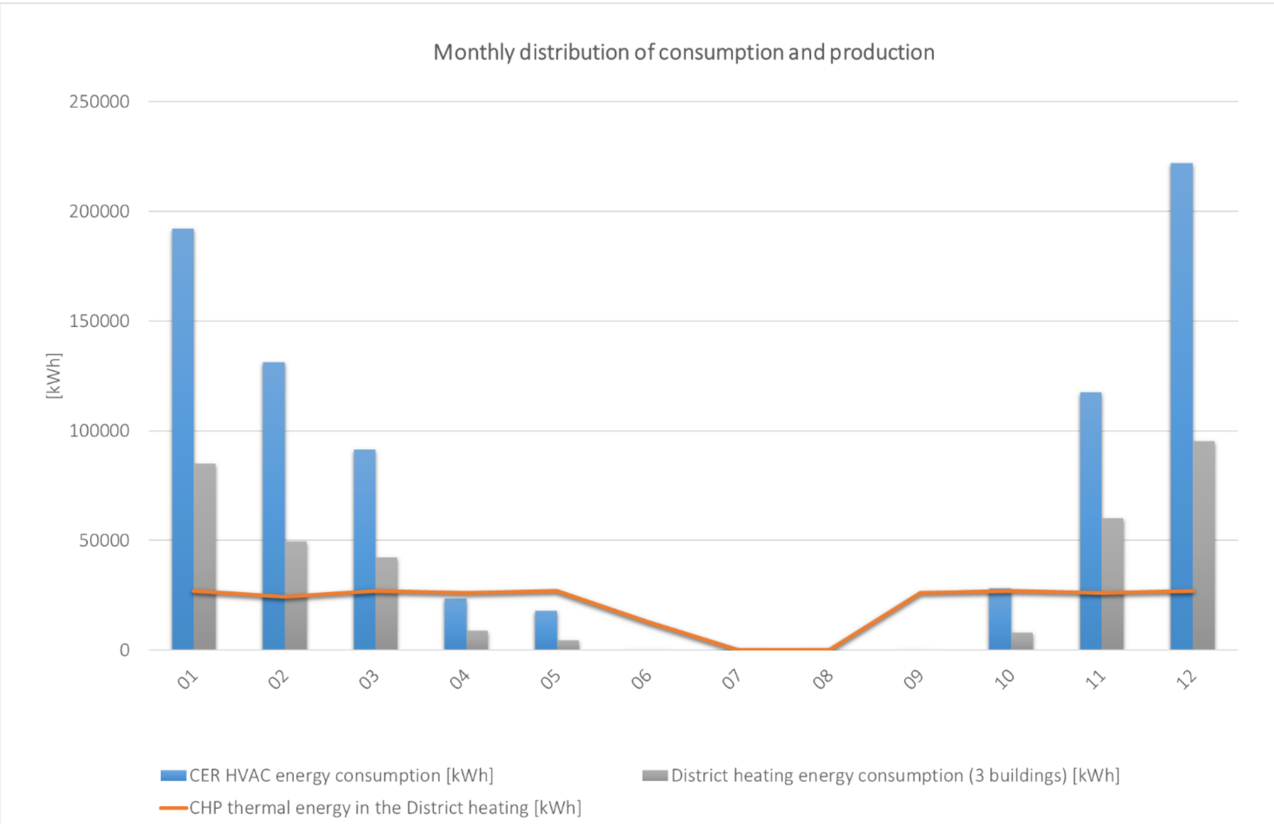


Figure 59 Monthly distribution of consumption and production

The processing of all these data allows us to identify the SSI and SCI indices for each scenario and to draw up the relative distribution graphs. The percentages of reduction of CO_2 emissions following each intervention are also indicated in the table below.

Table 62 Comparison between the scenarios based on the SCI and SSI index

	SCI electric	SSI Electric	SCI HVAC	SSI HVAC	Reduction of CO_2 emissions
	[%]	[%]	[%]	[%]	[%]
SCENARIO 1	43%	45%	0%	0%	14%
SCENARIO 2	70%	30%	0%	0%	9%
SCENARIO 3	80%	25%	0%	0%	8%
SCENARIO 4	90%	18%	0%	0%	6%
SCENARIO 5	100%	31%	0%	0%	3%
SCENARIO 6	79%	34%	0%	0%	10%
SCENARIO 7	52%	80%	0%	0%	25%
SCENARIO 8	69%	76%	0%	0%	24%
SCENARIO 9	79%	72%	0%	0%	21%
SCENARIO 10	83%	69%	0%	0%	20%
SCENARIO 11	73%	81%	0%	0%	23%
SCENARIO 11.b	73%	81%	70%	0%	23%
SCENARIO 11.c	83%	81%	70%	6%	27%
SCENARIO 11.d	83%	81%	70%	0%	23%
SCENARIO 11.e	76%	81%	70%	20%	36%
SCENARIO 12	83%	76%	0%	0%	21%
SCENARIO 13	76%	79%	0%	0%	23%

