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

GREENChainSAW4Life

Project n° LIFE18 CCM/IT/001193

"Integrated local plan for climate, energy and bioeconomy"

Action Number and Title	Action C4 - DSS, Technologies and Integrated Local Plan for Climate and Energy
Task	C4.2 Integrated local plan for climate, energy and bioeconomy
Starting Date	M15 – 01/08/2020
Duration	16 months
Due Date of Delivery	M22 01/03/2021
Actual Submission Date	M30 – 01/11/2021
Author(s)	Cecilia Bocca (IRIS), Lucio Vaira (WALDEN), Paolo Albertino (IRIS), Manuel Lai (IRIS)
Version	1.0

Keyword list

Climate change, green strategy plan, ecological transition, political involvement

This document has been produced in the context of the GREENChainSAW4Life Project.
This project has received funding from the European Union's LIFE18 programme under grant agreement No. CCM/IT/001193

1 SUMMARY

2 INTRODUCTION

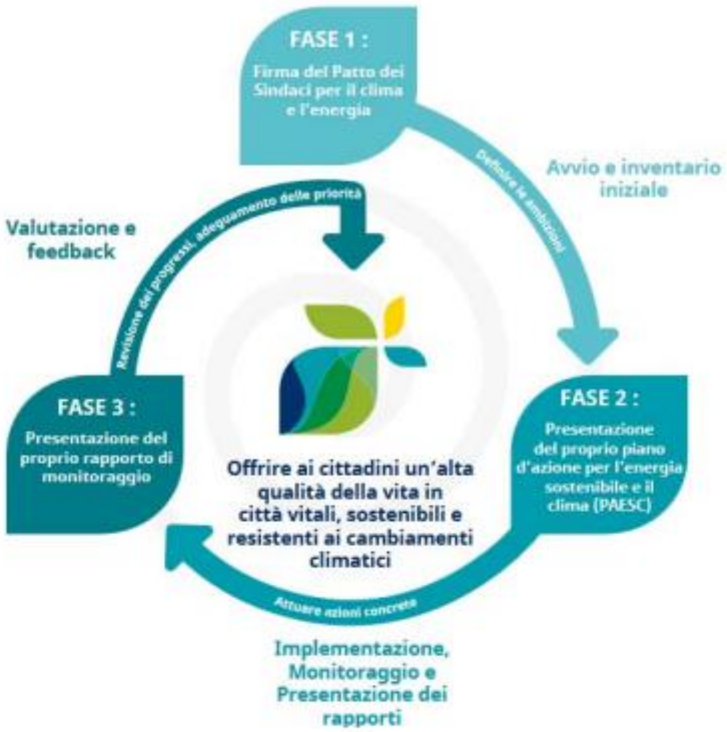
2.1 CONTENTS OF PAESC

The Covenant of Mayors for Climate and Energy involves local and regional authorities committed on a voluntary basis to achieving EU energy and climate goals on their territory. This inclusive grassroots movement began in 2008 with the support of the European Commission. In 2015, the Covenant of Mayors initiative takes a longer-term perspective: with the Covenant of Mayors for Climate and Energy, the initial Covenant of Mayors commitment to reducing CO2 emissions is increased and includes adaptation to climate change. The time horizon is lengthened with the goal of accelerating the decarbonization of the territories involved in the process, strengthening the capacity to adapt to the inevitable effects of climate change, and ensuring citizens' access to safe, sustainable, and affordable energy; in fact, the time scenario is shifted from 2020 to 2050, quadrupling the minimum CO2 reduction target (from 20% to 80%). The signatories commit to develop Sustainable Energy and Climate Action Plans (SEAPs) by 2050, and to adopt a joint approach to integrating climate change mitigation and adaptation. As shown in the diagram below, the new PAESC includes two central and one cross-cutting element of energy efficiency and increased use of renewables:

1. mitigation (an objective already present in the SEAP) - the reduction of CO2 emissions (decarbonization of territories);
2. adaptation (a new goal of the SEAP) - the reduction of climate change risks

Below is the outline found in the "Guidelines for the Drafting of the SEAP," which returns the main stages of the process of its definition, which involves three steps:

- Step 1: Signing of the Covenant of Mayors for Climate and Energy and Climate;
- Step 2: Within two years of joining and sending the SEAP;
- Step 3: Within 4 years of the approval of the SEAP the submission of the "Action Monitoring Report" and within 6 years of the approval of the SEAP the "Complete Monitoring Report"



The SEAP document includes three main parts briefly described below to which more detail is provided in the following chapters: the municipal inventory of energy consumption and CO2 emissions-Baseline Emission Inventory (BEI) and the framework of risks and vulnerabilities to which the municipality is subject, the Decarbonization Action Plan, and the Adaptation Action Plan.

2.1.1 THE BASELINE

The activity consists of the preparation of the consumption budget by sector (public and private tertiary, residential, public lighting, production activities, agriculture, public transport, private transport, with the exclusion of the sectors not under municipal jurisdiction: ETS industries and crossing roads) and by carrier (natural gas, diesel, electricity, ...). The consumption budget is estimated for the agreed baseline year to the year 2018. In the BEI (Baseline Emission Inventory) and in the MEI (Monitoring Emission Inventory), if any, the electric and thermal production from renewable sources is estimated and consequently on the basis of the IPCC emission factors the CO2 emission balance is reconstructed. Finally, on the basis of spatial and settlement developments and socioeconomic dynamics, a "business as usual" scenario is defined to estimate the emission reduction target of the SEAP: all procapita/absolute assumptions, without industry, are evaluated to give the full spectrum of possible choices.

2.1.2 THE MITIGATION ACTION PLAN

This phase consists of the development of the Action Plan from the findings of the Baseline, the trend scenario, the target that it is reasonable to set and based on the outcome and input from the City Administration. The Action Plan has as a minimum target an 80% reduction to 2050 in absolute CO2 emissions by not including the industry's share compared to those in the baseline year 2018. The SEAP includes general strategies aimed at rationalization of energy consumption in each sector and then efficient and renewable production; the strategies are differentiated by existing and new construction and are articulated in specific actions which are detailed in specific qualitative and quantitative sheets.

2.1.3 THE ADAPTATION ACTION PLAN

Specifically with regard to the climate change adaptation objective, the SEAP reasons in terms of reducing the risk to which territories are exposed due to their vulnerability through actions to adapt to future risk related to climate change. For the definition of risks in terms of impacts (e.g. hydrogeological, forest fires ...) and vulnerability (urbanized, sensitive buildings ...) reference is made to the Municipal Emergency Plans made available by municipalities.

3 SPATIAL FRAMING

The municipalities currently found to be participating in the LIFE project are: Bagnolo Piemonte, Barge, Brondello, Crissolo, Gambasca, Martiniana Po, Pagno, Martiniana Po, Ostana, Sanfront. GreenChainSAW4Life presents a project aimed at managing local forests in innovative, sustainable and shared ways, countering climate and environmental risks such as fire, hydrogeological instability and biodiversity loss. The same program intends to use the timber obtained to produce green energy and biomaterials to benefit the local economy and nature, while also implementing an integrated Local Climate, Energy and Bioeconomy Plan.

Figure 1. Map of municipalities participating in the SEAP

3.1 MUNICIPALITY OF BAGNOLO PIEMONTE

Bagnolo Piemonte is an Italian town of 5,877 inhabitants in the province of Cuneo in Piedmont. There is a strong rooted Chinese culture due to the stone industry strongly present in the area. Located in a mountainous area, bordering the town Barge is a modestly sized artificial lake called

"Rossano Lake." It is located in the northernmost part of the province of Cuneo and includes a flat area in which the main town is located, immediately at the foot of the mountainous reliefs marked by the Grana Torrent, which flows in a valley closed at the top by Punta Ostanetta of 2,375 m a.s.l. and Mount Friolànd of 2,720 m a.s.l. To the north it borders the lower Pellice Valley while to the south for a substantial stretch with the town of Barge. The hamlet of Montoso, located at 1276 meters above sea level, constitutes an authentic natural terrace. From Montoso the view sweeps over the entire plain of Turin and much of the Piedmont Alpine chain. Montoso can be reached from Bagnolo Piemonte by an easy road about 10 km long or from Bibiana by a less easy road that climbs for about 9.5 km and is closed in winter.

3.2 MUNICIPALITY OF BARGE

Barge is an Italian municipality of 7471 inhabitants in the province of Cuneo, in Piedmont. It is part of the mountain union Barge - Bagnolo Piemonte. The town is situated at the foot of the Cottian Alps, in the vicinity of the Monviso and more precisely, in a basin at the foot of Mount Bracco and Mount Medìa. The built-up area is crossed by two streams (the Chiappera and theInfernotto), which join to form a third, the Ghiandone, which flows in the vicinity of Staffarda into the river Po. The main settlement lies at about 360/390 meters a.s.l.

3.3 MUNICIPALITY OF BRONDELLO

Brondello is an Italian municipality of 273 inhabitants in the province of Cuneo in Piedmont. The municipality is located in the Bronda valley, with the main town on the banks of the stream of the same name .

3.4 MUNICIPALITY OF CRISSOLO

Crissolo is an Italian municipality of 157 inhabitants in the province of Cuneo in Piedmont, where the Monviso and the source of the river Po. The municipality of Crissolo is located at the head of the Po valley. The center, in the hamlet of Villa, is at an elevation of 1333 m a.s.l.; the whole territory has an altitude ranging from a minimum of 1100 m a.s.l. to a maximum of 3841 m a.s.l., corresponding to the summit of the Monviso (point of union of the municipalities of Crissolo, Oncino e Pontechianale). The territory extends on both sides of the valley, which in the lower part becomes very narrow, almost a gorge. A first widening occurs at Villa.

3.5 MUNICIPALITY OF GAMBASCA

Gambasca is an Italian commune of 340 inhabitants in the province of Cuneo in Piedmont. It was part of the mountain community of the Po, Bronda, Infernotto and Varaita Valleys. Located on the orographic right of the Po River and in its valley, it enjoys a panorama that ranges from Mount Monbracco (1307 m a.s.l.), the last offshoot of the Monviso orographic group on the Saluzzo plain, to Monviso itself, and on to the Langhe.

3.6 MUNICIPALITY OF MARTININANA PO

Martiniana Po is an Italian municipality of 720 inhabitants in the province of Cuneo in Piedmont. It is located in the lower Po Valley.

3.7 MUNICIPALITY OF OSTANA

Ostana is an Italian commune of 88 inhabitants in the province of Cuneo in Piedmont. It is located in the Po Valley and is included in the list of The Most Beautiful Villages of Italy, created by the Tourism Council of the Association of Italian Municipalities (ANCI). Located on the slopes of the south-facing slope of the Po Valley, the entire village is dominated by the spectacular mass of the Monviso Group, particularly the North and East walls.

3.8 MUNICIPALITY OF PAGNO

Pagno is an Italian commune of 580 inhabitants in the province of Cuneo in Piedmont. It is located in the Bronda Valley.

3.9 MUNICIPALITY OF PAESANA

Paesana is an Italian municipality of 2,661 inhabitants in the province of Cuneo in Piedmont. Spread over two distinct villages straddling the Po (*Santa Margherita* on the right and *Santa Maria* on the left of the river), it is located in the valley of the same name (Po Valley).

3.10 MUNICIPALITY OF SANFRONT

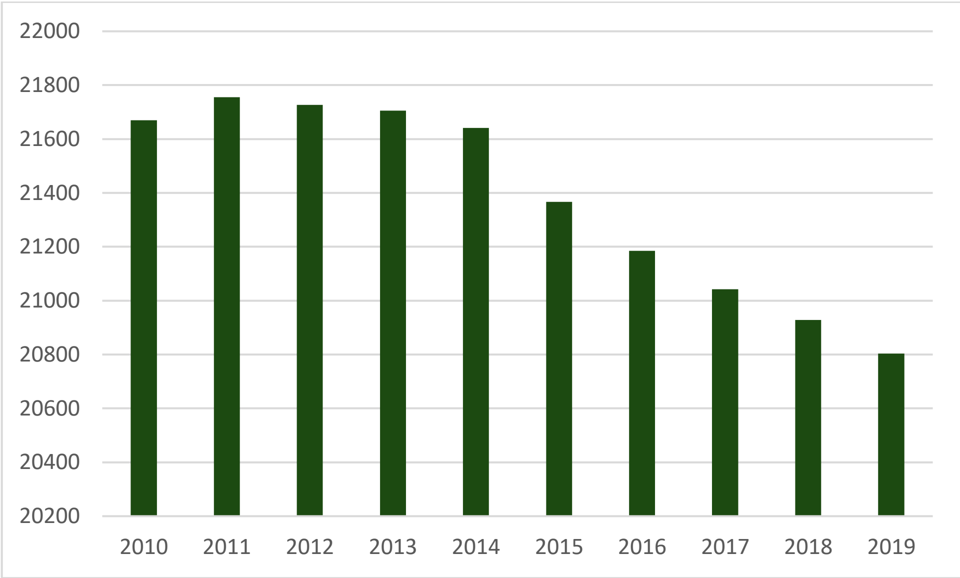
Sanfront is an Italian commune of 2,319 inhabitants in the province of Cuneo in Piedmont. It is located at the mouth of the Po Valley.

4 SOCIOECONOMIC ASPECTS

4.1 THE POPULATION

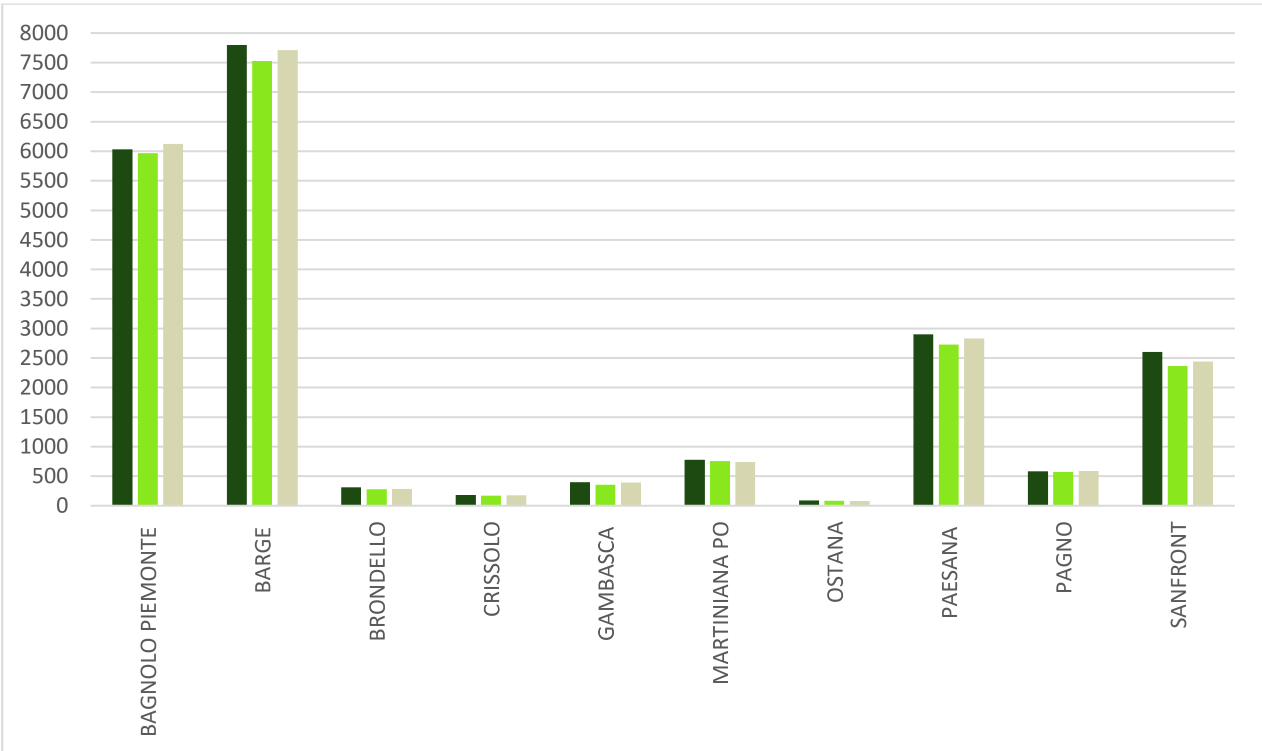
The following figure shows the trend of the resident population in the municipalities of the Cluster in 2010 to 2019 (data source: ISTAT): it shows an almost constant equal growth overall until 2012, while for the other years there is a significant decrease in population.

Table 1. Population trends in the Monviso Community (ISTAT).



In more detail, the population trends of each municipality are presented in the graph in the year 2010, 2015 and 2019.

Table 2. Population trend in the year 2010, 2015, 2019.



The table also shows some general data referring to the municipalities participating in the project.