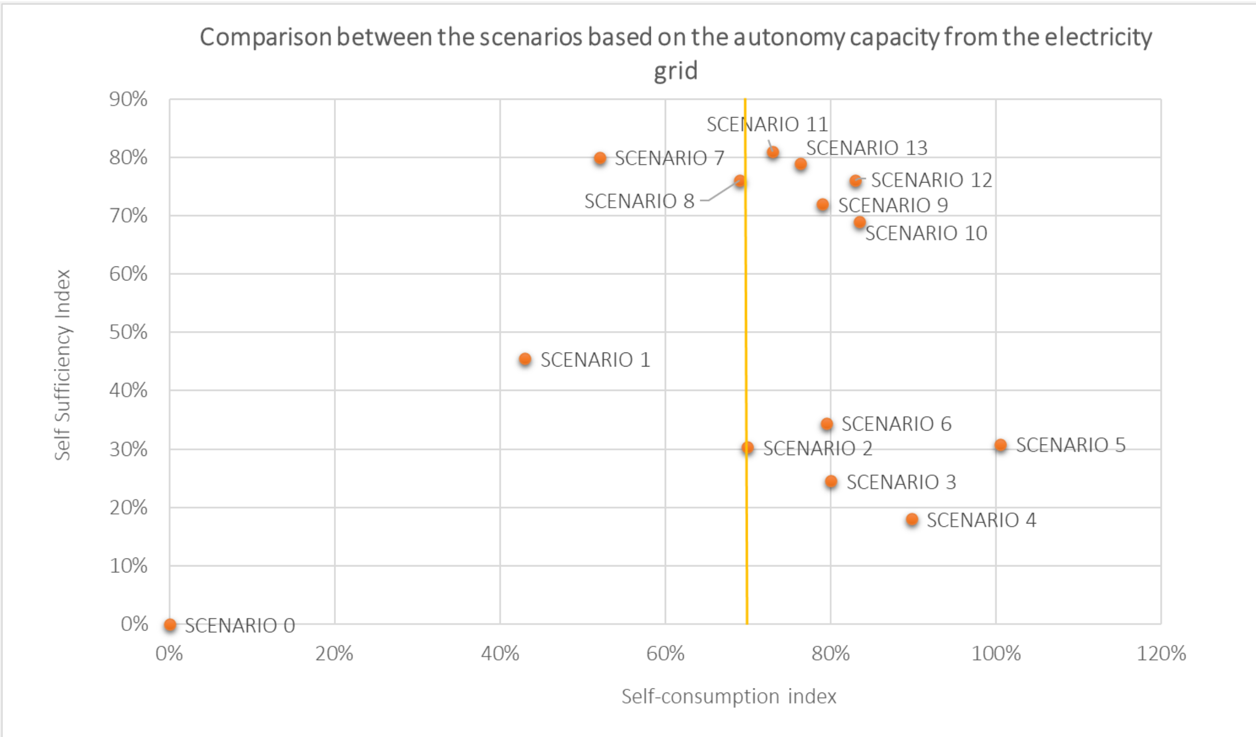


Figure 60 Comparison between the scenario based on the SCI and SSI index

The yellow line corresponds to the limit of SCI = 70% imposed by the regulation. We have to consider only the points arranged to the right of the limit line.

In addition to this caution, it should be noted that the scenarios are grouped into two areas:

- the lower one sees the scenarios without the CHP
- the area positioned at the top corresponds to the scenarios combined with the CHP.

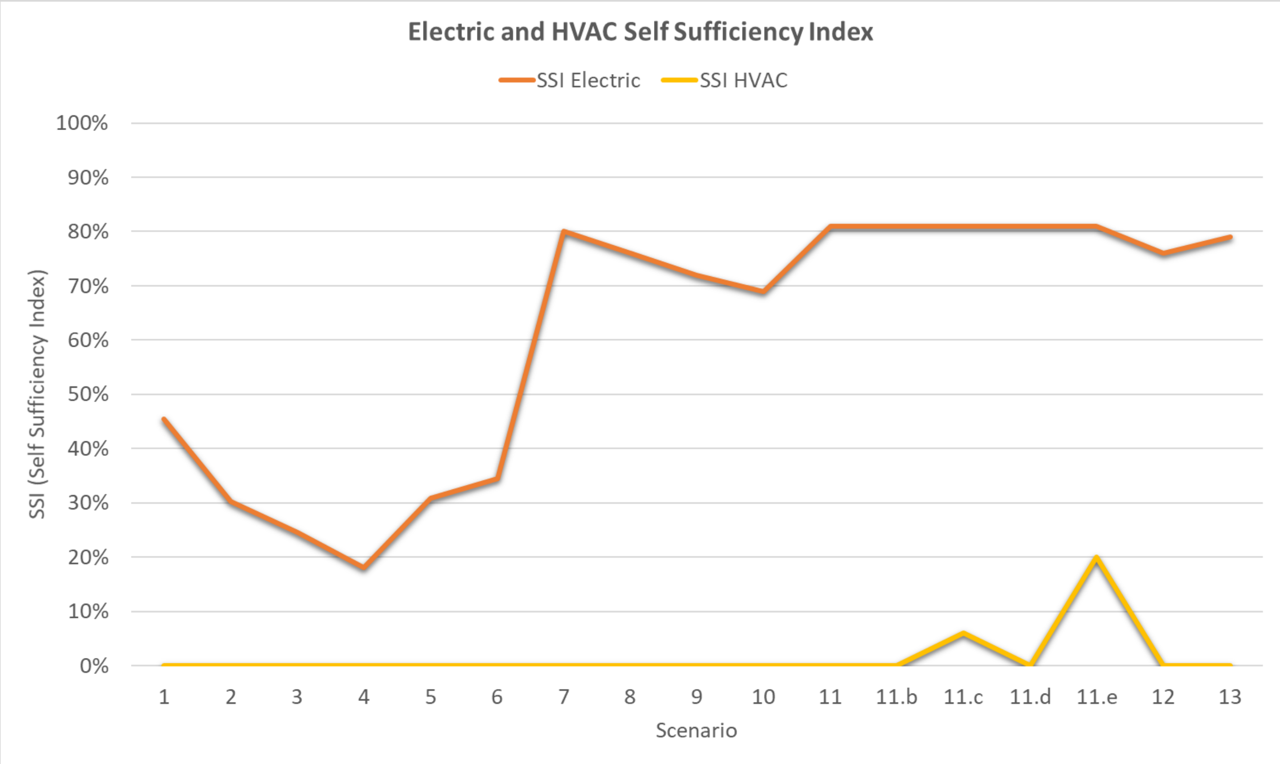


Figure 61 Electric and HVAC Self Sufficient Index

The more the scenarios advance along the ordinate, the more the configuration is energetically independent (SSI). Thanks to this provision, we can easily guess that the best scenario is 11. We also see Scenery 13, with a higher SCI than 11 but a lower SSI. The Scenario 11 was then analysed in detail by simulating the use of excess thermal energy to heat the building and to dry a part of local biomass to be sold. On the basis of this scenario, the project KPIs for the Small scale were obtained.

4.6.6. FUNDING ANALYSIS AND ECONOMIC EVALUATION

An analysis was carried out on the incentives currently in force envisaged for energy efficiency measures.