Figure 2. General data of the area of the group of municipalities

GC AREA			GENERAL DATA.		
Code	Acronym	Municipality	Population	Territorial area	Density

			[ab.°]	[km]^2	[ab./km]^2
			Actual Data - 01/01/2019 Istat	Real data - Wikipedia	Actual Data - 01/01/2019 Istat
1	BAP	BAGNOLO PIEDMONT	5.953	63	94
2	BAR	BARGE	7.616	82	93
3	BRO	BRONDELLO	282	10	28
4	CRI	CRISSOL	165	52	3
6	GAM	GAMBASCA	350	6	61
7	MAP	MARTINIAN PO	747	13	56
9	OST	OSTANA	85	14	6
10	PAE	PAESANA	2.713	58	47
11	PAG	PAGNO	560	9	65
14	SAN	SANFRONT	2.354	40	59
TOTAL			20.825	347	

Figure 3. Economic data of the area of the group of municipalities

Code	Acronym	Number of buildings	Number of buildings used	Percentage of empty buildings	Local economic impact (LEI) (project area) generated by €1 invested in RES.				
					REN Electrical	Thermal RENs	Local biomass for electricity generation (cogeneration)	Local biomass for thermal	Total RENs
		[n]	[n]	[%]	[€ /€]$_{LEIINV}$	[€ /€]$_{LEIINV}$	[€ /€]$_{LEIINV}$	[€ /€]$_{LEIINV}$	[€ /€]$_{LEIINV}$
				D6	D13a	D13b	D14a	D14b	D18
		Real Istat	Real Istat	Real Istat	Calculated data - MISE	Calculated data - MISE	Calculated data - MISE	Calculated data - MISE	Calculated data - MISE
1	BAP	2.847	2.518	12%	3,49	2,74	3,5	5,76	3,48
2	BAR	4.064	3.174	22%					
3	BRO	244	146	40%					
4	CRI	835	112	87%					
6	GAM	253	180	29%					

7	MAP	392	351	10%					
9	OST	592	60	90%					
10	PAE	2.652	1.412	47%					
11	PAG	326	259	21%					
14	SAN	1.514	1.096	28%					

5 BASELINE INVENTORY

5.1 BASELINE METHODOLOGY

The Baseline Emission Inventory (BEI) is the inventory of annual CO2 emissions as of 2018 related to final energy uses attributable to direct and/or indirect attributable activities. To the former refer the energy consumption of the municipality's public building stock, public lighting and vehicle fleet. To the latter refer emissions from the private building stock and the tertiary sector. The fact-finding survey conducted in the area delves into both national/regional/provincial and municipal databases (natural gas distributor data, other consumption data, private building stock data, production activities, commercial activities, utility bills...). This activity is carried out in close collaboration with municipal technical offices. The BEI quantifies the CO2 emitted in the local authority's (i.e., the Covenant Signatory's) territory during the reference year and is of crucial importance as it is the tool through which to measure the impact of its interventions related to CO2 mitigation actions and climate change. In fact, while the BEI shows the baseline situation for the local authority, subsequent Monitoring Emission Inventories (MEIs), provided for in Phase 3 of the Covenant of Mayors for Climate and Energy, will show progress against the target. Emission inventories are therefore very important elements in keeping the motivation of all parties willing to contribute to the municipal area's CO2 reduction target high, as they allow them to see the results of their efforts. Another key aspect related to the baseline emission inventory is the definition of the overall CO2 reduction target, which must be at least 80 percent of the estimated emissions for the base year of the inventory.

5.1.1 THE CONSTRUCTION OF EMISSION INVENTORIES

The first step in the construction of the BEI as of 2018 is the determination of final energy consumption broken down by carrier (fuel) and sector (residential, tertiary, public buildings, public lighting, public transport). This estimation is based for the private part mainly on information obtained from surveys in different municipalities. In addition, consumption data collected from electricity and natural gas distributors were collected where available.
The transition from energy consumption to emissions is done through the Inter-governmental Panel for Climate Change (IPCC) emission factors suggested by the European Guidelines, which provide an emission value (tons of CO2) per unit of energy consumed (MWh) for each fuel type.

In particular

Figure 4. Calculation of biomass emission factors

Biomass type	Local	CO_2 emission factor	Non-local	CO_2 emission factor	Global CO_2 emission
	[%]	tCO /MWh₂	[%]	tCO /MWh₂	tCO /MWh₂
Percentage of average biomass	70%	0,000	30%	0,403	0,121

Figure 5. Emission factors

Electricity	Fossil fuels					Renewable energy		
Local	Natural gas	LPG	Oil	Diesel fuel	Gasoline	Other bio-mass	Local bio-mass	Gc bio-mass area
tCO /MWh₂								
0,343	0,202	0,227	0,267	0,267	0,249	0,403	0	0,121

5.1.2 THE DRAFTING OF THE ACTION PLAN

The results of the municipal BEIs, which involves identifying the local authority's strengths and weaknesses in the field of energy and climate management, as well as opportunities and threats in the municipal context, are the starting point for defining the priorities and measures to be undertaken as part of the Action Plan. Regarding the SEAP's goal of reducing municipal emissions to be achieved by 2050, the Guidelines state that it can be determined in absolute terms as a percentage of total emissions reported in the BEI: this percentage cannot be less than 80 percent (excluding the industries sector from the BEI). The SEAP makes it possible to translate the vision into actual measures to achieve the set target, setting deadlines and budgets for each of the planned interventions and thus becoming a reference point during the implementation and monitoring process. Specifically, the JRC form, which each signatory is required to fill out, in the section devoted to the SEAP requires them to indicate for each measure:

- the department, person or company responsible for implementing the intervention, an assignment that could also be assigned to third parties such as utility/energy service companies or local energy agencies;
- the start and end date of the action/measure to distinguish short/medium-term actions from long-term measures;
- The estimated costs of implementation;
- The expected energy savings in MWh;
- The renewable energy production, if any, provided locally by the action;
- The reduction of CO2 emissions in tons per year (t/a).

5.1.3 DATA COLLECTION

In this paper, it was 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, according to the reliability and accessibility of the source:

- **actual/monitored data** (Priority 1): can be obtained directly from direct measurement, without additional calculations (e.g., energy bills of local DSOs; aggregate or point data from market operators, such as E-distribuzione SpA, Iren Spa; consumption measurements of fuels for energy production and HVAC systems) or from literature research (e.g., GSE Atlas, Istat database, local authorities). For energy consumption and emissions from non-traceable energy carriers (woody biomass, liquefied petroleum gas), an Energy Tool App has been developed that collects energy data from citizens and records them in a database.
- **simulated data** (Priority 2): can be obtained by simulations from a direct data set (e.g., HVAC efficiency, SIPEE database);
- **calculated data** (Priority 3): can be obtained by calculations from a direct data set (e.g., CO2 emissions, energy consumption of the transport sector). For energy consumption assessment, IRIS followed the methodology endorsed by the Covenant of Mayors for Climate and Energy's "How to Grow a Sustainable Energy Action Plan"

5.2 ENERGY BALANCE

5.2.1 ENERGY PRODUCED BY RES (ELECTRIC AND THERMAL)

Energy produced from renewables is divided into two subcategories: electricity and energy for HVAC systems.

- Power generation:
    - Photovoltaic power generation facilities derived from the sum of public facilities (actual data) and facilities in GSE Atlas (actual data)
    - Hydropower plants: data provided by government agencies based on production in recent years (actual data)

- Thermal power generation (HVAC)
    - Biomass thermal power plants: data determined from EPA-ACE simulations of the area
    - Biomass heating systems: data determined from APE-ACE simulations of the area

Figure 6. Electricity generated from renewables

GC AREA		POWER GENERATION FROM RENEWABLES							
		Photovoltaic						Hydroelectric	
Code	Acronym	Number of public installations	Annual public production	Number of private installations	Total private production	Total number	Total production	Number of installations	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	*Royal-bills*	*Real Atlas GSE*	*Real Atlas GSE*	*Real-public information + GSE atlas*	*Real- public information + GSE atlas*	*Real-public information*	*Real- 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	GAM			2	46	2	46		
6	MAP			10	128	10	128		
7	OST	1	8	5	24	6	24		
8	PAE	1	12	36	373	37	373	1	971
9	PAG			14	133	14	133		
10	SAN			33	1.012	33	1.012		
TOTAL		8	99	345	12472	353	12472	2	1100

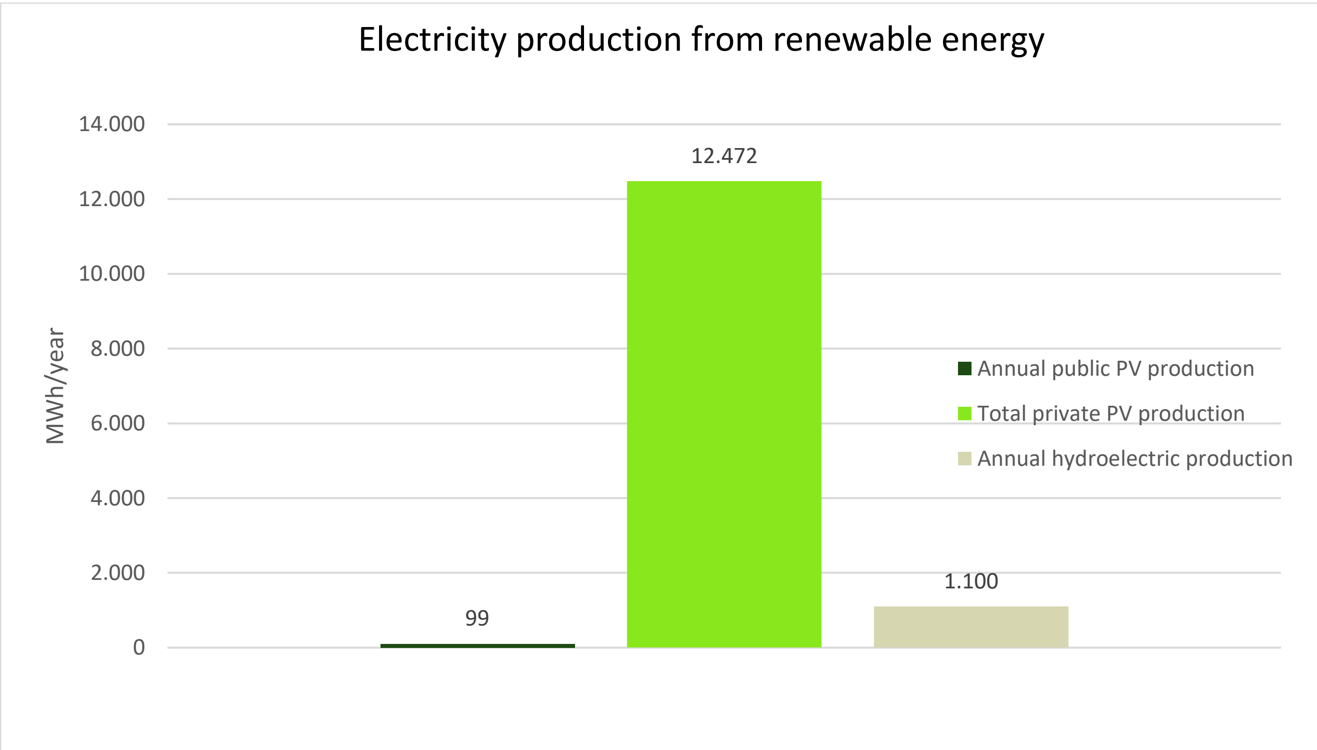
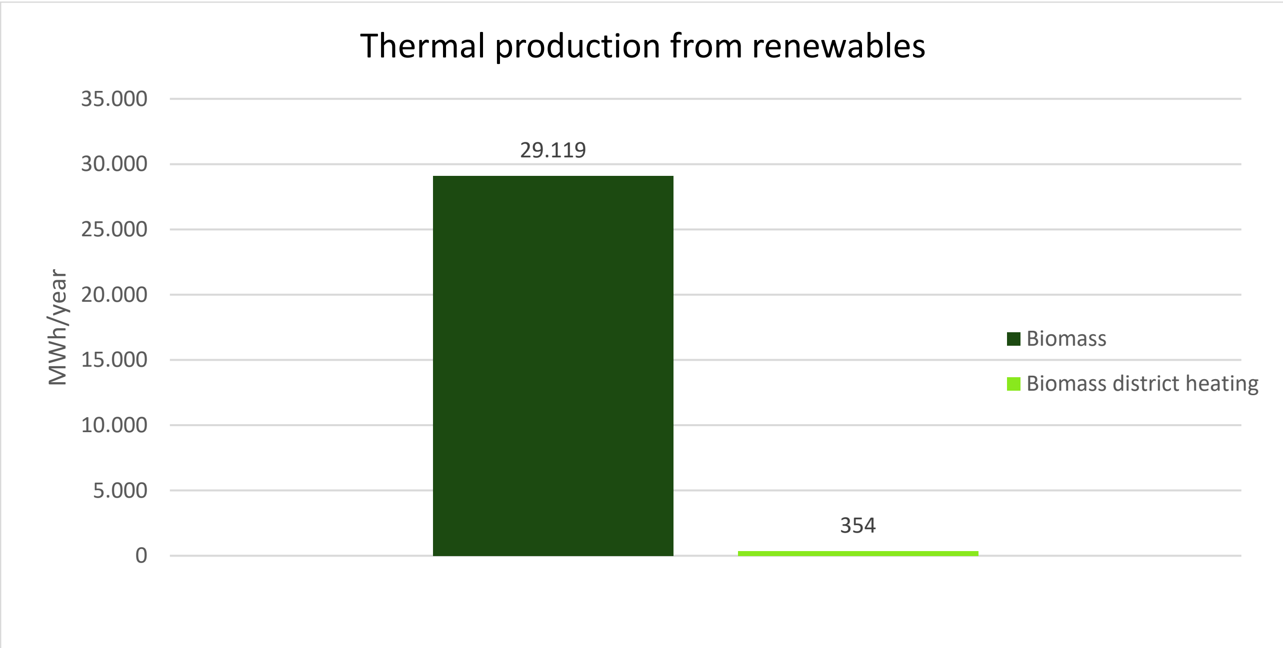


Figure 7. Thermal energy produced from renewables

GC AREA		THERMAL ENERGY PRODUCTION FROM RENEWABLES			
Code	Acronym	Biomass		Biomass district heating	
		Size	Annual production	Number	Annual production

		[kW]th	[MWhth /year]	[n°]	[MWhth /year]
		D20a	D20b	D20c	D20d
		Actual/monitored data - GSE Atlas.	*Simulated data - SIPEE*	*Actual/monitored data - GSE Atlas.*	*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	GAM	130	197		
6	MAP	419	702	5	150
7	OST	36	309		
8	PAE	987	4.092		
9	PAG	153	720		
10	SAN	861	1.231		
TOTAL		**5.400**	**29.119**	**7**	**354**



The images below are taken from Atlaimpianti and depict on atlas the current distribution of renewables already installed.

Figure 8. Installed hydroelectric

Figure 9.Installed photovoltaic

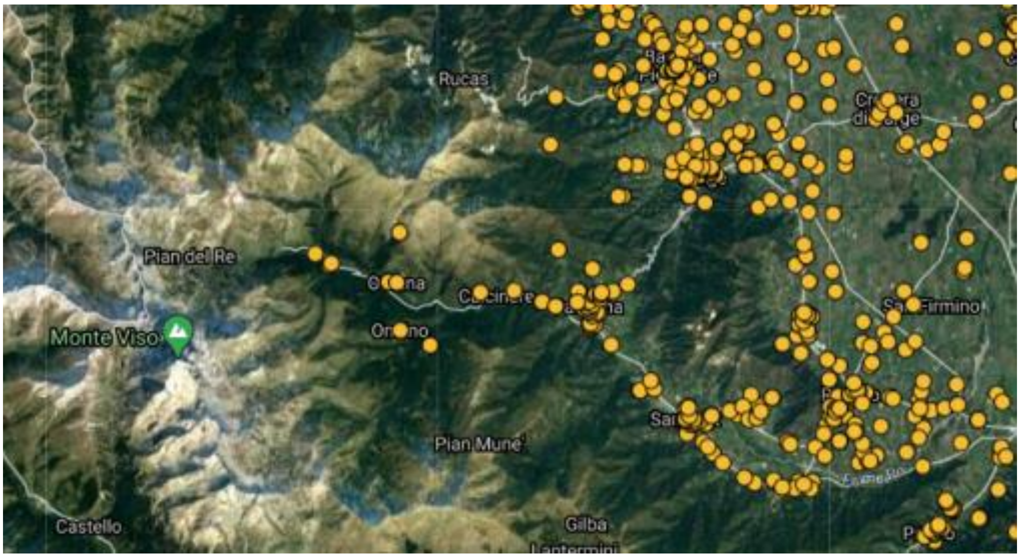


Figure 10.Biomass plants

5.2.2 ELECTRICITY CONSUMPTION AND EMISSIONS

Electricity consumption data were divided in the first instance between:

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

The Data involved in the **public sector** are:

- D66a: Electricity consumption in public buildings [MWhel/year]: data were determined from the energy bills of municipalities (2018 real) and the company "e-Distribution" (real);
- D73a: C02 emissions related to electricity consumption in public buildings [tCO2/year]: C02 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.
- D66b: Electricity consumption in public lighting [MWhel/year]: data were determined from the energy bills of municipalities (real) and the company "e-Distribution" (real);
- D76: C02 emissions related to electricity consumption in public lighting [tCO2/year]. C02 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.

The data were taken from the annual consumption shown on the bills. The definition of annual consumption is taken from the glossary on the ARERA website:

"Electricity or natural gas consumption for 12 months of supply derived from the customer's past consumption information. If actual data are not available, this information is estimated. In the case of new activations, for which 12-month data is not available, the seller must indicate on the bill that this is the consumption recorded or estimated since the beginning of supply, based on the data available to him, calling it "consumption since the beginning of supply"; after 12 months, actual data should be available. The annual consumption for the electricity sector is further broken down for each time slot."

The Data involved in the **private sector** are:

- D66c: electricity consumption in private residential buildings [MWhel/year]: data were provided by "e-Distribution" as actual aggregate data (2018 - actual) and by the company."
- D66d: electricity consumption in the private agricultural sector [MWhel/year]: data were provided by "e-Distribution" as actual aggregate data (2018 - actual) and by the company."
- D66e: electricity consumption in private tertiary and industry [MWhel/year]: data were provided by "e-Distribution" as actual aggregate data (2018 - actual) and by the company."

- D73c: C02 emissions related to electricity consumption in private residential buildings [tCO2/year]: CO2 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.
- D73d: C02 emissions related to electricity consumption private agricultural sector [[tCO2/year]: CO2 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.
- D76: C02 emissions related to electricity consumption in the private tertiary and industrial sector [tCO2/year]: CO2 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier

The Data were collected in a special Excel file consisting of one row for each building in which all the data described below are collected. Only the total data for the municipality are reported in this document.

Figure 11. Description of electrical data tables.