CAPEX founding

Chapter 2 allows us to define how the only possible incentive is the GSE CAR incentive. This incentive is applicable only from scenario 7 to scenario 13 to finance the installation of the cogenerator. This incentive is equal to € 3.183.

There are also incentives for municipalities ("DL Crescita") equal to € 50,000 for energy efficiency interventions. This incentive is applicable to all scenarios and can be combined with the CAR incentives and with the energy incentives (SEI).

OPEX founding Shared Energy Incentive (SEI)

GSE remuneration of 118,22 [€ / MWh] is envisaged for the portion of energy self-consumed by users of a CER. In the calculations this figure, due to its dependence on variables dependent on the electricity market, is approximated to 119 [€ / MWh].

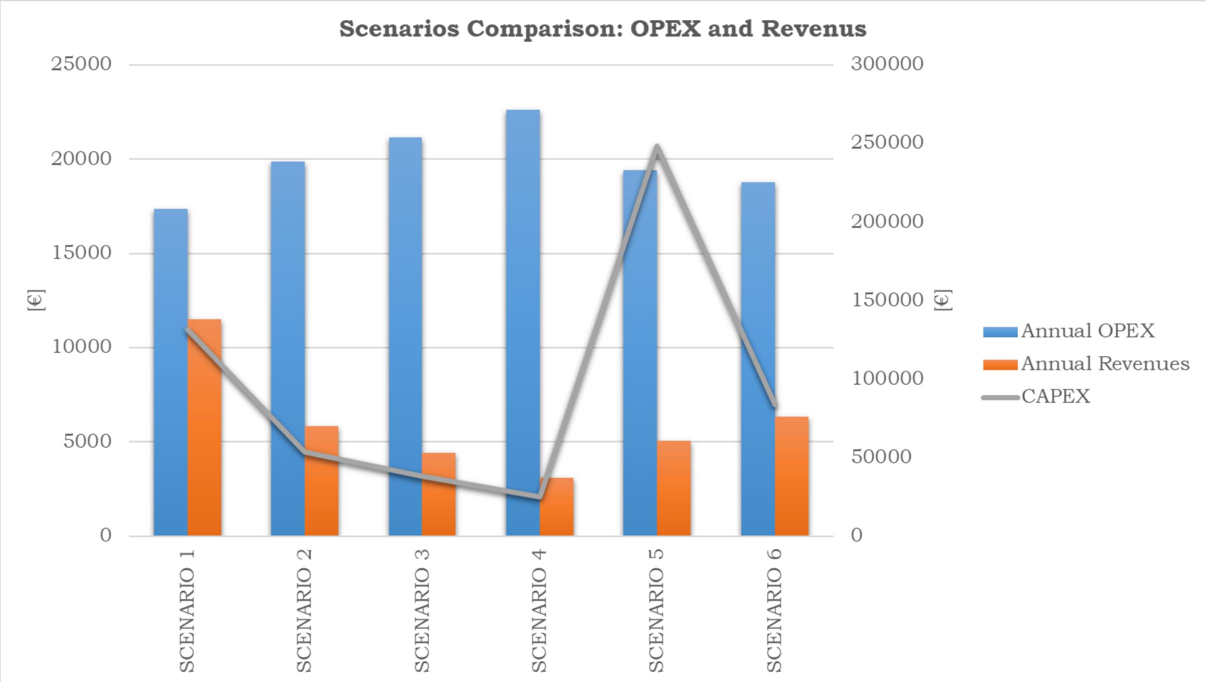
$$\text{IEC} = \text{GSE incentive rate [€/kWh]} \times \text{Self-consumed energy [kWh]}$$

Annual balance

Value determined by the subtraction between OPEX Pre-intervention costs (Fuel costs + Maintenance) and post-intervention OPEX (Fuel costs + Maintenance costs + energy sales revenues + SEI + dried wood chips sales revenues)

Table 63 Summry of economic KPI

INTERVENTION	Investment	Founding		Annual balance Revenue	Return of investment	
	CAPEX	CAPEX Founding	OPEX Founding Shared Energy Incentive		Return of investment with SCI (ROI)	Return of investment with CAPEX founding + SCI (ROI)
	[€]	[€]	[€/year]	[€/year]	[year]	[year]
SCENARIO 1	131.350	DL crescita = 50.000€	Shared Energy Incentive (IEC) = 7.491€	21.163	6	4
SCENARIO 2	53.854	DL = 50.000€	IEC =4.991€	12.926	4	-
SCENARIO 3	38.092	DL =50.000€	IEC =4.041€	10.277	4	-
SCENARIO 4	24.957	DL =50.000€	IEC =2.968€	7.449	3	-
SCENARIO 5	248.092	DL =50.000€	IEC =5.079€	12.641	20	16
SCENARIO 6	83.854	DL =50.000€	IEC =5.671€	14.548	6	2
SCENARIO 7	381.350	DL =50.000€ CAR = 3183€	IEC =16.260€	25.692	15	13
SCENARIO 8	315.675	DL =50.000€ CAR = 3183€	IEC =15.440€	24.291	13	11
SCENARIO 9	285.465	DL =50.000€ CAR = 3183€	IEC = 14.468€	22.022	13	11
SCENARIO 10	273.643	DL =50.000€ CAR = 3183€	IEC = 14.468€	20.538	13	11
SCENARIO11.a	360.675	DL =50.000€ CAR = 3183€	IEC = 16.321€	24.792	**16**	12
SCENARIO11.b	410675	DL =50.000€ CAR = 3183€	IEC = 16.321€	23.587	**17**	15
SCENARIO 11.c	443675	DL =50.000€ CAR = 3183€	IEC = 16.321€	22.584	**20**	17
SCENARIO 11.d	410675	DL =50.000€ CAR = 3183€	IEC = 16.321€	29.682	**14**	12
SCENARIO 11.e	693075	DL =50.000€ CAR = 3183€	IEC = 16.321€	43.927	**16**	15
SCENARIO 12	327.838	DL =50.000€ CAR = 3183€	IEC = 15.140€	21.900	15	13
SCENARIO 13	333.854	DL =50.000€ CAR = 3183€	IEC = 13.652€	23.786	14	12