GENERAL DATA								
Common acronym	Building sequence number	Properties	Type of data	Type of user	Building name	POD	PDR	Address
Unique code for each municipality	Unique code for each building	Private or public	Real/Simulation	Electrical, HVAC	Building name	Electricity distribution point	HVAC distribution point	Address

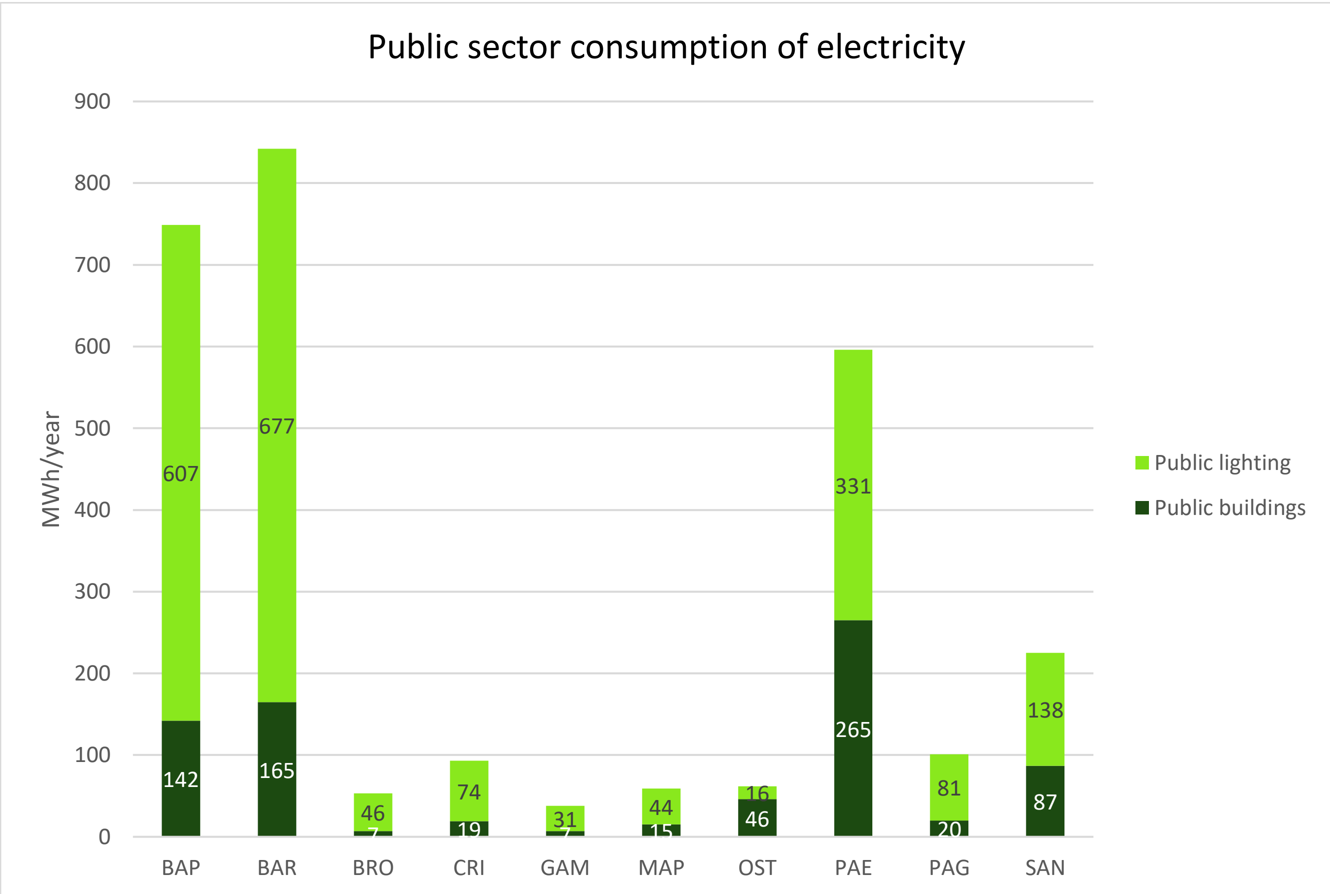
ELECTRICITY						
CONSUMPTION		PRODUCTION				EMISSIONS FROM ELECTRICITY
POWER	ENERGY CONSUMED	SOURCE OF ENERGY	SOURCE OF ENERGY	INSTALLED POWER	ENERGY PRODUCED	
kW_p	kWh_e /year			kW_p	kWh_{el} /year	$kgCO_2$ /year
Maximum power from the grid	Electricity consumed (2018)			Maximum power that can be produced	Electricity produced	CO2 emissions from electricity consumed

PUBLIC SECTOR

Figure 12. Electricity consumption and CO2 emissions in the public sector.

AREA		Electricity consumption and emissions			
		Public buildings		Public lighting	
Code	Acronym	*[MWh_{el} /year]*	*[tCO_2 /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*
		D66a	D73a	D66b	D73b
		Actual/monitored data - bills	*Calculated data*	*Actual/monitored data - 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	GAM	7	2	31	10
6	MAP	15	5	44	14
7	OST	46	14	16	5
8	PAE	265	83	331	103
9	PAG	20	6	81	25
10	SAN	87	27	138	43
TOTAL		773	241	2045	637

Figure 13. Distribution of electricity consumption between public sector and public lighting



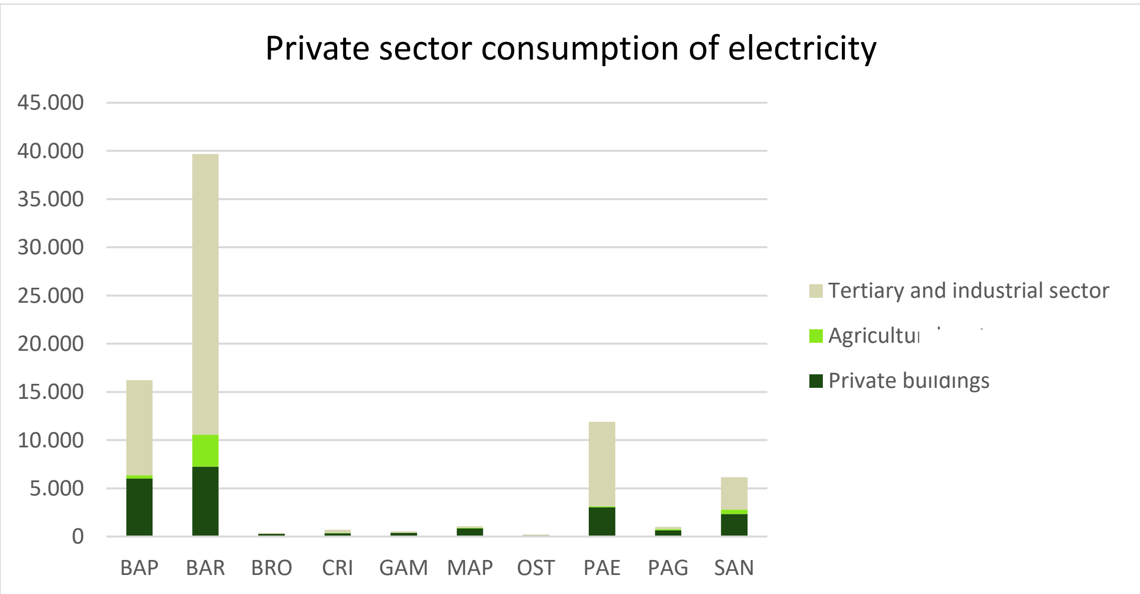
In the public sector, the largest share of electricity consumption is attributed to public lighting as can be seen in the graph above.

PRIVATE SECTOR

Figure 14. Electricity consumption and CO2 emissions in the private sector.

GC AREA		Electrical energy consumption and related CO_2 emissions					
Code	Sign	Private buildings		Agricultural sector		Tertiary	
		[MWh_{el} /year]	*[tCO_2 /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*
		D66c	D73c	D66d	D73d	D66e	D76
		Actual Data - e-distribution	*Calculated figure*	*Actual Data - e-distribution*	*Calculated figure*	*Actual Data - e-distribution*	*Calculated figure*
1	BAP	6012	1876	337	105	9875	3081
2	BAR	7238	2258	3347	1044	29097	9078
3	BRO	286	89	3	1	74	23
4	CRI	344	107	29	9	332	103
5	GAM	361	113	17	5	174	54
6	MAP	840	262	49	15	182	57
7	OST	93	29	0	0	98	31
8	PAE	3034	947	107	33	8776	2738
9	PAG	629	196	154	48	217	68
10	SAN	2337	729	451	141	3372	1052
TOTAL		**21174**	**6606**	**4494**	**1401**	**52197**	**16285**

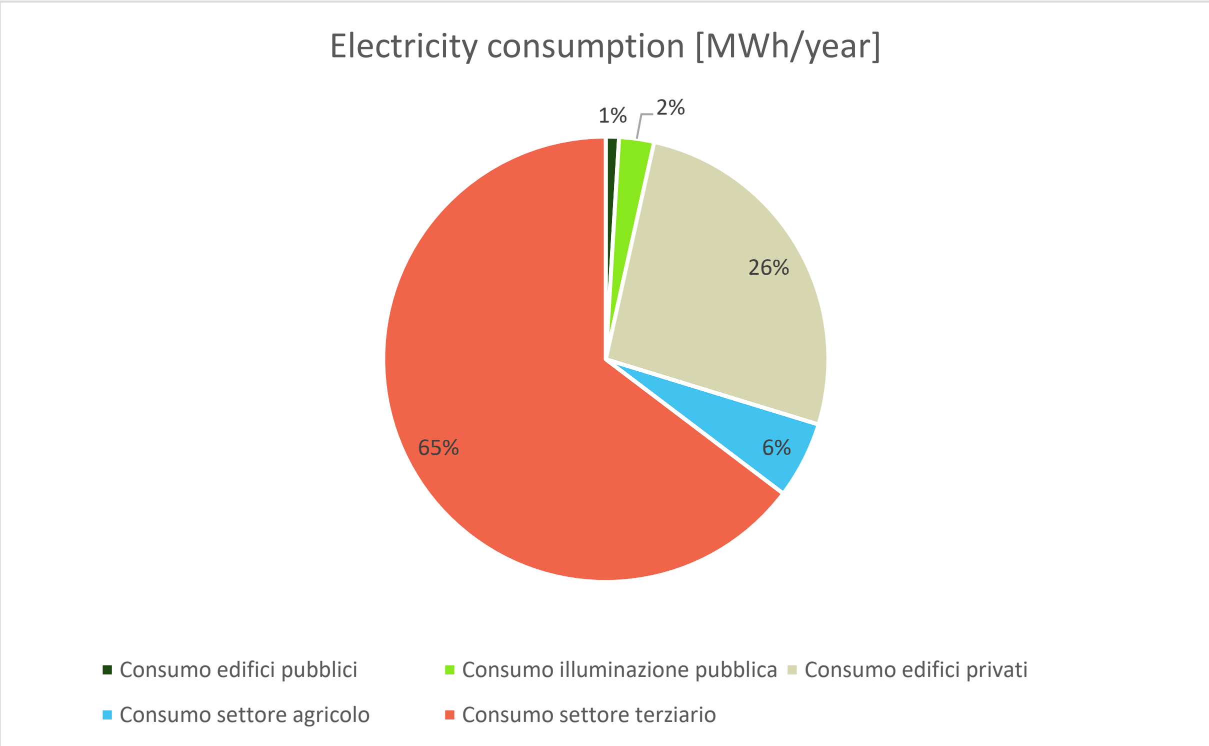
Figure 15. Electricity consumption in the private sector



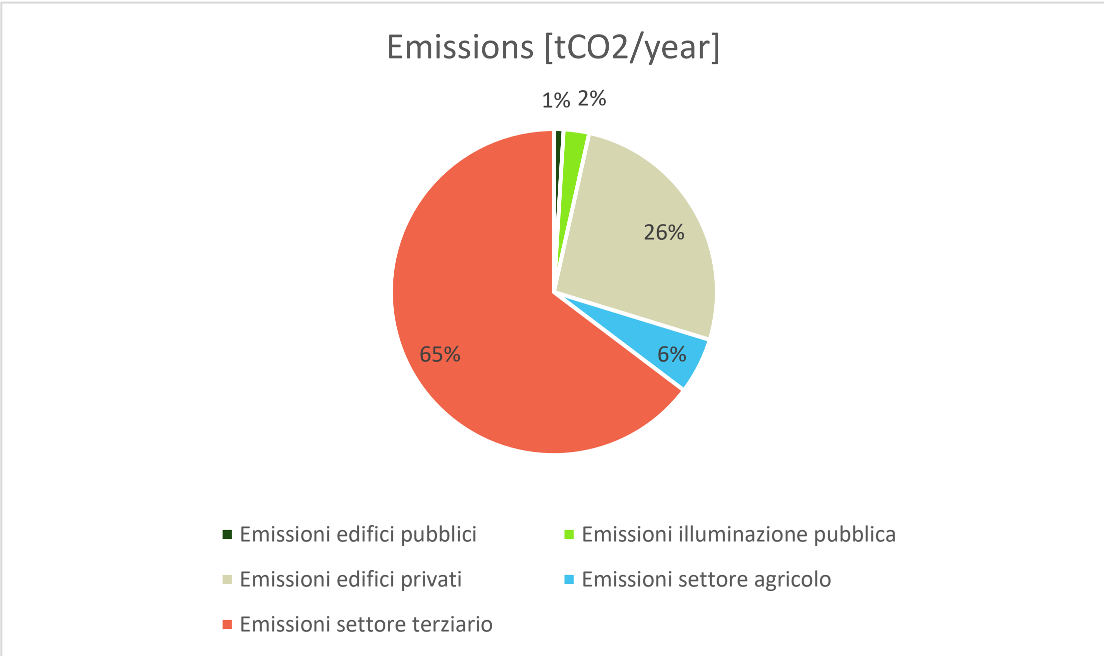
To recapitulate, the total electricity consumption of the BEI is broken down as follows:

Table 3. Summary EIB electricity consumption and emissions from EIB electricity.

Description	Value	Unit of measurement
Consumption of public buildings	773	MWh/year
Public lighting consumption	2045	MWh/year
Private building consumption	21174	MWh/year
Agricultural sector consumption	4494	MWh/year
Tertiary sector consumption	52197	MWh/year
Total consumption	**80683**	**MWh/year**



Description	Value	Unit of measurement
Emissions from public buildings	241	tCO2/year
Public lighting emissions	637	tCO2/year
Private building emissions	6606	tCO2/year
Agricultural sector emissions	1401	tCO2/year
Tertiary sector emissions	16285	tCO2/year
Total emissions	**25170**	**tCO2/year**



5.2.3 THERMAL ENERGY CONSUMPTION AND EMISSIONS

HVAC energy consumption data were divided in the first instance between.

- Public: public buildings
- Private: residential sector and non-residential sectors (agriculture, industry and service sector)

The Data involved in the **public sector** are:

- D65a: HVAC energy consumption in public buildings [MWhel/year]: data were determined from municipalities' energy bills (2018 - actual) (actual).
- D73a: C02 emissions related to HVAC energy consumption in public buildings [tCO2/year]: C02 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.

The Data involved in the **private sector** are:

- D65b: HVAC energy consumption in public buildings [MWhel/year]: data were obtained in different ways depending on fuel type:
  - Natural gas: actual data from Siatel
  - Biomass: simulated data derived from (1) SIPEE's public databases and (2) dynamic uploading and updating via the "Energy Tool" app developed by Compolab and IRIS during the GreenchainSaw4Life project o Electric HVAC: simulated data derived from SIPEE's public databases.
  - LPG: simulated data derived from SIPEE public databases.
  - Diesel: simulated data derived from SIPEE public databases.
  - Solar thermal: simulated data derived from SIPEE public databases.
  - District heating: simulated data derived from SIPEE public databases.
- D72b: C02 emissions related to HVAC energy consumption in private buildings [tCO2/year]: C02 emissions were calculated by multiplying energy consumption by the emission factor (EF) for the relevant energy carrier.

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 [MWhel/year].
- D72c: C02 emissions related to HVAC energy consumption considering both public and private buildings [tCO2/year].

The simulated data were derived from public databases of SIPEE (Sistema Informativo per la Prestazione Energetica degli Edifici) of the Piedmont Region: in particular, the research focused on APE (Attestato di Prestazione Energetica) and ACE (Attestato di Certificazione Energetica).
From the APE database, a simulation of heat loads was performed with calculations based on fuel consumption data, broken down by fuel type and grouped over the entire building stock.
Buildings in the SIEPEE databases are divided into building categories, summarized in the following list according to the activities taking place in the building and by type of users (Art.3 of Presidential Decree 412/93):

- E.1 residential buildings
- E.2 collective residences, offices and the like

- E.3 Hospitals, clinics or nursing homes and similar buildings
- E.4 recreational, association or worship activities and similar buildings
- E.5 commercial buildings
- E.6 buildings used for sports activities
- E.7 School Buildings
- E.8 buildings for agricultural, industrial and craft activities

All APEs and ACEs from all 14 municipalities in the investigated area (provided by the Environment Sector of the Piedmont Region) were collected. The discriminant parameters used are:

- total energy consumption, with a cap set at 100,000 kWh;
- total energy consumption per unit area, with a ceiling set at 400 kWh/m2.

Table 4. Description of heat consumption tables.

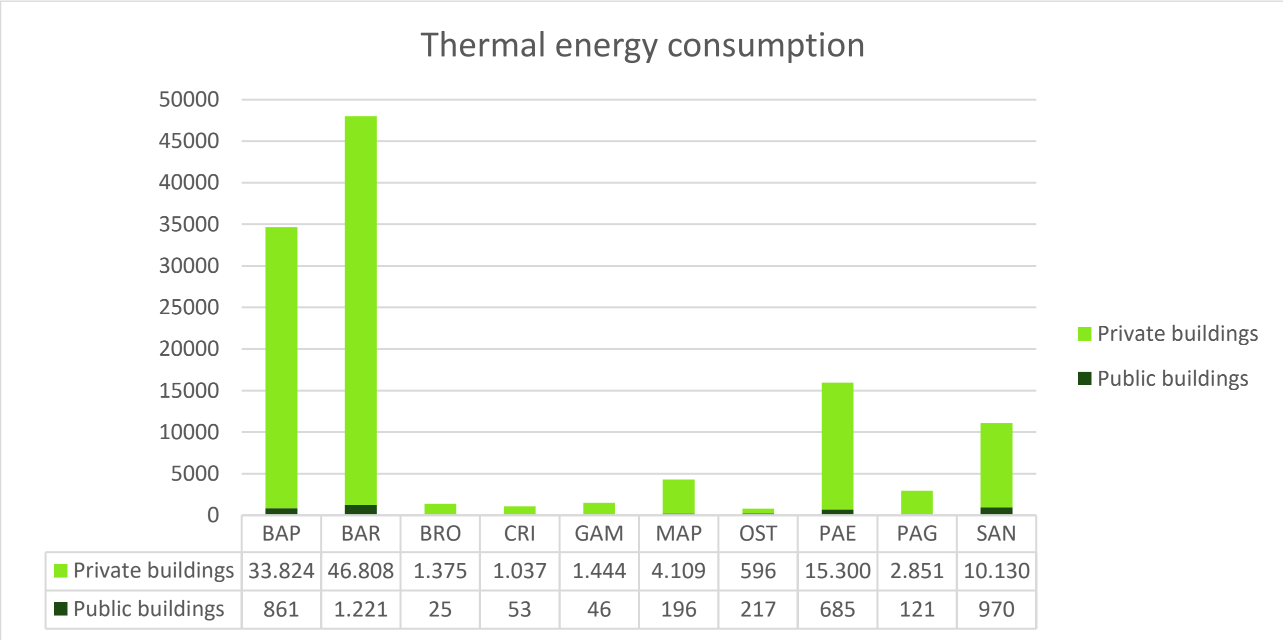
GENERAL DATA.								
MUNICIPALITY ABBREVIATION	BUILDING PROGRESSION	PROPERTIES	DATA TYPE.	USER TYPE.	BUILDING	P.O.D. ()	P.D.R.	ADDRESS
Unique code for each municipality	Unique code for each building	Private or public	Real/Simulation	Electrical, HVAC	Building name	Electricity distribution point	HVAC distribution point	Address

ENERGY FOR HVAC					
TYPE OF FUEL	ELECTRICITY CONSUMPTION FOR HVAC.	HVAC HEAT CONSUMPTION			EMISSIONS FROM HVAC
		INSTALLED POWER	FUEL SPENT	ENERGY CONSUMED	
	kWh /year$_{el}$	*kW$_p$*	*litres/year - Sm^3 /year - kg/year*	*kWh /year$_{th}$*	*kgCO /year$_2$*
Type of fuel used by HVAC	Share of electricity consumed by HVAC.	Sum of peak powers of HVAC	Sum of annual combustible consumption (2018)	Thermal energy consumed	CO emissions $_2$

Figure 16. HVAC thermal energy consumption and emissions

GC AREA			ENERGY FOR HVAC AND RELATED EMISSIONS					
Code	Acronym	Municipality	Public buildings		Private buildings		Total thermal energy consumption and emissions	
			[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 PIEDMONT	861	177	33824	6883	34685	7060
2	BAR	BARGE	1221	241	46808	8762	48029	9003
3	BRO	BRONDELLO	25	5	1375	260	1400	265
4	CRI	CRISSOL	53	14	1037	215	1090	229
5	GAM	GAMBASCA	46	9	1444	292	1490	301
6	MAP	MARTIN, PO	196	27	4109	822	4305	849
7	OST	OSTANA	217	60	596	108	813	168
8	PAE	PAESANA	685	138	15300	3030	15985	3168
9	PAG	PAGNO	121	24	2851	531	2972	555
10	SAN	SANFRONT	970	249	10130	2098	11100	2347
TOTAL			**4395**	**944**	**117474**	**23001**	**121869**	**23945**

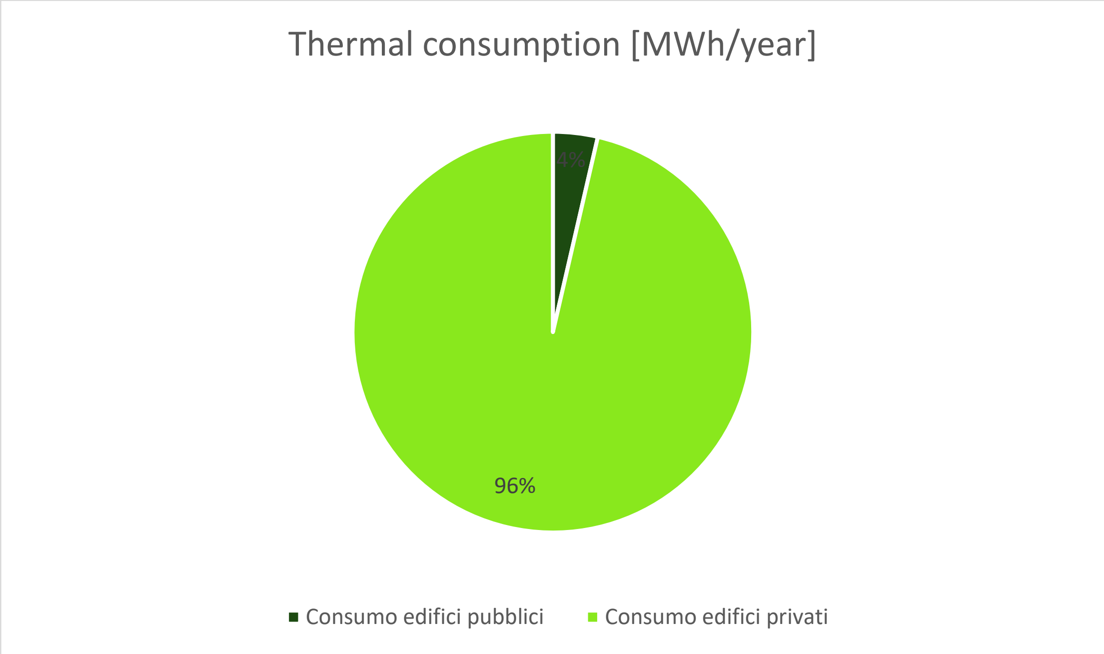
Figure 17. HVAC thermal energy consumption



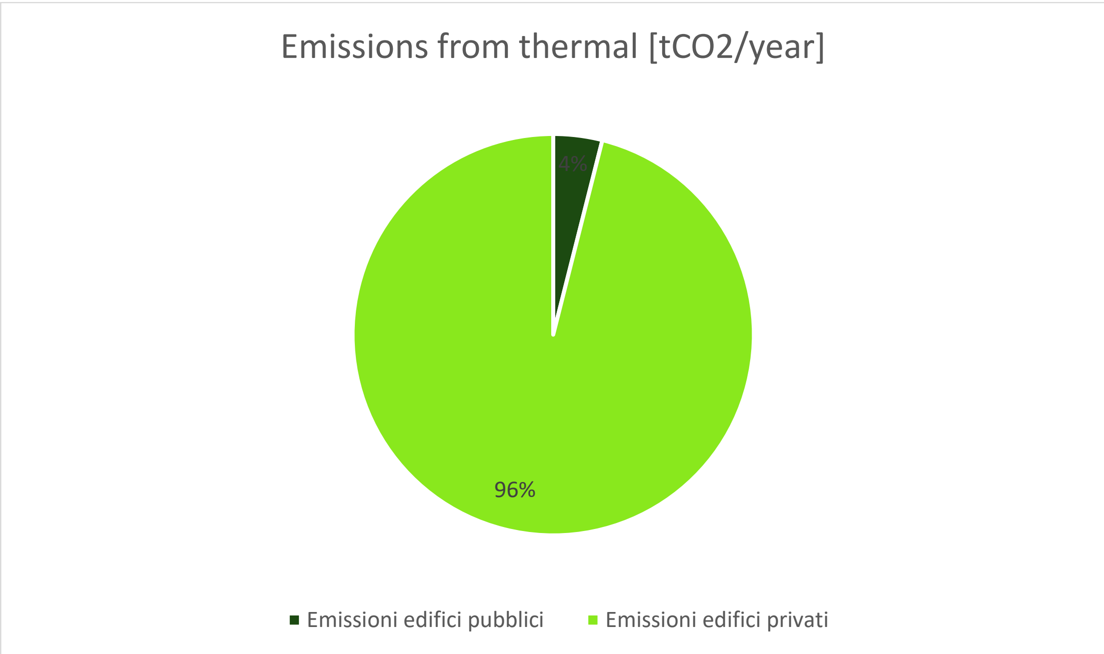
It is possible to observe the almost total consumption by the private sector compared to the consumption by the public sector, which is much less.
To recap, below is a summary on thermal consumption and emissions related to thermal.

Table 5. Summary of consumption and emissions by thermal energy

Description	Value	Unit of measurement
Consumption of public buildings	4395	MWh/year
Private building consumption	117474	MWh/year
Total consumption	**121869**	**MWh/year**



Description	Value	Unit of measurement
Emissions from public buildings	944	tCO2/year
Private building emissions	23001	tCO2/year
Total emissions	**23945**	**tCO2/year**



In more detail, a data analysis was done on the type of fuel used to produce the thermal energy.

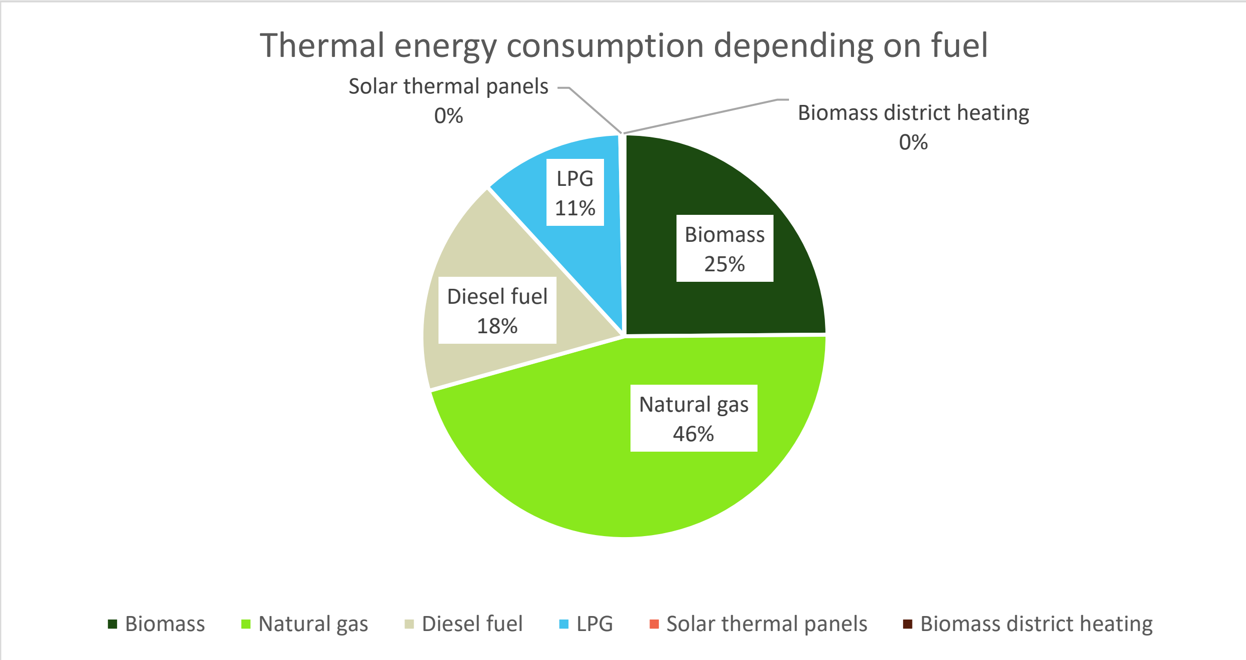


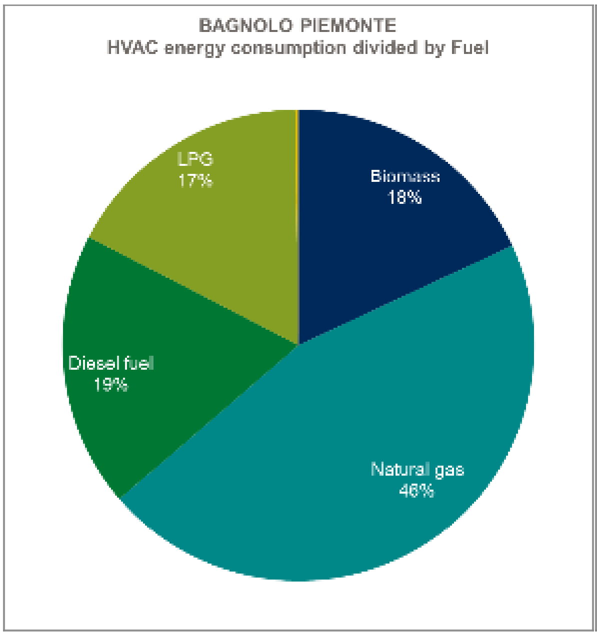
Figure 18. Thermal energy consumption by fuel type

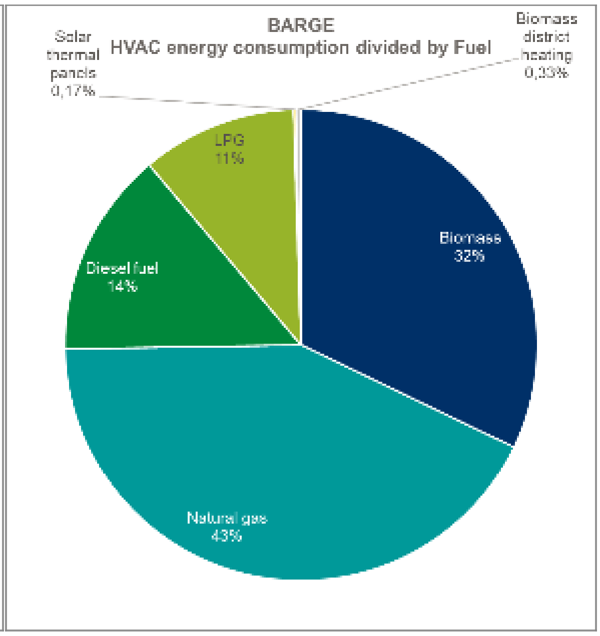
Figure 19. Thermal energy consumption divided by fuel

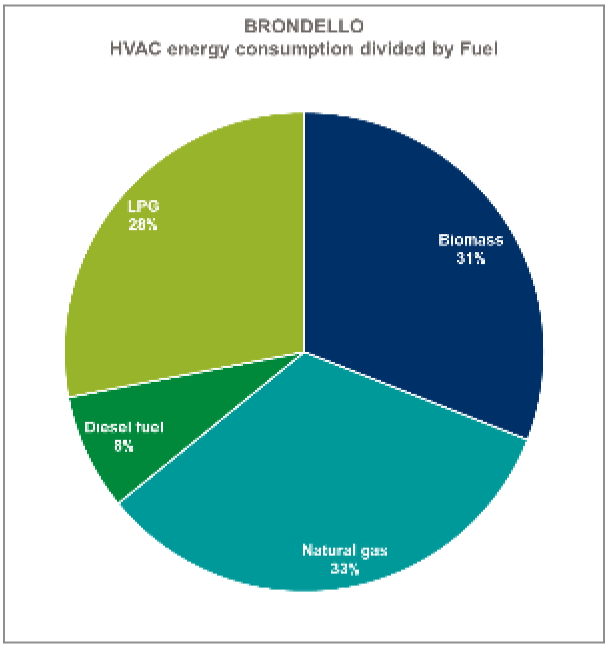
Municipality	Biomass		Natural gas		Diesel		LPG		Solar thermal panels		TLR biomass		TOTAL HVAC
	[MWh_{th} /year]	*tCO_2 /year*	*[MWh_{th} /year]*	*tCO_2 / year*	*[MWh_{th} / year]*	*tCO_2 / year*	*[MWh_{th} / year]*	*tCO_2 / year*	*[MWh_{th} / year]*	*tCO_2 / year*	*[MWh_{th} / year]*	*tCO_2 / year*	*[MWh_{th} / year]*
	D65		D65		D65		D65		D65		D65		D65
BAP	6104	739	15443	3119	6390	1706	5810	1319	78				33825
BAR	15045	1820	19934	4027	6610	1765	4983	1131	81		155	36	46808
BRO	426	52	456	92	108	29	385	87					1375
CRI	293	35	200	40	402	107	142	32	1				1038
GAM	197	24	855	173	151	40	241	55					1444
MAP	852	103	2352	475	411	110	493	123					4108
OST	265	32	181	37	128	34	22	5	0				596
PAE	4092	495	6518	1317	4047	1081	605	137	38				15300
PAG	720	87	1825	369	173	46	128	29	6				2852
SAN	1231	149	6024	1217	2170	579	674	153	31				10130
TOT	29225	3536	53788	10866	20590	5497	13483	3071	235	0	155	36	117476

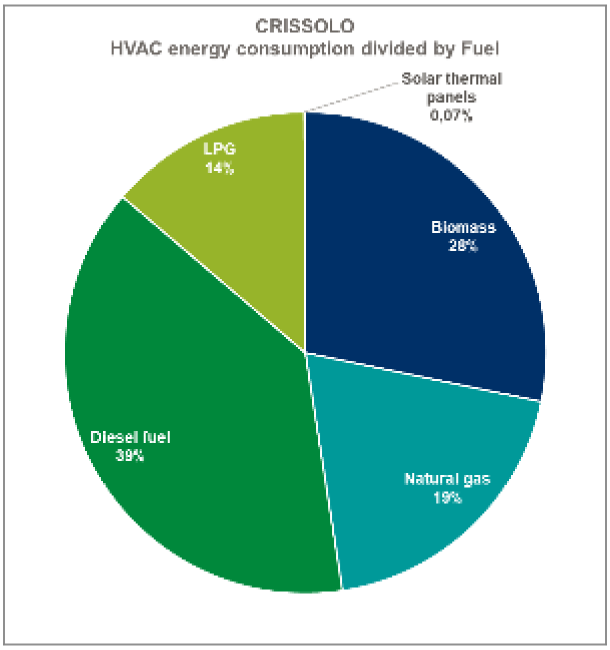
HVAC energy consumption per inhabitant was then defined by dividing the total consumption of the municipality by the number of inhabitant-residents in the municipality. The consumption was determined by taking into consideration the property occupancy factor from ISTAT source. The average value of per capita consumption is 5.49 MWh year/person.