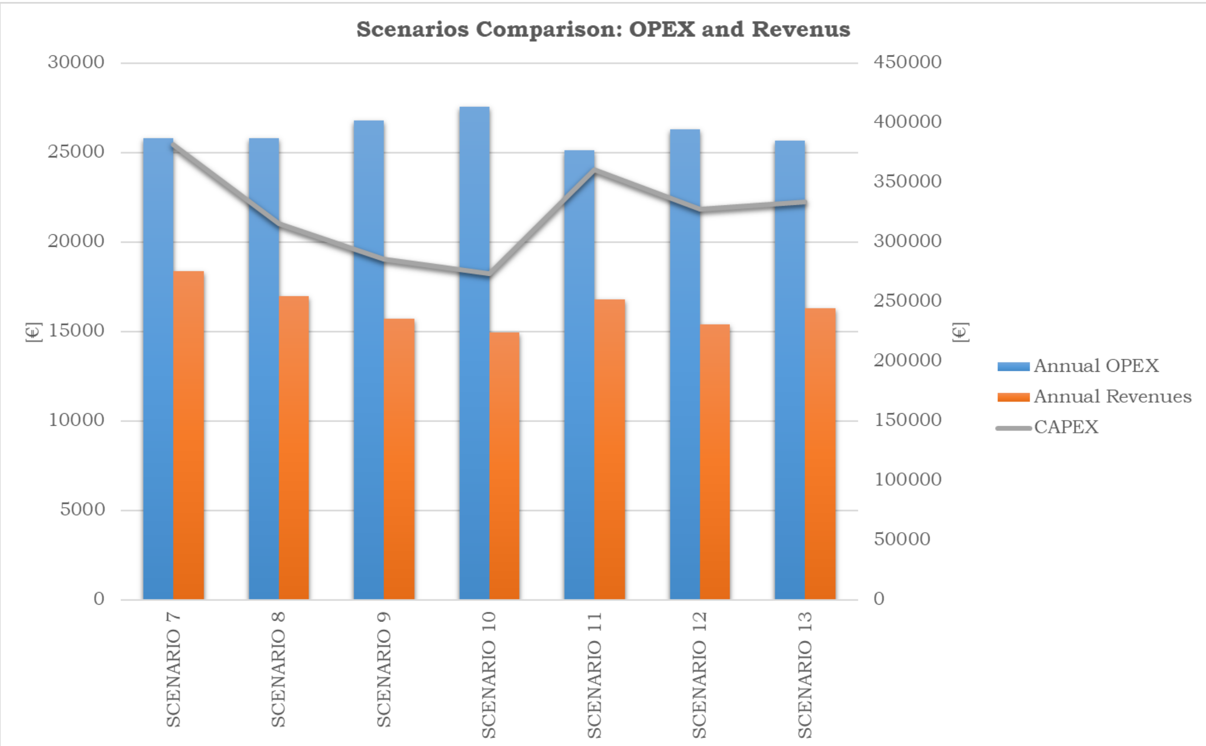


Figure 62 Economic comparison beetween scanario (Opex, revenues, CAPEX)

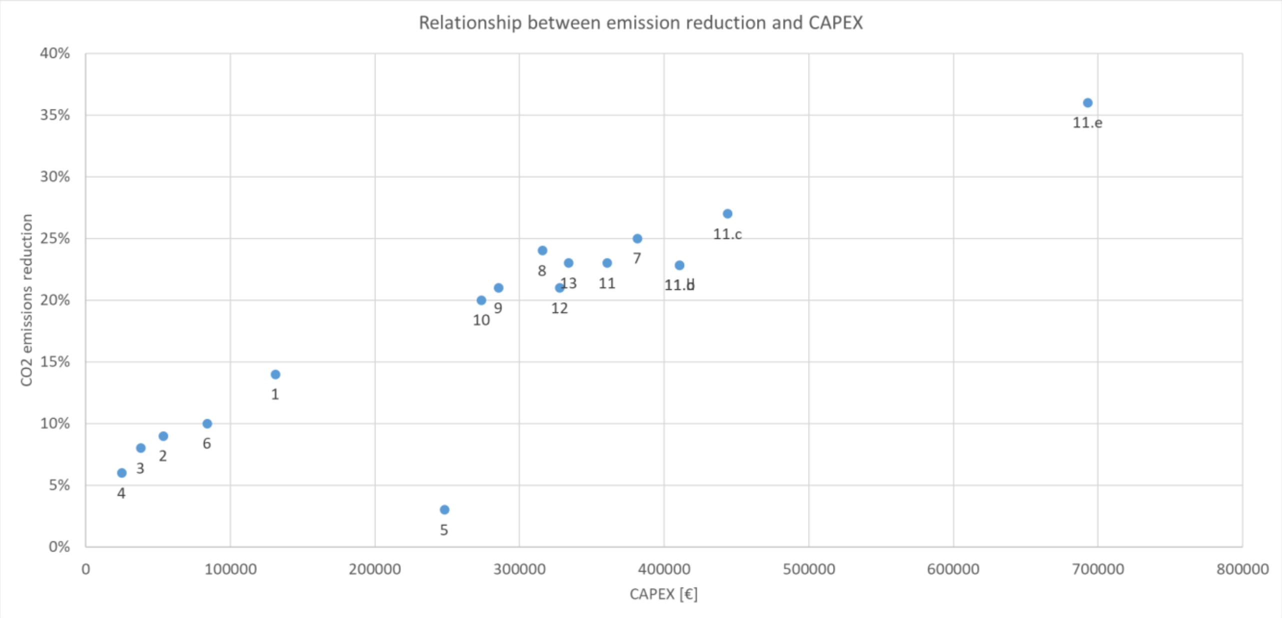


Figure 63 Relationship between emission reduction and CAPEX

4.6.7. SOCIAL EVALUATION

The social, economic and environmental advantages of the proposed intervention on the territory of the intervention are the following:

- Support for the local economy - in fact, it is estimated that the intervention can generate approximately € 2.500.000 in annual turnover in the area and 13 equivalent jobs.
- Territory maintenance and climate change mitigation - Considering the amount of biomass required annually and the average supply of local forests, the intervention can finance the sustainable maintenance of about 5,1 ha of forest.
- Reduction of CO_2 emissions - if coming from woods used according to sustainable forest management rules, where therefore the quantity of biomass withdrawn is always lower than the annual regrowth of the territory. The wood chips will in fact be purchased locally by companies that guarantee a certified product.