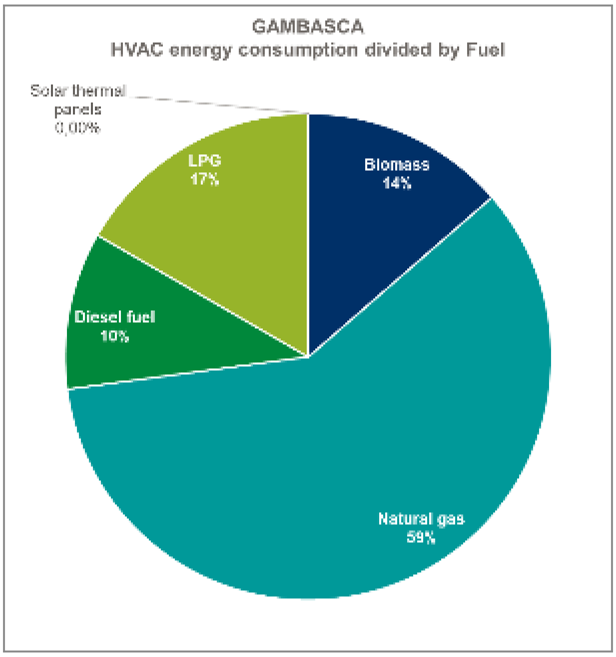
The graph shows that 75 percent of HVAC consumption comes from fossil fuels and only the remaining 25 percent from renewable sources. The presence of electric and geothermal heat pumps is neglected because in most cases they are secondary systems supporting the main fossil fuel plants.
Natural gas is the most used fuel (almost 47% MWh/year - actual data derived from actual SIATEL consumption), followed by biomass (24% data derived from survey and simulation - APE and ACE Region archive). This makes it possible to highlight that about 24% of consumption comes from biomass. In 2013, according to the ISTAT report, 20 percent of Italian households and 24.4 percent of Piedmontese households used biomass of plant origin as their main source of domestic heating. Among these, those of woody origin are the majority component. The Istat report shows that households use biomass more as a heating source in smaller municipalities, especially in the mountains.
The graphs on the following pages show the breakdown of HVAC consumption by fuel for each municipality.

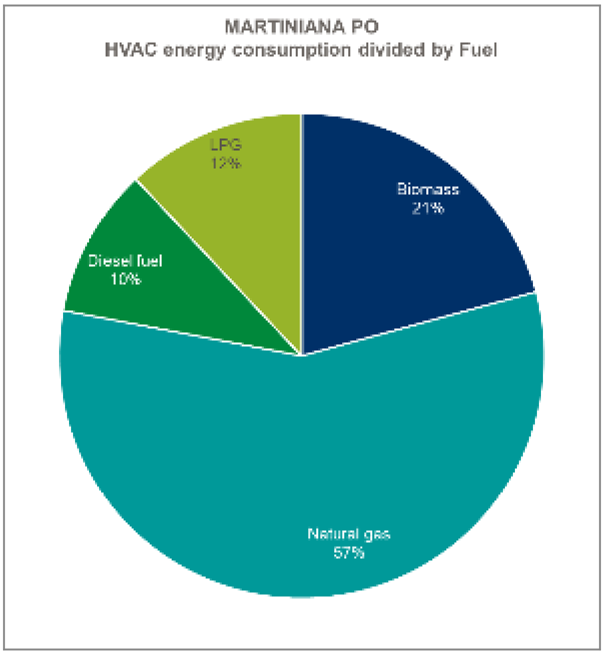


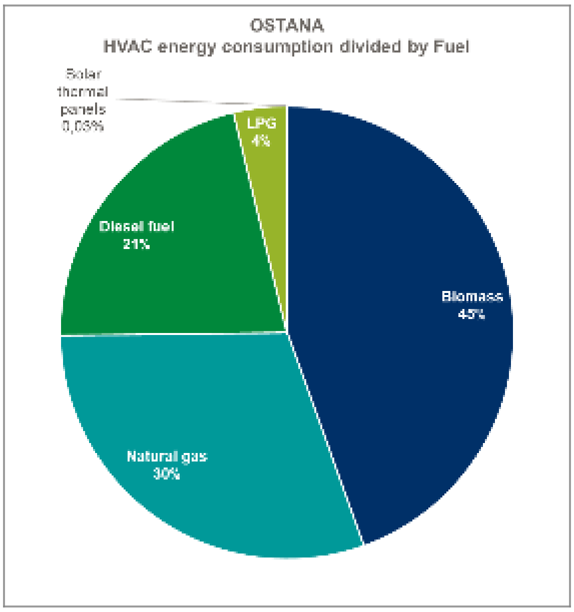


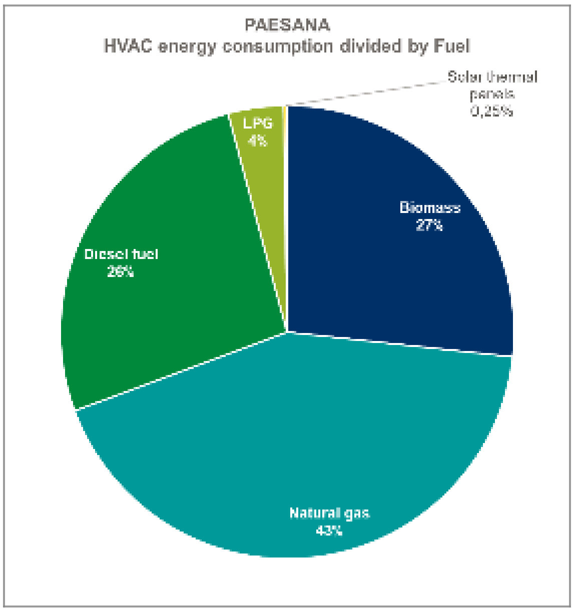

BRONDELLO
HVAC energy consumption divided by Fuel
Biomass
31%
Natural gas
33%
Diesel fuel
8%
LPG
28%

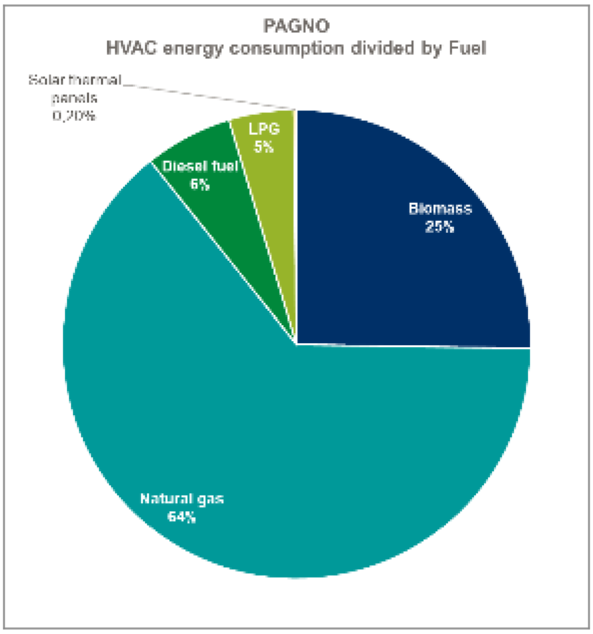

CRISSOLO
HVAC energy consumption divided by Fuel
Solar thermal panels 0,07%
LPG
14%
Biomass
28%
Natural gas
19%
Diesel fuel
39%

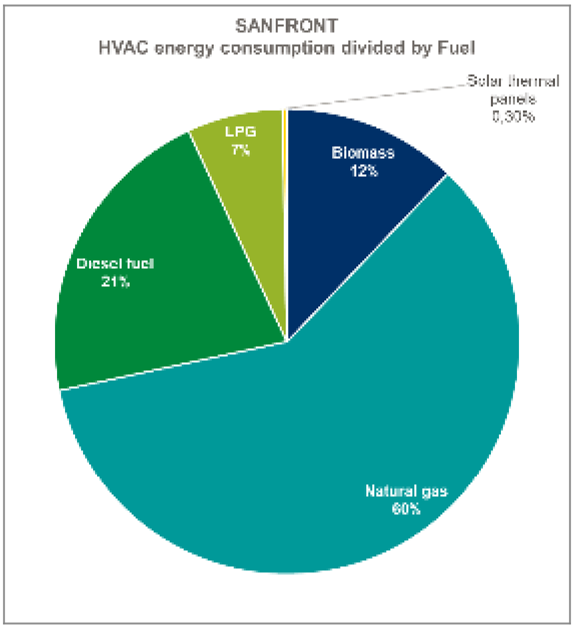

GAMBASCA
HVAC energy consumption divided by Fuel
Solar thermal panels 0,00%
LPG
17%
Biomass
14%
Diesel fuel
10%
Natural gas
59%


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









After determining the total consumption data divided by fuel, the consumption derived from biomass was analyzed in detail. By analyzing the biomass consumption of the HVAC system in detail, some important parameters are determined such as consumption per building (calculated by considering the number of buildings in each municipality heated mainly by biomass).

For the calculations, an average heating value (LHV) of biomass (dry u.r.<10%) of 4 kWh/kg was used. This value is an average derived from a weighted average between the use of pellets (4.4 kWh/kg) and wood chips (<4 kWh/kg).

In the case of land, an analysis was used to define a weighted average coefficient according to the amount of biomass from forest management and that from non-sustainable management:

- Wood chips and wood (70% of total biomass) with LHV < 4 kWh/kg
- pellets (30% of total biomass) with LHV of 4.4 kWh/kg

Figure 20. Average calorific value of biomass for energy valorization (Source: Piedmont Region "Energy from wood).

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

The Table below collects detailed data on biomass consumption for HVAC among the project municipalities.

Figure 21. Specific data on biomass utilization

Code	Acronym	HVAC energy consumption - biomass	HVAC emission from biomass	HVAC consumption from biomass	Incidence in use from biomass	Average consumption from biomass
		[MWh_{el} /year]	*[tCO_2 /year]*	*t/year*	*[%]*	*t/year*
		D65		D65		

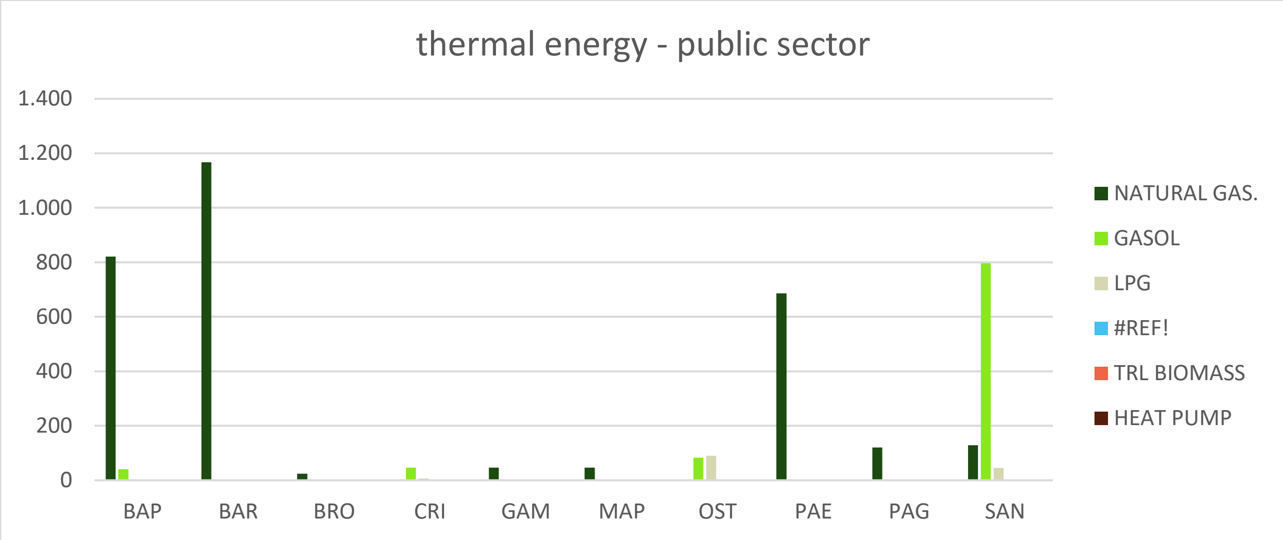
		Real data (Siatel) + Simulated data (SIPEE)	Calculated data	Calculated data	Calculated data	Calculated data
1	BAP	6.104	739	1.526	18,04%	3,36
2	BAR	15.045	1.820	3.761	32,14%	3,69
3	BRO	426	52	106	30,97%	2,35
4	CRI	293	35	73	28,26%	2,32
5	GAM	197	24	49	13,62%	2,01
6	MAP	852	103	213	20,75%	2,93
7	OST	265	32	66	44,49%	2,48
8	PAE	4.092	495	1.023	26,74%	2,71
9	PAG	720	87	180	25,26%	2,75
10	SAN	1.231	149	308	12,16%	2,31

Once the breakdown of thermal energy produced by type of fuel used is clear (actual data obtained from utility bills and material provided by the various municipalities), at the regional and municipal level there are no documents that report the consumption of that specific fuel for a specific precise sector (residential, industry, nonresidential) unless the public sector.
Thus, for the public sector, data from bills in which the type of fuel is made explicit for each building were used. The final values are shown below in the table.

Table 6. Thermal consumption divided by fuel type for the public sector.

Code	Acro-nym	NATURAL GAS.	GASOL	LPG	SOLID BIO-MASS	TRL BIOMASS	HEAT PUMP
		[MWhth/year]	[MWhth/year]	[MWhth/year]	[MWhth/year]	[MWhth/year]	[MWhth/year]
		Real (Siatel) + Simulated Data (SIPEE)	*Real (Siatel) + Simulated Data (SIPEE)*	*Real (Siatel) + Simulated Data (SIPEE)*	*Real (Siatel) + Simulated Data (SIPEE)*	*Real (Siatel) + Simulated Data (SIPEE)*	*Real (Siatel) + Simulated Data (SIPEE)*
1	BAP	820	40	0	0	0	0
2	BAR	1.168	0	0	0	33	0
3	BRO	25	0	0	0	0	0
4	CRI	0	47	7	0	0	0
5	GAM	46	0	0	0	0	0
6	MAP	46	0	0	0	150	0
7	OST	0	83	90	44	0	0
8	PAE	685	0	0	0	0	0
9	PAG	121	0	0	0	0	0
10	SAN	128	797	45	0	0	0

Figure 22. Thermal consumption divided by fuel type for the public sector.



For the private sector, it was decided not to consider the "industrial" sector in the calculations, as suggested by the Covenant of Mayors guidelines, as there was insufficient data for analysis. Therefore, it was decided to consider the "tertiary" and "residential" sectors.
From SIATEL sources, it is possible to derive the consumption of MWhth/year produced by natural gas for the "residential" and "tertiary" sectors. Below is the table with the values.

Table 7. Natural gas consumption from SIATEL data by residential and tertiary sectors.

Code	Acronym	Natural gas - residential use	Natural gas - tertiary
		[MWhth/year]	*[MWhth/year]*
1	BAP	11346	4097
2	BAR	15214	4720
3	BRO	420	36
4	CRI	0	0
5	GAM	725	131
6	MAP	0	0
7	OST	0	0
8	PAE	5214	1304
9	PAG	0	0
10	SAN	3966	2059

The villages of Crissolo, Martiniana Po, Ostana and Pagno are not connected to natural gas distribution and therefore, in the table above, the values are zeros.
Since natural gas is the only fuel whose consumption for the two sectors residential and tertiary is known, as for the other fuels such as biomass, natural gas, diesel, LPG, solar thermal, photovoltaic and wind power, it was decided to apply an estimate based on the same proportion as there is in the different countries between the share of natural gas intended for residential use and the share intended for tertiary use. This assumption is plausible since the nature of the countries considered is the same. Taking a weighted average for each country gives the results in the table below.

Table 8. Percentages of natural gas consumption by residential and tertiary sectors.

Code	Acronym	Residential	Tertiary
1	BAP	73%	27%
2	BAR	76%	24%
3	BRO	92%	8%
4	CRI	85%	15%
5	GAM	85%	15%
6	MAP	85%	15%
7	OST	85%	15%
8	PAE	80%	20%
9	PAG	85%	15%
10	SAN	66%	34%

Finally, by making a weighted average of the percentages obtained (it is noted that for the values that were zeros, the same percentage was estimated as for another country taken as an example since the nature of the countries is the same), a percentage of consumption compared to total consumption of 75 percent is obtained for residential and a percentage of 25 percent for tertiary. With these percentages, the consumption of the other sources is scaled as follows in the table with the exception of solar thermal and biomass which, at the moment, do not yet see applications in the tertiary sector but only residential.

Table 9. Thermal consumption of residential and tertiary sectors

COMBUSTIBLE	SOLID BIOMASS	GASOL	LPG	SOLAR THERMAL.	HEAT PUMPS	TLR BIOMASS	TLR NATURAL GAS	PHOTOVOLTAIC	WIND
	[MWhth/year]	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*	*[MWhth/year]*
RESIDENTIAL	28374	15117	9732	233	0	116	0	0	0
TERTIARY	0	5060	3258	0	0	39	0	0	0

5.2.4 TRANSPORTATION SECTOR CONSUMPTION AND EMISSIONS

Measuring transportation emissions and collecting associated data is critical to driving climate change mitigation actions, but it can also drive more comprehensive transportation policy and planning.
This section aims to provide practical approaches to construct emission inventories for the transport macrosector focusing on CO2. Different resources and capabilities of local authorities are considered, and options are provided that are considered feasible to be implemented in medium-sized and even smaller local authorities.
Popular methods include the fuel sale method, the spatial method, the residential method, and the city induced method. The method to be used to collect data is the spatial 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 mileage traveled within the local area and can be relatively simple to apply while still allowing for the identification and quantification of mitigation actions. Using a spatial approach is also a good trade-off in terms of the accuracy and resources required in terms of data collection, estimation of CO2 emissions, and analysis of the impact of local actions.
It can be difficult to account for emissions from the road transport activity sector in urban areas, given the nature of road transport, which contains numerous mobile sources that move within but also across urban boundaries in various patterns. Depending on the purpose of the inventory, energy consumption and associated emissions could be accounted for in different ways.
The following parameters underlie the territorial method.
Therefore, the following equation was used to estimate the total GHG emissions.

$$\text{GHG emissions} = \Sigma\text{MODI}\ \Sigma\text{COMBUSTIBILI}\ [\text{Emission factor} * \text{VKT} * \text{Energy intensity}]$$

The input data are:

- **Fleet type distribution [n°]**: indicates the number of vehicles in each municipality divided by type. This parameter was provided for each individual municipality from ACI Automobile Club Italia data and public vehicle data provided by the municipalities. Similarly, the fuel used was also determined. To simplify the calculations, all fuels in 3 main ones (gasoline, diesel and electricity) were combined. The percentage of electric cars is less than 0.04% of the total fleet and therefore they were not included in the calculations.
- **Average Mileage [km/year]**: the average number of kilometers traveled each year (10,000 km) was multiplied by a reduction coefficient of 50% because the remainder of the trips are made outside the project area.
- **Average fuel consumption of each vehicle type [l fuel/km]**: depends on the types of vehicles in the category, their age, and also several other factors, such as driving cycle. Data are available in the EMEP/EEA 2016 Air Pollutant Emissions Inventory Guidebook (EEA, 2016)
- **The Net Calorific Values (NCV) [Wh/l]** of each fuel type are available as default values from the IPCC.
- **Emission factors (EF) [tCO2/MWh]** of each fuel type are available as IPCC defaults.

The calculated parameters are:

- **Vehicle-Kilometers Traveled (VKT)** [million km/year]: is a measure of traffic flow. The value is determined by multiplying the distribution of fleet type by the average mileage.
- **Distribution by Fleet Type (DFT) [% of VKT]**: shows the percentage distribution of motor vehicles according to the following classes: municipal fleet, public transport, private transport and commercial transport.
- **Energy intensity (EI) [Wh/km]**: is a measure of energy consumption per kilometer driven and derived from the multiplication of fuel consumption per kilometer and fuel calorific value.
- **Estimated Final Energy Consumption by Fleet Type (EFIN) [MWh/year]**: is a measure of total energy consumption in the municipality and is derived from the multiplication between unit energy intensity and - Vehicle-Kilometers Traveled (VKT).
- **Estimated GHG emissions by fleet type (EmCO2) [tCO2/year]**: shows the total emissions for each municipality determined by multiplying the Final Energy Consumption by fleet type of each fuel by the emission factor.

The calculation of energy consumption and GHG emissions is explained in the following steps:
1**. Step 1**: Estimated activity/mileage by fleet type [million km/year] = Total VKT [million km/year] x Fleet type distribution (in % of VKT).
2. **Step 2**: Energy intensity by fleet type [Wh/km] = Average fuel consumption [l/km] x Net calorific value [Wh/l].
3. **Step 3: Estimated** Final Energy Consumption by Fleet Type [MWh/year] = Estimated Mileage by Fleet Type [million km/year] x Energy Intensity [Wh/km]. **Step** 4: Estimated greenhouse gas emissions by fleet type [tCO2] = Estimated final energy consumption [MWh/year] x Emission factors [tCO2/MWh].

The input data that were entered for the area of interest are shown below and were the result of analysis of documents provided by the various municipalities.

Figure 23.Input data: distribution of public vehicle fleet.

Input data: Vehicle type [n°]													
D_{FT}	Municipal fleet				Public transportation			Commercial and private transportation				Total
	Passenger cars	Light duty vehicles	Heavy vehicles	Two wheels	Bus	COndivision(auto-	Sharing(two wheels)	Passenger cars	Light duty vehicles	Heavy duty	Two wheels	

										vehi cles		
	[n°]	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*	*[n°]*
BAGNOLO PIEDMONT	4	3	4	1	2			4478	7	803	676	**5978**
BARGE	6	2	3	1	8			5756	12	958	781	**7527**
BRONDELLO	2	1	2					232	1	32	42	**312**
CRISSOL	3	1	5					122	1	33	29	**194**
GAMBASCA			3					311	2	47	51	**414**
MARTINIAN PO	1		3					558	3	66	110	**741**
OSTANA	2	1	2					63	1	7	11	**87**
PAESANA	2		8		11			2053	13	251	288	**2626**
PAGNO	1		3					426		85	106	**621**
SANFRONT	2	1	6					1799	6	244	338	**2396**
GC AREA	**23**	**9**	**39**	**2**	**21**	**0**	**0**	**15798**	**46**	**2526**	**2432**	**20896**

Figure 24. Input data: average mileage of public vehicle fleet.

Input data: Total kilometers (vehicle-kilometers traveled) and fleet distribution [n°].			
D_{FT} , VKT	TOTAL	Total mileage	Total mileage
	[n°]	*[km/year]*	*[million km/year]*
BAGNOLO PIEDMONT	**5978**	5000	30
BARGE	**7527**	5000	38
BRONDELLO	**312**	5000	2
CRISSOL	**194**	5000	1
GAMBASCA	**414**	5000	2
MARTINIAN PO	**741**	5000	4
OSTANA	**87**	5000	0
PAESANA	**2626**	5000	13
PAGNO	**621**	5000	3
SANFRONT	**2396**	5000	12
GREENCHAINSAW 4 LIFE AREA	**20896**	5000	105

Figure 25. Input data: average consumption, NCV and emissions.

Input data: average fuel consumption, NCV and emission factor					
FC_{AVG} , NCV, EF	Municipal fleet	Public transportation	Commercial and private trans-portation		Emission factors (EF)

	Passerreger cars	Light vehicles	Heavy vehicles	Two wheels	Bus	Car sharing (car)	Car sharing (two wheel-	Passenger Machine	Light vehicles	Heavy vehicles	Two wheels	Net calorific value-PCI	
	[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

Figure 26. Input data: Energy intensity

Input data: Energy intensity											
EI	Municipal fleet				Public transportation			Commercial and private transportation			
	Passerreger cars	Light vehicles	Heavy vehicles	Two wheels	Bus	Car sharing (car)	Car sharing (two wheelers)	Passenger Machine	Light vehicles	Heavy vehicles	Two wheels
	[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			

The following results on final consumption emerge from the analysis and calculations made with the data

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

GreenChainSAW4Life

Calculation of final energy consumption											
E_{FIN}		Municipal fleet				Public transportation	Private and commercial transportation				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 PIEDMONT	Total	14	15	54	2	29	15331	35	10768	1244	27491
	Gasoline	8	2		2		8701	4		1244	9960
	Diesel fuel	6	13	54		29	6630	31	10768		17531
BARGE	Total	21	10	40	2	117	19706	60	12847	1437	34239
	Gasoline	12	1		2		11184	7		1437	12643
	Diesel fuel	9	9	40		117	8522	53	12847		21596
BRONDELLO	Total	1	0	2	0	5	817	2	533	60	1419
	Gasoline	0	0		0		464	0		60	524
	Diesel fuel	0	0	2		5	353	2	533		895
CRISSOL	Total	4	3	17			494	3	267	48	836
	Gasoline	2	0				280	0		48	332
	Diesel fuel	2	3	17			214	3	267		504
GAMBASCA	Total					12	1087	8	636	86	1829
	Gasoline						617	1		86	704
	Diesel fuel					12	470	7	636		1125
MARTINIAN PO	Total			72			1906	18	1128	168	3292
	Gasoline						1082	2		168	1252
	Diesel fuel			72			824	16	1128		2040
OSTANA	Total	0		5			224	2	104	24	359
	Gasoline	0					127	0		24	151
	Diesel fuel	0		5			97	2	104		207
PAESANA	Total						5428		5980	1094	12502
	Gasoline						3081			1094	4175
	Diesel fuel						2347		5980		8327
PAGNO	Total	49	36	191			1540	36	670	144	2666
	Gasoline	28	4				874	4		144	1055
	Diesel fuel	21	31	191			666	31	670		1611
SANFRONT	Total						6178	13	3565	594	10351
	Gasoline						3506	2		594	4102
	Diesel fuel						2672	12	3565		6249
GC AREA	**Total**	**88**	**63**	**386**	**4**	**163**	**52808**	**179**	**36602**	**4899**	**95172**
	Gasoline	50	7	0	4	0	29916	20	0	4899	34898
	Diesel fuel	38	56	386	0	163	22892	159	36602	0	60292
	Electricity	0	0	0	0	0	0	0	0	0	0

Table 10. Final consumption calculations

Table 11. Calculation of final emissions

Calculation of CO2 emissions											
Em_{CO2}		Municipal fleet				Public trans-portation	Private transportation				Total
		Passenger cars	Light vehicles	Heavy vehicles	Two wheels	Bus	Passenger cars	Light vehicles	Heavy vehicles	Two wheels	
		[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 PIEDMONT	**Total**	**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
BARGE	**Total**	**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
BRONDELLO	**Total**	**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
CRISSOL	**Total**	**1**	**1**	**4**			**127**	**1**	**71**	**12**	**217**
	Gasoline	1	0				70	0		12	83
	Diesel	0	1	4			57	1	71		135
ENVIE	**Total**	**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
GAMBASCA	**Total**					**3**	**279**	**2**	**170**	**21**	**476**
	Gasoline						154	0		21	175
	Diesel					3	126	2	170		300
MARTINIAN PO	**Total**			**19**			**489**	**5**	**301**	**42**	**856**
	Gasoline						269	1		42	312
	Diesel			19			220	4	301		545
ONCINO	**Total**			**3**			**70**	**1**	**43**	**6**	**123**
	Gasoline						39	0		6	45
	Diesel			3			31	1	43		78
OSTANA	**Total**	**0**		**1**			**58**	**0**	**28**	**6**	**93**
	Gasoline	0					32	0		6	38
	Diesel	0		1			26	0	28		55
PAESANA	**Total**						**1.394**		**1.597**	**272**	**3.263**
	Gasoline						767			272	1.040
	Diesel						627		1.597		2.223
PAGNO	**Total**	**13**	**9**	**51**			**395**	**9**	**179**	**36**	**693**

	Gasoline	7	1				218	1		36	263
	Diesel	6	8	51			178	8	179		430
REVELLO	**Total**	**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
REFREDDO	**Total**	**2**		**18**			**645**		**524**	**84**	**1.272**
	Gasoline	1					355			84	439
	Diesel	1		18			290		524		833
SANFRONT	**Total**						**1.586**	**4**	**952**	**148**	**2.690**
	Gasoline						873	0		148	1.021
	Diesel						713	3	952		1.668
GC AREA	**Total**	**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										

5.2.5 FINAL RESULTS

The collection of all the data described in the previous chapters resulted in a final summary table.

The table below collects all the final data from the analyses, broken down by production and consumption. Consumption is in turn divided into electrical consumption, HVAC consumption, and transportation sector. Emissions were then identified for each consumption according to the fuels used for air conditioning.

Figure 27. Final results.

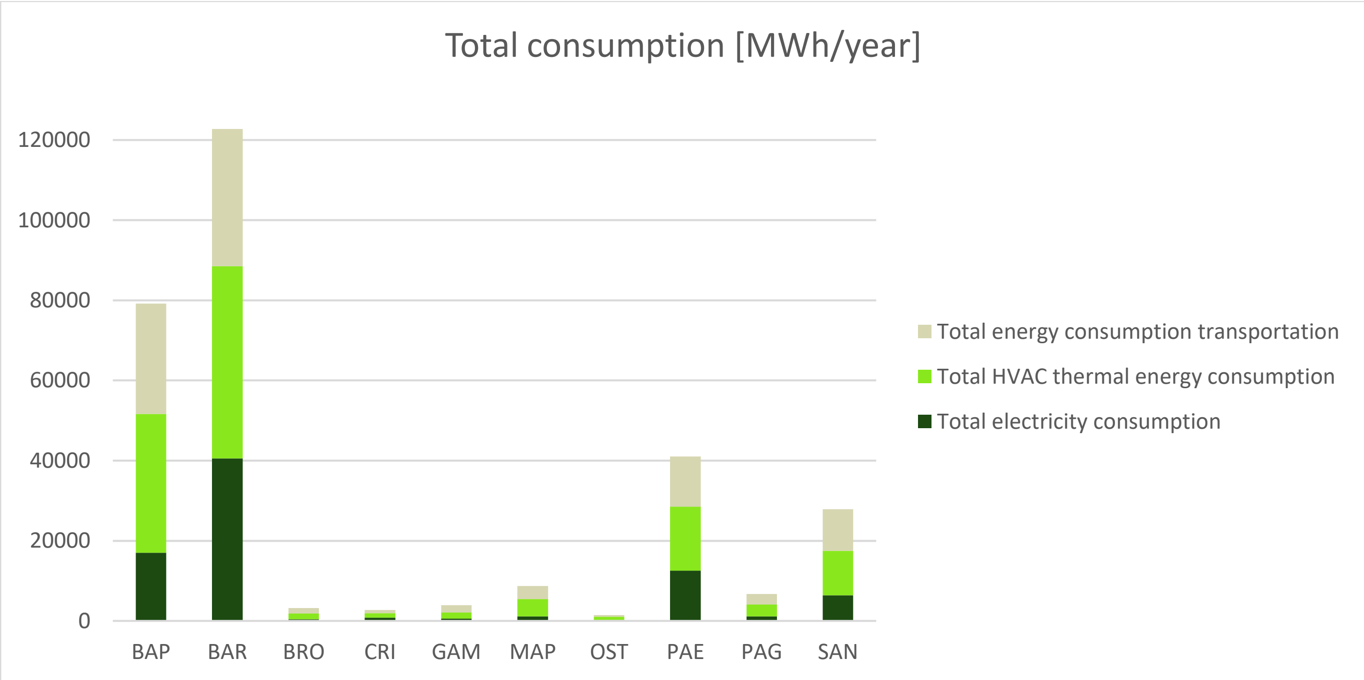
	Pop.	Electricity production from renewables	Thermal production from renewables	Total electric consumption and emissions		Total HVAC consumption and emissions		Total emission buildings	Transport sector energy consumption and emissions		Total emissions
	[ab.°]	*[MWh_{el} /year]*	*[MWh_{el} /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*	*[tCO_2 /year]*	*[MWh_{el} /year]*	*[tCO_2 /year]*	*[tCO_2 /year]*
	D1	D19	D20	D67	D73	D65	D72		D74a	D74b	
BAP	5953	1994	6104	16973	5295	34685	7059	12355	27491	7161	19516
BAR	7616	8769	15250	40524	12644	48029	9005	21648	34239	8914	30563
BRO	282	5	426	417	130	1399	265	395	1419	370	764
CRI	165	196	293	798	249	1091	229	478	836	217	695
GAM	350	46	197	590	184	1490	301	485	1829	476	960
MAP	747	128	852	1130	352	4305	849	1202	3292	856	2058
OST	85	31	309	252	79	813	168	247	359	93	340
PAE	2713	1356	4092	12513	3904	15986	3168	7072	12502	3263	10335
PAG	560	133	720	1102	344	2972	555	899	2666	693	1592
SAN	2354	1012	1231	6386	1992	11100	2347	4339	10351	2690	7029
TOTAL	20825	13670	29474	80685	25173	121870	23946	49120	94984	24733	73852

Table 12. Percentages of consumption covered by energy from renewable sources.