Table 64 Impact on the GCArea

Increase in the number of jobs (Direct + indirect, temporary + permanent)	[n]	13
Investments in energy efficiency measures	[€]	693.075
Increase in local economic impact generated	[€]	2.423.710

4.7. RESULTS AND FINAL EVALUATION

4.7.1. KPI BUSINESS CASES RESULTS

The values of the KPIs linked to the LIFE project have been defined for each intervention.
The KPI coefficients were determined as the relationship between the state of the art and the results of the simulations of the efficiency measures (only HVAC and electric power plants intervention)
For each size of intervention, one or more improvement interventions were identified and therefore the KPIs for each were calculated.

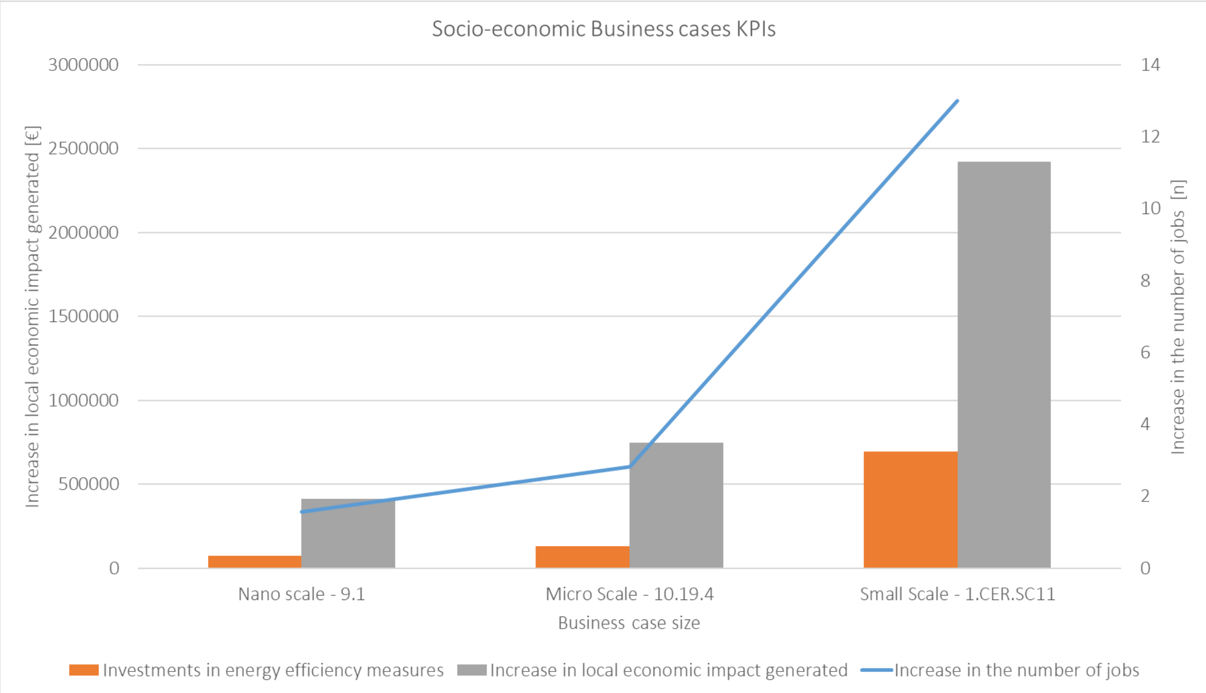


Figure 64 Socio-economic Business cases KPIs

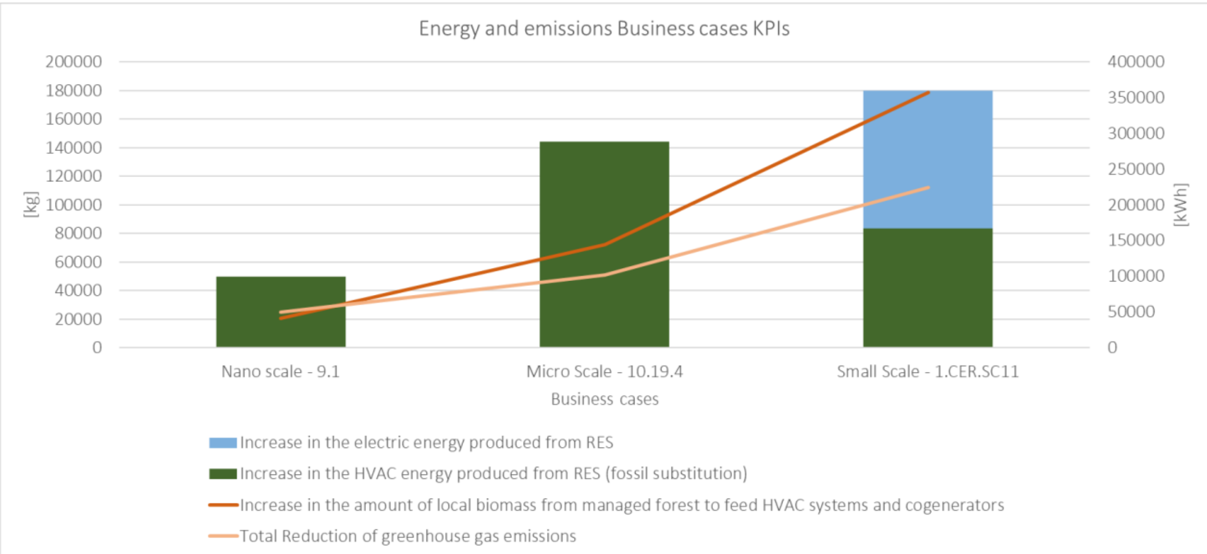


Figure 65 energy and emissions Business cases KPIs

Table 65 Final business cases GC KPI

KPI			Nano scale 9.1	Micro Scale 10.19.4	Small Scale 1.CER.SC11
			Replacement of Diesel boiler with a Biomass condensation boiler fuelled with Local pellet	Replacement of Natural Gas boiler with a Wood chip boiler	Creation of a REC with installation of photovoltaic panels + lithium battery + wood chips microcogenerator
1	Increase in the number of jobs	[n]	2	3	13
2	Investments in energy efficiency measures	[€]	72000	130000	693075
3	Increase in local economic impact generated	[€]	414720	748800	2423710
4	Local economic impact generated (€) for each euro invested from EU for GreenChainSAW4LIFE project	[€]	5,76	5,76	3,50
5	Reduction of HVAC primary energy consumption in building	[%]	10,37%	9,37%	5,00%
		[kWh]	11450	29774	41244
6	Reduction of fossil fuels consumption for HVAC systems	[%]	100,0%	100,0%	25,1%
		[m3]	8872	33608	17636
7	Increase in the efficiency of heating systems	[%]	14,3%	11,5%	5,0%
8	Increase in the efficiency of HVAC systems fuelled by biomass	[%]	14,3%	11,5%	5,0%
10	Increase in the HVAC energy produced from RES (fossil substitution)	[kWh]	98988	287819	166342
11	Increase in the electric energy produced from RES	[kWh]			193628
12	Increase in the HVAC energy produced by biomass (fossil substitution)	[kWh]	98988	287819	166342
13	Increase in the electric energy produced by biomass	[kWh]			114722
14	Increase in the total primary energy need covered by biomass	[kWh]	98988	287819	281064
15	Increase in the HVAC systems fuelled by local biomass	[kW]	60	150	40
16	Increase in the power of district heating fuelled by local biomass	[kW]			40
17	Increase in the installation of cogeneration systems fuelled by biomass	[kW]			40
18	Increase in the amount of local biomass from managed forest to feed HVAC systems and cogenerators	[kg]	20307	71954	178650
21	Reduction of greenhouse gas emissions in Building sector	[%]	83,9%	81,0%	36,0%
		[kgCO_2]	24748	50676	112000
23	Total Reduction of greenhouse gas emissions	[kgCO_2]	24748	50676	112000

4.7.2. LIFE TERRITORY SIMULATION SCENARIO

The KPIs were applied to the electrical and thermal consumption and emissions of the entire project territory, to simulate a scenario at the end of the project and a scenario 5 years after the end of the project.