Acronym	Electricity consumption covered by REN	Thermal consumption covered by REN
	[%]	*[%]*

	Calculated data	*Calculated data*
BAP	12%	18%
BAR	22%	33%
BRO	1%	31%
CRI	25%	28%
GAM	8%	14%
MAP	11%	
OST	12%	45%
PAE	11%	27%
PAG	12%	25%
SAN	16%	12%
TOTAL	20%	24%

Figure 28. Summary table of total consumption divided by transportation, HVAC, electricity



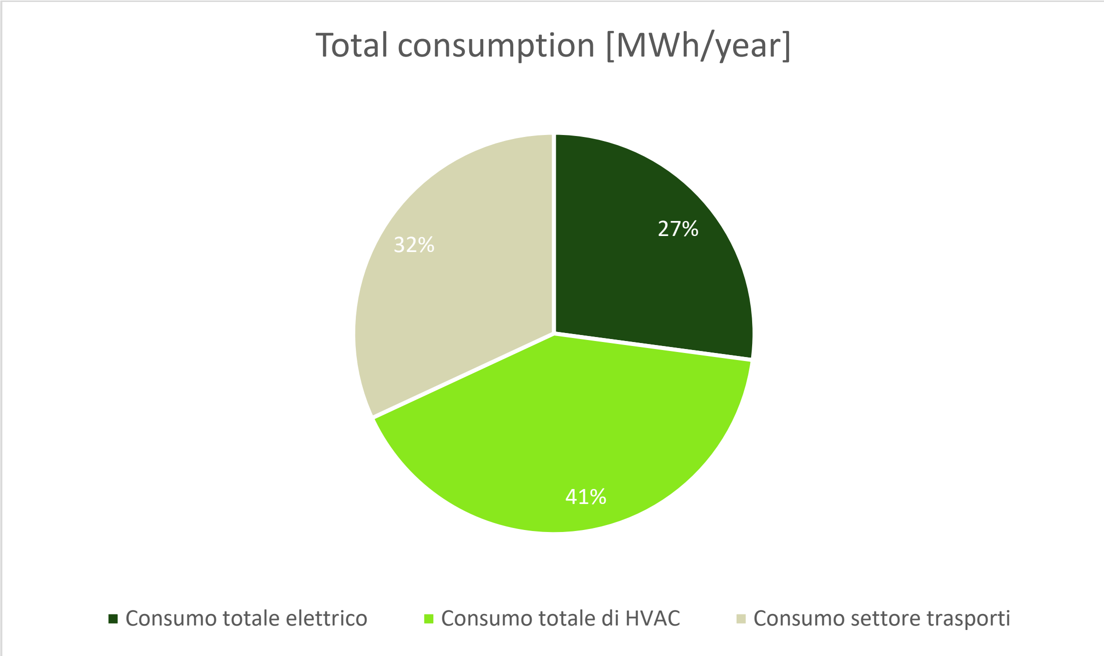
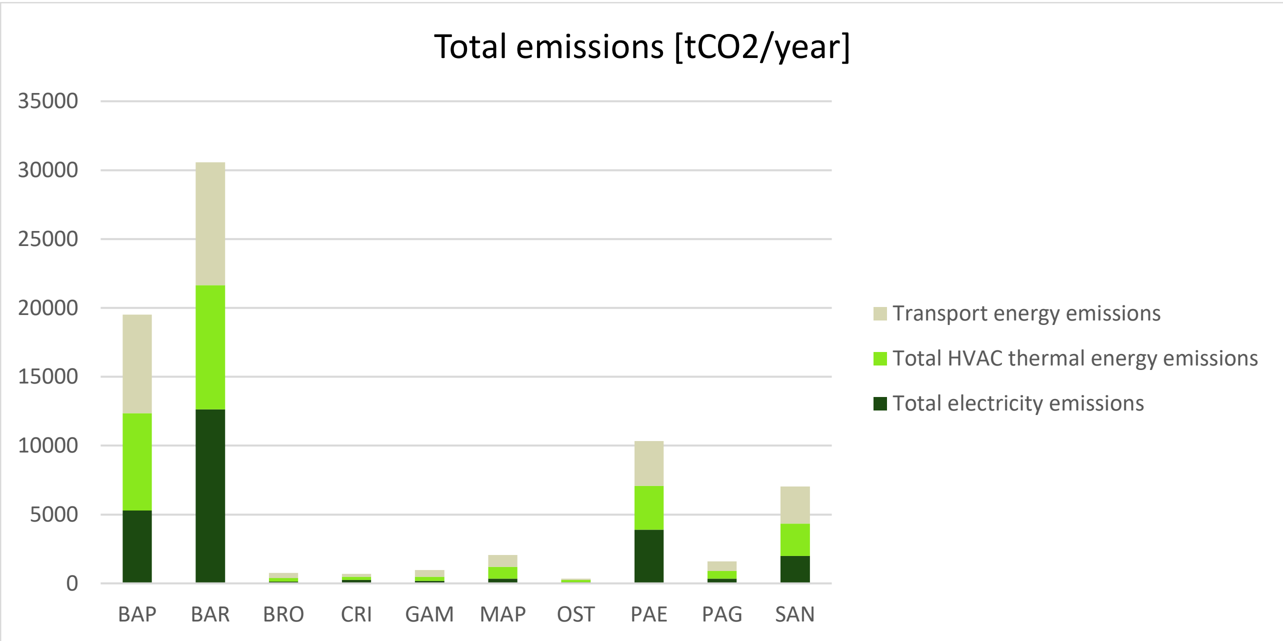


Figure 29. Total emissions divided by country



Energy consumption and related CO2 emissions are shared almost equally:

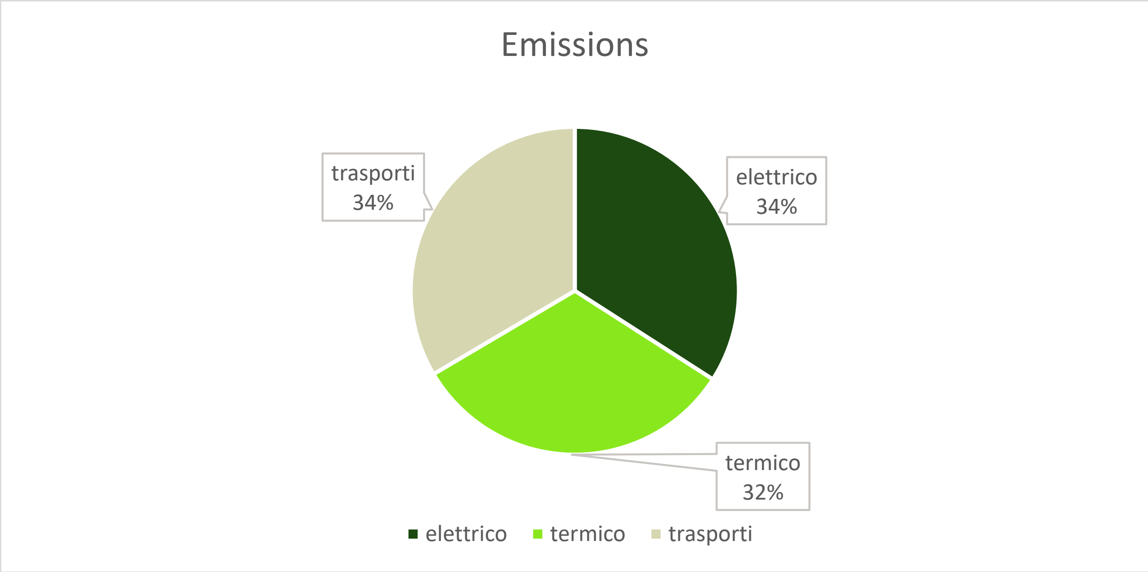
- the transportation sector 34 percent of the total,

- 34% electricity consumption,

- HVAC systems consumption 32%.

Thus, the building sector (residential and nonresidential) absorbs about 70 percent of total land emissions.

Figure 30. Emissions by sector.



6 Analysis of risks and vulnerabilities

6.1 Climate change

Since the early 2000s, several future scenarios have been developed by the IPPC (Intergovernmental Panel on Climate Change, or the UN body that deals with meteorology and climate change) to try to predict the evolution of the phenomenon and the possible effects on planet Earth.

6.1.1 Climate scenarios

The IPCC's reference scenarios are continuously being updated, and as for the scenarios developed since the new millennium, there are those defined in the IPCC's Special Report on Emissions Scenario (SRES) of 2000[1] , and the more recent Representative Concentration Pathways (RCP), also from the IPCC, which are currently in use.
The SRES scenarios were based on four main "development stories" (storylines) and took into account various demographic, social, technological and environmental developments that influence future GHG emissions. The different scenarios based on a "development storyline" constitute a family of scenarios:

- The **A1** family of scenarios describes a future world of very rapid economic growth, a world population peaking at mid-century and then declining, and the rapid introduction of new and more efficient technologies;
- The **A2** family of scenarios describes a very heterogeneous world with continuous population growth. Economic development is essentially regionally oriented, and per capita economic growth and technological change are very fragmented and slower than in the other scenarios;
- Scenario family **B1** describes a converging world with the same change in global population as predicted for scenario A1, but with a rapid change in economic structure toward an information and service economy, with a reduction in material-use intensity and the introduction of efficient and clean resource technologies;
- Scenario family **B2** describes a world where the emphasis is on local solutions for economic, social and environmental sustainability. It is a world in which the global population grows continuously, but at a lower rate than scenario A2, where economic development has intermediate levels and technological changes are less rapid and more diverse than in scenarios B1 and A1.

[1] Intergovernmental Panel Climate Change, 2000. IPCC Special Report Emission Scenarios: summary for policymakers.

As for the most recent Representative Concentration Pathways (RCPs) also from the IPCC, there are 4 of them (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) and they define different developments of greenhouse gas (GHG) emissions and concentration, pollutant emissions and land use and were used in the IPCC's 2014 Fifth Assessment Report (AR5)[2] as the basis for climate forecasts/projections:

- RCP8.5: No action is taken in favor of climate protection. Greenhouse gas emissions are continuously increasing.
- RCP6.0: Mild measures are taken in favor of climate protection, The goal of "+2 °C" compared to the pre-industrial period (1850) is not achieved.
- RCP4.5: The emission of greenhouse gases is curbed, but their concentrations in the atmosphere increase further in the next 50 years. The goal of "+2 °C" relative to the pre-industrial period (1850) cannot be considered safely achieved.
- RCP2.6: Measures are taken in favor of climate protection. The increase of greenhouse gases in the atmosphere is halted within 20 years through the immediate reduction of emissions. In this way, the goals of the 2016 Paris Climate Agreement can be achieved. The increase compared to the pre-industrial period is stated to be between +1.5 and +2.0 °C.

Projections of GHG emissions obtained from climate scenarios can be used as inputs into a variety of analyses, including climate modeling, which also allows us to study future changes in quantitative data such as temperature and precipitation.

In terms of the needs of the present GreenChainSaw4LIFE project, the objective is to analyze the impacts of climate change at the valley (Po Valley) scale in order to propose forest management choices for adaptation and mitigation. Climate models are usually applied at smaller scales than the individual valley, such as regional, national, or continental/global scales. As for the study area, the Piedmont region is likely to be the reference scale.

Detailed studies and reporting regarding climate change issues have already been carried out for the Piedmont region by various groups of experts and scholars. In particular, two studies were considered for modeling future effects on the Po Valley.

ARPA Piemonte is definitely the scientific reference for Piedmont climate issues and is a constant presence in climate reports and studies of interest to the GreenChainSaw4LIFE project.

We relied on two studies, both published by ARPA Piemonte, to quantify impacts at the local level. The first study, entitled "*Climate change, future scenarios,*" is emblematic of the complexity and uncertainty in working with climate models, in this case with a model calibrated to 2100. Only one IPCC scenario, SRES A1B, was chosen to obtain the temperature and precipitation predictions, based on which seven different mathematical climate models were made to calculate, using an approach called Multimodel. In the study, temperature change is reported for both maximum and minimum, making it explicit for the four seasons. The precipitation variation, on the other hand, is the average precipitation, again specified for the four seasons. The elevation variable was taken into account by considering areas with elevation <700 m and mountains with elevation >700 m as plains.

[2] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

An example of the results obtained can be seen in the following images.

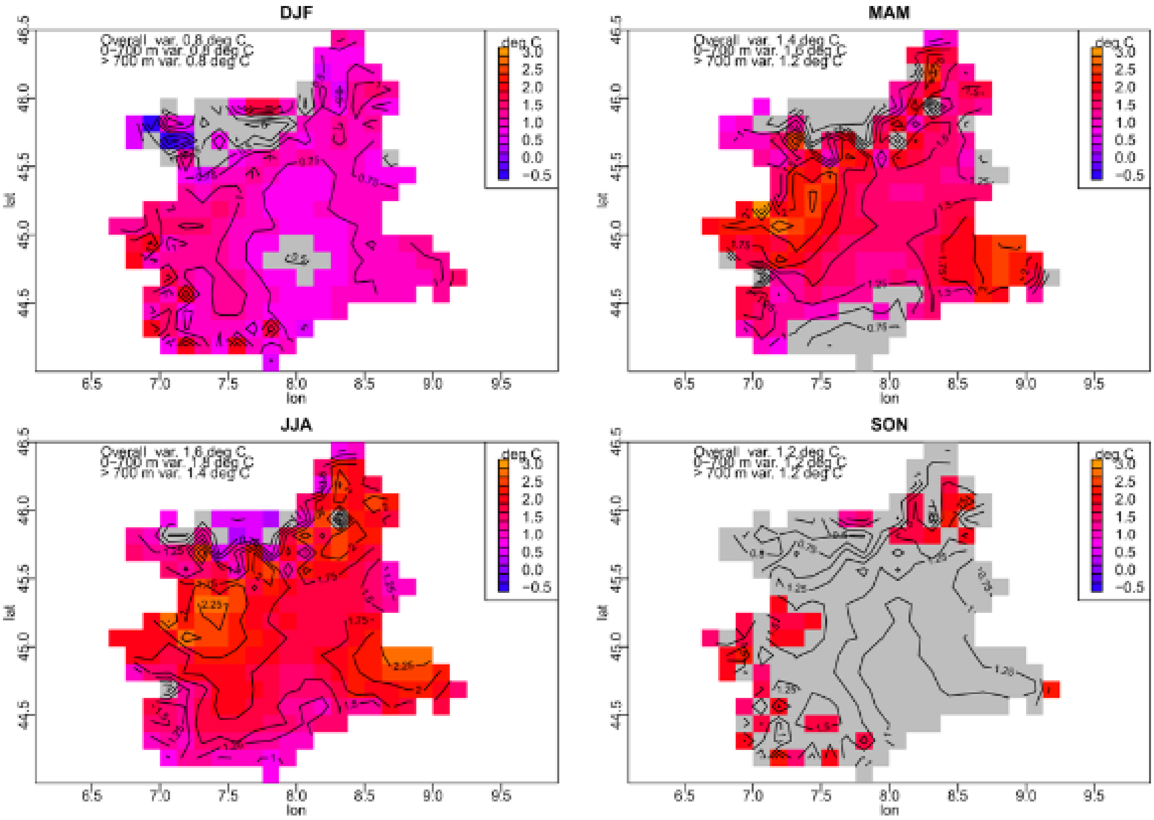


Figure 31: *Difference between maximum temperatures obtained with Multimodel SuperEnsemble on A1B scenario averaged over the period 2031-2050 compared with 1981-2000 as a function of season. Temperature differences that are not significant for a T-Test with a 95% confidence level are shown in gray*

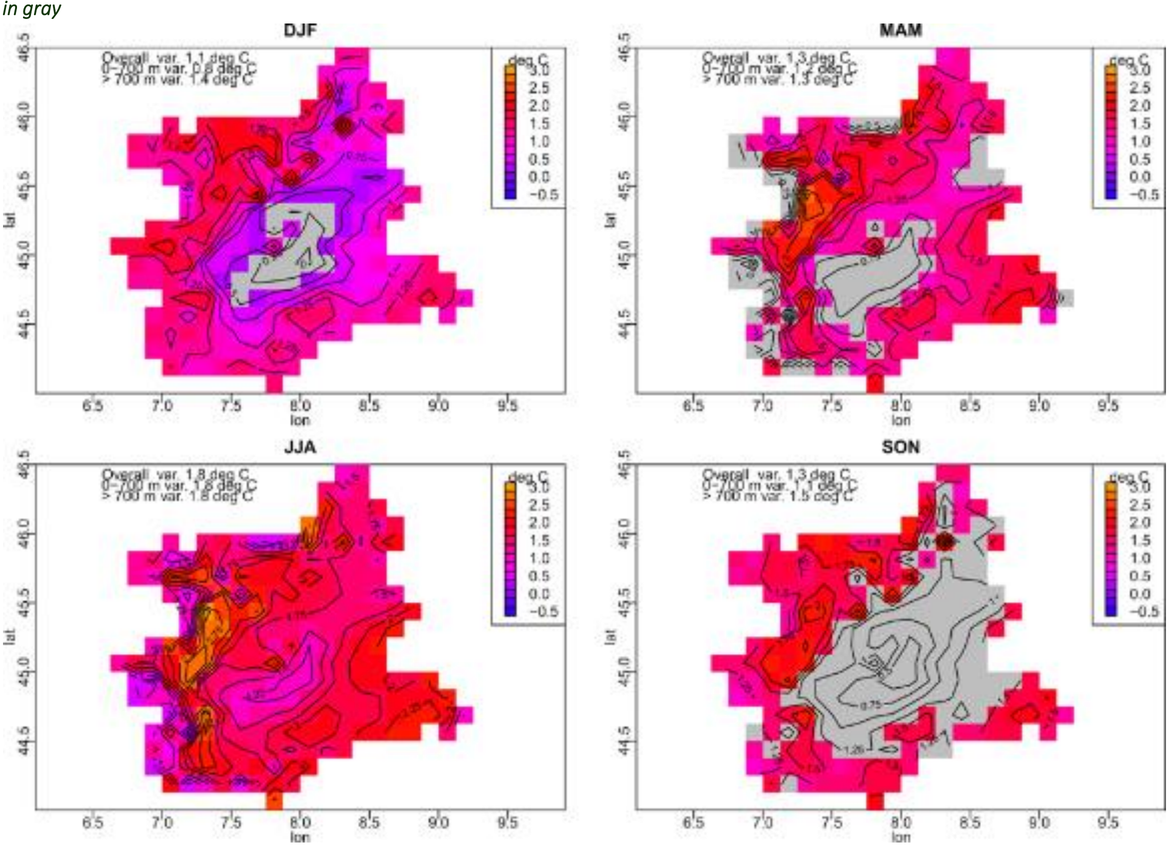


Figure 32: *Difference between minimum temperatures obtained with Multimodel SuperEnsemble on A1B scenario averaged over the period 2031-2050 compared with 1981-2000 as a function of season. Non-significant temperature differences for a T-Test with 95% confidence level are shown in gray.*