The scenario at the end of the project was simulated assuming the following parameters:

- the replacement of 15% of existing traditional wood boilers with condensing pellet boilers or high efficiency Wood chip boiler. It was also considered to increase by 20% the use of local biomass from sustainable forest management.
- the replacement of 15% of existing fossil fuel boilers with pellet condensing boilers or high efficiency Wood chip boiler. It was also considered to increase by 20% the use of local biomass from sustainable forest management.
- the installation of 3 micro-cogeneration systems (Bagnolo Piemonte, Barge, Sanfront) in the project area with thermal and electrical connection.
- a 2% reduction in general electricity consumption due to a greater awareness of the population after the meetings relating to the energy community.

		State of the art		At the end of the project		
Code	Sign	Total electric energy consumption and emissions		Electrical energy consumption and related CO_2 emissions		Reduction of Total emissions
		[MWh_{el}/year]	*[tCO_2/year]*	*[MWh_{el}/year]*	*[tCO_2/year]*	*[%]*
		D67	D73			
		Real / monitored data	*Calculated data*	*Simulated*	*Simulated*	*Simulated*
1	BAP	16.973	5.295	16.633,13	5.064,74	4,36%
2	BAR	40.524	12.644	39.713,89	12.265,93	2,99%
3	BRO	417	130	408,34	127,40	2,00%
4	CRI	798	249	782,01	243,99	2,00%
5	ENV	7.956	2.482	7.796,88	2.432,63	2,00%
6	GAM	590	184	577,74	180,26	2,00%
7	MAP	1.130	352	1.106,99	345,38	2,00%
8	ONC	139	43	136,19	42,49	2,00%
9	OST	252	79	247,06	77,08	2,00%
10	PAE	12.513	3.904	12.262,46	3.825,89	2,00%
11	PAG	1.102	344	1.079,62	336,84	2,00%
12	REV	14.814	4.622	14.517,70	4.529,52	2,00%
13	RIF	4.176	1.303	4.092,48	1.276,85	2,00%
14	SAN	6.386	1.992	6.257,92	1.890,07	5,13%
TOTAL	TOTAL	**107.768**	**33.624**	**105.612**	**32.639**	**2,93%**

Table 66 HVAC scenario at the end of the project

GC AREA		State of the art		At the end of the project			
Code	Sign	Total HVAC consumption and emissions		Total Consumption and emission		Reduction of Total consumption and emissions	
		[MWh_{th}/year]	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[%]*	*[%]*
		D65	D72				
		Calculated data	*Calculated data*	*Simulation - At the end of the project*	*Simulation - At the end of the project*	*Simulation - At the end of the project*	*Simulation - At the end of the project*
1	BAP	34.685	7.059	32.928	6.019	5,07%	14,75%
2	BAR	48.029	9.005	45.405	7.555	5,46%	16,10%
3	BRO	1.399	265	1.337	225	4,46%	15,04%
4	CRI	1.091	229	1.008	185	7,59%	19,38%
5	ENV	8.998	1.703	8.466	1.412	5,91%	17,08%
6	GAM	1.490	301	1.407	258	5,56%	14,13%
7	MAP	4.305	849	4.003	705	7,02%	16,97%
8	ONC	413	71	402	61	2,70%	14,23%
9	OST	813	168	580	92	28,68%	45,29%
10	PAE	15.986	3.168	14.891	2.635	6,85%	16,84%
11	PAG	2.972	555	2.779	468	6,48%	15,63%
12	REV	23.910	4.839	23.255	4.250	2,74%	12,19%
13	RIF	4.138	838	4.032	739	2,57%	11,82%
14	SAN	11.100	2.347	9.872	1.840	11,06%	21,62%
TOTAL	**TOTAL**	**159.328**	**31.399**	**150.366**	**26.444**	**5,63%**	**15,78%**

Table 67 HVAC scenario divided by fuel at the end of the project

HVAC consumption and emissions - Simulation - At the end of the project												
Sign	Biomass		Natural gas		Diesel fuel		LPG		Solar thermal panels		Biomass district heating	
	[MWh_{th}/year]	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*	*[MWh_{th}/year]*	*[tCO_2/year]*
	Simulation - At the end of the project											
BAP	9.963	964	12.961	2.618	5.112	1.365	4.648	1.055	78		166	16
BAR	19.106	1.850	16.623	3.358	5.288	1.412	3.986	905	81		321	31
BRO	555	54	387	78	86	23	308	70				
CRI	402	39	170	34	321	86	114	26	1			
ENV	3.517	340	2.348	474	1.214	324	1.079	245	14		294	28
GAM	366	35	727	147	121	32	192	44				
MAP	1.280	124	1.999	404	329	88	394	90				
ONC	215	21	143	29	39	11	4	1				
OST	306	30	154	31	102	27	18	4	0			
PAE	5.591	541	5.541	1.119	3.238	864	484	110	38			
PAG	982	95	1.551	313	138	37	102	23	6			
REV	6.884	666	10.764	2.174	4.059	1.084	1.417	322	95		37	4
RIF	1.161	112	1.995	403	653	174	217	49	6			
SAN	2.446	237	4.955	1.001	1.736	463	539	122	31		166	16
TOT.	52.776	5.109	60.317	12.184	22.436	5.990	13.503	3.065	348		984	95

The scenario beyond 5 years after the end of the project was simulated assuming the following parameters:

- the replacement of 30% of existing traditional wood boilers with condensing pellet boilers or high efficiency Wood chip boiler. It was also considered to increase by 20% the use of local biomass from sustainable forest management.
- the replacement of 30% of existing fossil fuel boilers with pellet condensing boilers or high efficiency Wood chip boiler. It was also considered to increase by 20% the use of local biomass from sustainable forest management.
- the installation of one micro-cogeneration systems for each municipality and 2 in Bagnolo Piemonte, Barge, and Sanfront, with thermal and electrical connection.
- a 3% reduction in general electricity consumption due to a greater awareness of the population after the meetings relating to the energy community.

Table 68 Electric scenario at the end of the project

		State of the art		Beyond 5 years after the end of the project		
Code	Sign	Total electric energy consumption and emissions		Electrical energy consumption and related CO_2 emissions		Reduction of Total emissions
		[MWh_{el}/year]	*[tCO_2/year]*	*[MWh_{el}/year]*	*[tCO_2/year]*	*[%]*
		D67	D73			
		Real / monitored data	*Calculated data*	*Simulated*	*Simulated*	*Simulated*
1	BAP	16.973	5.295	16.134,14	4.846,65	8,48%
2	BAR	40.524	12.644	38.522,47	11.831,81	6,42%
3	BRO	417	130	396,09	61,18	52,94%
4	CRI	798	249	758,55	174,27	30,00%
5	ENV	7.956	2.482	7.562,97	2.297,25	7,45%
6	GAM	590	184	560,41	112,45	38,87%
7	MAP	1.130	352	1.073,78	272,62	22,65%
8	ONC	139	43	132,11	25,62	40,92%
9	OST	252	79	239,65	12,37	84,27%
10	PAE	12.513	3.904	11.894,58	3.648,71	6,54%
11	PAG	1.102	344	1.047,23	264,33	23,09%
12	REV	14.814	4.622	14.082,17	4.331,24	6,29%
13	RIF	4.176	1.303	3.969,71	1.176,15	9,73%
14	SAN	6.386	1.992	6.070,19	1.706,70	14,34%
TOTAL	**TOTAL**	**107.768**	**33.624**	**102.444**	**30.761**	**8,51%**

Table 69 HVAC scenario beyond 5 years after the end of the project

Code	Sign	State of the art		Beyond 5 years after the end of the project			
		Total HVAC consumption and emissions		Total consumption and emission		Reduction of Total consumption and emission	
		[MWh$_{th}$/year]	*[tCO_2/year]*	*[MWh$_{th}$/year]*	*[tCO_2/year]*	*[%]*	*[%]*
		D65	D72				
		Real / monitored data	*Calculated data*	*Simulated*	*Simulated*	*Simulated*	*Real / monitored data*
1	BAP	34.685	7.059	30.568	5.133	11,87%	27,29%
2	BAR	48.029	9.005	42.687	6.574	11,12%	26,99%
3	BRO	1.399	265	1.243	175	11,18%	34,08%
4	CRI	1.091	229	921	135	15,58%	40,91%
5	ENV	8.998	1.703	7.894	1.194	12,27%	29,89%
6	GAM	1.490	301	1.318	204	11,53%	32,06%
7	MAP	4.305	849	3.772	598	12,39%	29,54%
8	ONC	413	71	383	34	7,32%	51,73%
9	OST	813	168	546	60	32,90%	64,04%
10	PAE	15.986	3.168	13.914	2.264	12,96%	28,54%
11	PAG	2.972	555	2.649	398	10,85%	28,40%
12	REV	23.910	4.839	21.748	3.664	9,04%	24,28%
13	RIF	4.138	838	3.781	622	8,64%	25,73%
14	SAN	11.100	2.347	9.235	1.568	16,80%	33,17%
TOTAL	TOTAL	159.328	31.399	140.657	22.626	11,72%	27,94%

Table 70 HVAC scenario divided by fuel Beyond 5 years after the end of the project

HVAC consumption and emissions - Simulation - Beyond 5 years after the end of the project												
Sign	Biomass		Natural gas		Diesel fuel		LPG		Solar thermal panels		Biomass district heating	
	[MWh$_{th}$/ year]	*[tCO_2/year]*	*[MWh$_{th}$/ year]*	*[tCO_2/year]*	*[MWh$_{th}$/ year]*	*[tCO_2/year]*	*[MWh$_{th}$/ year]*	*[tCO_2/year]*	*[MWh$_{th}$/ year]*	*[tCO_2/year]*	*[MWh$_{th}$/ year]*	*[tCO_2/year]*
BAP	12.372	1.198	10.561	2.133	3.709	990	3.362	763	66		498	48
BAR	21.709	2.101	13.628	2.753	3.803	1.015	2.826	642	68		653	63
BRO	628	61	239	48	25	7	191	43			160	15
CRI	454	44	60	12	201	54	45	10	1		160	15
ENV	3.986	386	1.949	394	797	213	696	158	12		454	44
GAM	484	47	519	105	51	14	104	24			160	15
MAP	1.583	153	1.567	316	207	55	256	58			160	15
ONC	232	23	38	8	-10	-3	-37	-8			160	15
OST	329	32	47	9	37	10	-27	-6	0		160	15
PAE	6.527	632	4.483	906	2.388	638	323	73	32		160	15
PAG	1.187	115	1.197	242	64	17	37	8	5		160	15
REV	8.666	839	8.796	1.777	2.995	800	1.013	230	81		197	19
RIF	1.480	143	1.563	316	449	120	123	28	5		160	15
SAN	3.286	318	4.057	820	1.222	326	324	74	26		320	31
TOTAL	**62.923**	**6.091**	**48.702**	**9.838**	**15.937**	**4.255**	**9.237**	**2.097**	**296**		**3.562**	**345**

5. CONCLUSIONS AND NEXT ACTIONS

5.1. CONCLUSIONS

The deliverable made it possible to obtain and collect a substantial amount of social, economic and technical data. The harvesting phase has allowed the individual municipalities to order consumption often unknown, identify the most energy-intensive buildings and any malfunctions of the systems. The data made it possible to identify the biomass consumed for HVAC in the area, in relation to other fossil sources.

The analysis of the data has shown that the building sector (electrical and thermal) leads to almost 70% of the emissions of the territory. The interventions must therefore aim above all at this sector.

The study made it possible to verify that there are many incentives for both public and private interventions. The incentives make it possible to cover more than 50% of the initial costs, reducing the payback times of many investments under 10 years.

The complete simulations on 3 business cases of different sizes made it possible to obtain real data relating to the expenses and benefits deriving from the implementation of efficiency measures.

The results of the business cases led to the following conclusions:

- in order to reduce emissions, the most efficient strategy is therefore the replacement of fossil sources (methane gas, LPG, diesel) and non-local biomass with local biomass and from sustainable management and renewable sources. The replacement of fossil sources with biomass deriving from sustainable and local forest management leads to a reduction in emissions of up to 70%
- the replacement of traditional fossil fuel boilers with biomass returns on investment of less than 10 and are subject to various forms of financing for the initial investment;
- the installation of micro-CHP systems turns out to be convenient in terms of emissions and economic if connected to electrical (buildings + public lighting) and thermal (heating or drying of biomass) utilities that absorb the entire production.
- the creation of a renewable energy community REC with a biomass cogeneration system combined with photovoltaic panels allows, albeit with a high initial investment, benefits for the community: more than 35% reduction in emissions; more than 10 direct and indirect jobs on the territory; energy independence, both electrical and HVAC from fossil fuels, greater than 70%.
- the simple replacement of 30% of fossil fuel boilers throughout the territory and the implementation of a renewable energy community after 5 years from the end of the project can lead to a reduction in HVAC emissions by 30% and electrical emissions by almost 10% , without considering more expensive efficiency measures

The analysis on the municipality of Ostana was the basis for a real planning of interventions that will start in 2021.

5.2. NEXT ACTIONS

The next steps will be:

- transfer of all data collected on the DSS platform that COMPOLAB is developing (task C4.1);
- collection of updated data relating mainly to biomass consumption through the energy tool and automatic loading on the DSS platform (task C4.1);;
- definition of the carbon fluxes with a Life Cycle Assessment approach both for fossil fuel and RES fuel (task C3.4)
- implementation of territorial SECAP (task C 4.2) starting from the data collected in this deliverable and from the preliminary results of the business cases;
- support in the creation of an energy community between the municipalities of the Unione Monviso and the Unione Barge e Bagnolo through the preparation of the community energy balance starting from the data present in this deliverable (WP C8).

C.3	Resources Consumption Model and Carbon Flux Baseline	IRIS	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
1	Inventory and mapping of energy consumption	Iris																											
2	Business analysis	Iris																											
3	Potential CO2 stocked in biomaterials	Giusiano																											
4	Measuring current carbon fluxes	Iris																											
C.4	DSS, Technologies and Integrated Local Plan for Climate and Energ	COMPOLAB		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1	IT Platform	Compolab																											
2	Integrated Local Plan for climate, energy and Bioeconomy	Iris/Walden																											

These actions will be preparatory to the:

- deliverable DL.C3.3 Measuring current carbon fluxes. This last DL will contain the final indicators about the emissions balance.
- DL 4.1 ITC PLATFORM DSS Package and User Guide.
- DL4.2 Integrated local plan for climate, energy, and bioeconomy.

6. ANNEX

The following documents are attached to the deliverable:

- ANNEX 1: Energy consumption and production dataset
    - This document contains a complete dataset of all energy consumption and production collected from the project area, divided by municipalities, by intended use, by type of fuel, etc.
- ANNEX 2: Business Case 01: Comune e Museo di Ostana
    - This document contains a specific analysis of one representative case study: Municipio e Museo di Ostana (Business case 01). the document collects the energy audit, energy simulation to determine the energy consumption and KPIs, business and technical analysis of efficiency enhancement interventions and analysis of national funding. The document is in Italian as it was delivered to local administrations as a preliminary study.
- ANNEX 3: Business Case 02: Porta di Valle
    - This document contains a specific analysis of one representative case study: Porta di Valle Paesana (Business case 02). the document collects the energy audit, energy simulation to determine the energy consumption and KPIs, business and technical analysis of efficiency enhancement interventions and analysis of national funding. The document is in Italian as it was delivered to local administrations as a preliminary study.
- ANNEX 4: Business Case 03: Analisi tecnico, economica e sociale della Comunità Energetica Rinnovabile Monviso
    - As part of the GreenChainSaw4Life project it was possible to support a 6-month internship with an Energy Engineering student of the Turin Polytechnic. During this period, an evaluation of the technical-economic feasibility of the establishment of a renewable energy community was read, with an analysis of the case study of a micro-community in Bagnolo Piemonte (Business case 03). The complete results of the evaluation are collected in the final dissertation paper that is attached.