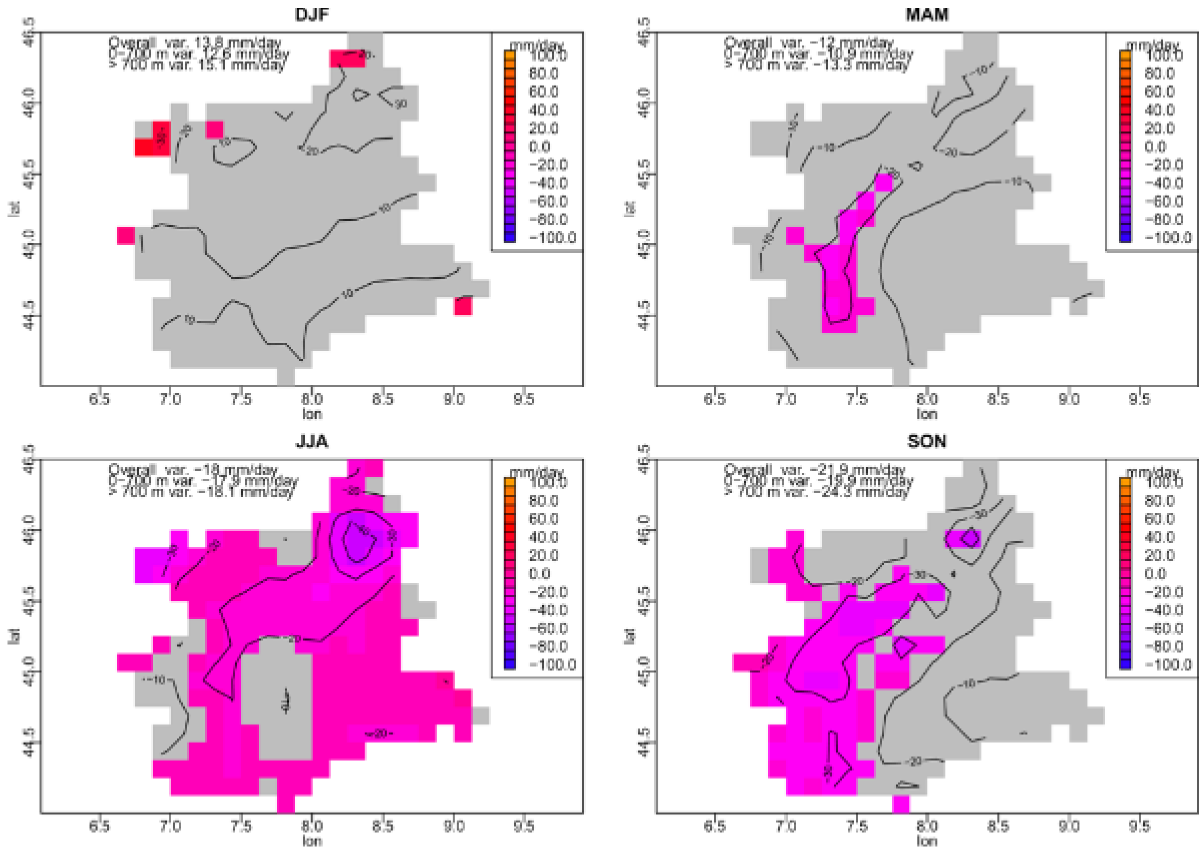


Figure 33: *Difference between precipitation obtained with Multimodel SuperEnsemble Dressing on A1B scenario averaged over the period 2031-2050 compared with 1981-2000 as a function of season. Non-significant temperature differences for a T-Test with 95% confidence level are shown in gray.*

The second study, derived from the recent (2019) "*State of the Environment in Piedmont*" report, includes a section on "*Climate Variations - Future Scenarios.*" Two IPCC Representative Concentration Pathways (RPC) scenarios, RCP 8.5 and RCP 4.5, are considered in the report. Again, multiple climate models on both scenarios were used for calculation, maintaining the distinction between mountains (>700m asl) and plains (<700m asl). For temperature trends, models developed by the EUROCORDEX consortium[3] were used, while for precipitation, the COSMO-CLM model

Specifically, both absolute, maximum and minimum temperature and their variation are studied at a resolution of 11km over the entire territory of the Piedmont region for the 4 seasons, and the two scenarios. As for precipitation, the resolution is 8km. The simulations focus on three forecast ranges: 2011-2040, 2041-2070, and 2071-2100. The average percent change in precipitation and the change in the maximum length of annual dry periods are also estimated.

The main results of our interest are given below:

"As for the **mountain**:

- **maximum temperature** trends over the entire period 2006-2100 are **+ 0.22°C/10y** according to the **RCP4.5** scenario, with an increase of about **+2.1°C to 2100**, and **+ 0.55°C/10y** over the period 2006-2100 in **RCP8.5** with an increase of about +5.**2°C to 2100**;

3 https://www.hzg.de/ms/remo-rcm/074090/index.php.en

- The **minimum temperature** trends over the entire 2006-2100 period are **+0.23°C/10y** in **RCP4.5** leading to an increase of about **+ 2.2°C to 2100** and **0.54°C/10y** 2006-2100 in **RCP8.5** leading to an increase of about **+5.1°C to 2100**.

As for the **plains and foothill areas,** the trends are the same or slightly lower:

- those of the **maximum temperature** over the entire period 2006-2100 are about **+ 0.2°C/10y** in **RCP4.5** with an increase of about +2°C to 2100 and + **0.5°C/10y** 2006-2100 in **RCP8.5** with an increase of about **4.8°C to 2100**;
- **minimum temperature** trends over the entire period 2006-2100 are **+0.19°C/10y** in **RCP4.5** with an increase of about **1.8°C to 2100** and **0.47°C/10y** 2006-2100 in **RCP8.5** with an increase of about **+4.5 C to 2100.**"

Thus, both studies show that climate change is having the greatest impact on mountain environments from the perspective of increasing temperatures

On the other hand, with regard to precipitation, ARPA PIEMONTE's work of 2020[4] was consulted, which analyzes the climatic trends of the past 60 years.

Considering mainly precipitation, some data are summarized below:

- The biggest differences are found when analyzing seasonal rainfall trends over the past 30 years with an increase in autumn rainfall and a decrease in spring rainfall while, considering the entire time series available since 1958, there is a decrease in winter rainfall (around 13-14%) and a slight increase in spring rainfall in the mountains. In the latest period, the wettest season tends to be spring as opposed to autumn, unlike in the entire time series.
- Daily cumulative rainfall maxima tend to increase over the years with a trend of about 1.28 mm/year for the plains and 1.38 mm/year for the mountains.
- A change in the rainfall pattern is observed in the period 1981-2018, with an increase in spring precipitation at the expense of autumn precipitation. The wettest month of the year from October in 1958-1980 becomes May in 1981-2018. The month with the lowest rainfall is July for the entire historical series
- The season where the decrease is greatest is summer. This decrease during summer is related to the increase in intense phenomena. Qualitatively, there is a decrease in the number of rainy days with precipitation up to 10 mm and an increase in days with precipitation above 50 mm.
- There is evidence of an increasing trend in the length of dry periods (maximum number of consecutive days without rain) over the years, particularly for lower elevations, with great inter-annual variability (very wet years in a drier climate or where precipitation is more concentrated). The driest years in the new millennium also involve mountainous areas, whereas in the last century drought was particularly evident in the lowlands.

---

[4] ARPA PIEDMONT (June 2020) - Analysis of regional climate from 1981-2010 and trends over the past 60 years

Forecasts for the future to 2100, extracted from a sister paper by ARPA PIEMONTE in 2020[5] report that:

- The month of July, results in the second driest month after the winter minimum in December. January, and February in the RCP4.5 scenario alone, are the months in which there is a slight increase in precipitation. In the RCP8.5 scenario, the decrease in spring precipitation is more gradual than in the RCP4.5 scenario.
- In the RCP4.5 scenario, the percentage change in seasonal cumulative precipitation over the 30-year periods 2011-2040, 2041-2070, and 2071-2100 shows an increase in the winter period, between 10 and 15 percent, which in the intermediate period reaches up to 20 percent over the mountainous areas In the RCP8.5 scenario, an increase in winter precipitation, also substantial, is observed only in the last 30-year period. Summer sees a gradual decrease, already at the beginning over the Cuneo area and then over the whole region, with a deficit reaching up to 30% at the end of the century. Spring also sees a decrease in precipitation starting around mid-century.
- In future scenarios, the number of rainy days tends to decrease by 5-8 days uniformly in the scenario with mitigation and more importantly at the end of the century in the trend scenario, where it reaches up to 15 days over most of the region. On the other hand, if we consider a higher daily rainfall amount (e.g., 30 mm), an increase in the number of rainy days is evident, around 10-20% in the RCP4.5 scenario and 10-15% in the RCP8.5 scenario. This provides an indication of an increase in the heaviest rainfall.
- As for the RCP4.5 scenario, there is a general upward trend in the duration of dry periods (maximum number of consecutive days with no precipitation), although a fair amount of variability remains until the end of the century, alternating between wetter periods and multi-year dry periods. The increase occurs mainly after mid-century, where it also affects the higher elevations, which seem to suffer from a more pronounced decrease in rainy periods. As for the RCP8.5 scenario this trend is even more evident from the second half of the century with values that, from 2070 onwards become more important, as does the frequency of drought years and the involvement of higher elevations. From the 2080s the possibility of average wetter years will tend to decrease significantly.
- The percentage of the land area experiencing extreme drought is seen to increase sharply over the past three decades. Extreme drought values, however, are found as early as mid-century, when alternating dry and wet periods still prevail. Severe drought conditions will be recurrent over the southern sector and the western prealpine zone.

6.2 Fires

[5] ARPA PIEDMONT (June 2020) - Analysis of regional climate scenarios for the period 2011- 2100

Fire passage has always characterized the valleys under study, as also reported by the PFT[6] . In particular, the Po Valley has characteristics that make it peculiarly susceptible in the lower and middle valley municipalities to fire ignition and spread events. As can be easily seen from the map of the fire cadastre of the Piedmont Region (Fig. 34 showing ignition events and areas covered from 2002 to 2016), climatic characteristics lead the southern slope to be more prone to such phenomena.
From the PFT analysis, the total area covered by fire over the period 1980-1998 appears to be highly variable with very high peaks (6556 ha in 1990) alternating with most years averaging low (4-7 ha). The fire cadastre of the Piedmont region, for the period 2002 - 2020 in the study area considered here, reports a total of 175.22 ha, or an average of about 9 ha covered by fire per year.
The surveys carried out during WPC.2 also showed that in about 13 % of the areas visited, signs of fire passage are detectable; to these it is necessary to add the areas with vegetation whose most probable origin is from a past fire event (areas with strong bracken, shrubs and pioneer thickets), which, however, cannot be counted given the uncertainty of the data.
More than 95 percent of the occurrences are in abandoned chestnut coppices, and of these about 90 percent are abandoned or unmanaged stands, in which large accumulations of dry biomass on the ground (coarse woody debris) and in standing (snag) are reported. This accumulation results in:

- an increase in the thickness of litter that was traditionally burned in small quantities or used as a substrate for housing domestic animals, and a slowing of decomposition;
- a failure to remove suckers that dry up due to competition and crash following adverse weather events;
- A generalized aging of the stand resulting in loss of viability of stumps and increased mortality in suckers.

Fire-affected stands, if not promptly reclaimed, cause easy stump mortality and risk compromising the tree cover of such areas. In addition, the increasing abandonment of the land causes the loss of the so-called buffer strips that allowed for the protection of the townships from forest fires; with the shrub and tree encroachment of the townships, an eventual fire can reach the townships with greater ease with all the risks that such an event may entail.

[6] Paolo Maria Terzuolo et al. (1991); Forest area: valley Po, Bronda and Infernotto: Territorial Forest Plan; Piedmont Region, pp. 306

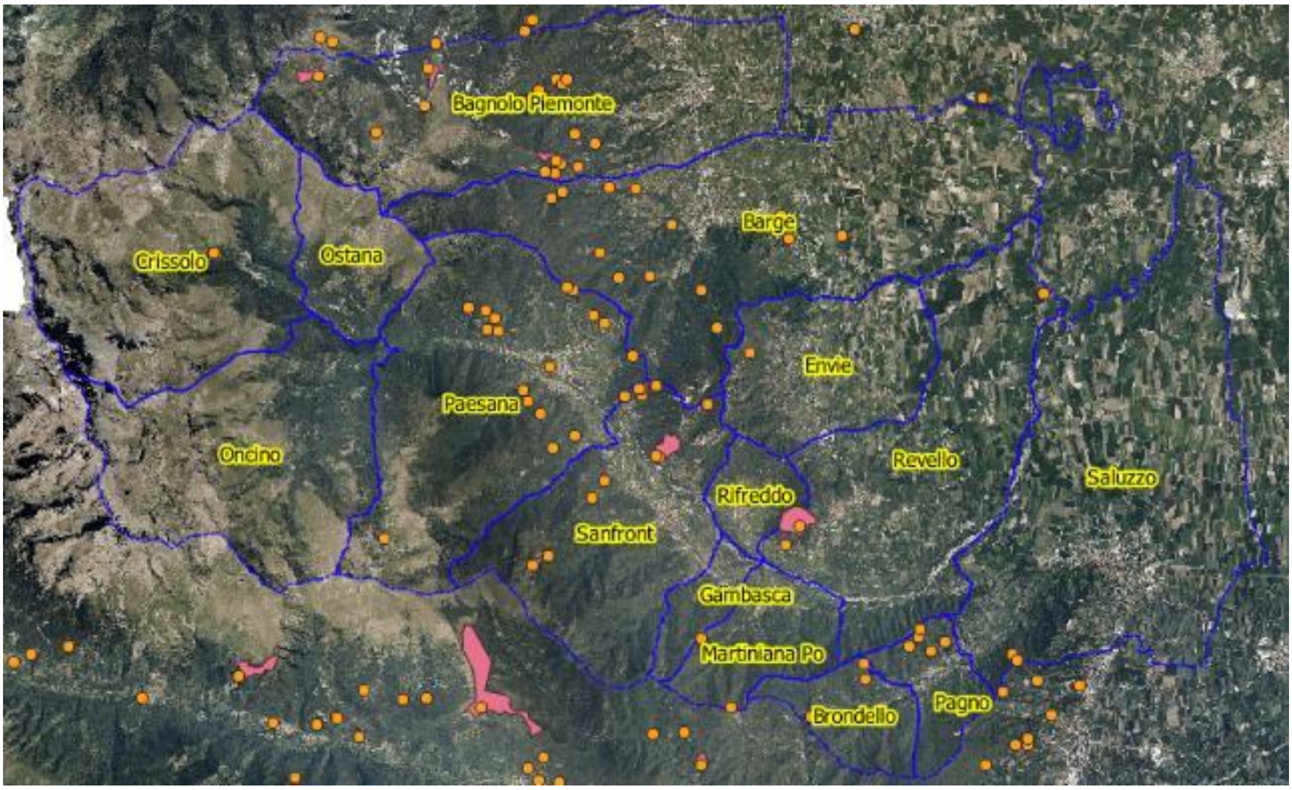


Figure 34: Satellite view (AGEA 2018 Orthophoto) showing location of major fire ignition points (orange dots) and fire-prone areas (pink polygons) during 2002 - 2016.

As an example, the various silvicultural parameters for standing necromass only are shown. The data were compiled from the surveys conducted during the 2021 season. The parameters of volume per hectare and plants per hectare were also compared with the same parameters referring to total standing mass (biomass and necromass). This comparison shows that, particularly in chestnut and oak groves (the data on oak groves should be considered not totally reliable since they are derived from a small number of test plots), necromass accounts for about 5 percent of the total volume and 17 percent and 32 percent of the plants per hectare, respectively. Data for all forest categories surveyed are provided below.

Forestry Category	V/Ha (m3)	% V.Tot/ha	No.plants/ha	% No. Plants/ha
Maple-Lime-Frassineti	7,38	1,80%	126	8,11%
Invasion thickets	1,36	0,88%	48	2,98%
Chestnut groves	23,20	5,45%	478	16,98%
Beech forests	5,11	1,10%	95	6,99%
Larch and cembran groves	12,35	2,86%	65	7,66%
Querco-Carpineti	1,73	0,46%	16	2,78%
Oak Oaks	9,42	4,55%	322	31,88%
Reforestation	9,17	1,50%	74	7,29%
Robinieti	1,31	0,97%	64	6,56%

Table 13: main parameters referred to standing necromass and incidence rates on total mass (biomass and necromass)

6.3 Forest and pasture management

Forest and pastoral management in the study area is highly fragmented and has little impact on land maintenance. These types of areas, in fact, are directly affected by the effect of depopulation of the

mountain territory that has occurred over the past century. With regard to pastures, management abandonment results in a rapid advancement of pioneer forest formations at the expense of areas historically conducted as mowed grassland and pasture; in particular, in the upland plain where forest colonization is most effective, the dynamics of forest advancement is particularly evident.
Forests undergo the same abandonment, which, however, manifests itself in a different way, namely with a generalized accumulation of biomass (and necromass) in standing and on the ground. The lack of anthropogenic intervention does not regulate the processes of inter- and intraspecific competition among individuals that undergo strong selection: there is therefore a large amount of dead standing individuals (or suckers in the case of frequent coppice governments) that over time tend to crash and accumulate on the ground. This phenomenon, in addition to having an impact, as seen above, on increased fire risk, also has negative effects on soil protection and the viability of the stand itself. In the first case, in fact, necromass often goes to create dams along The surface water flow channels and in the case of overturned stumps, to form trigger points for erosive processes.
In the second scenario, on the other hand, especially in coppices, lack of intervention causes stand aging and loss of vigor.
How the abandonment of management also involves instabilities can be seen from viewing the PAI map: major instabilities (especially focusing on areal instabilities) are concentrated in the middle and upper valley areas and especially in the most difficult to access areas. During field surveys, a direct correlation between areas without management and areas of instability was observed. Proper management of vegetation resources makes it possible to regulate surface stormwater runoff, reduce rainfall-related erosion, and support slopes with greater slope and criticality. In addition, the overturning of stumps or the crashing of one or more individuals can generate trigger points for channeled erosion processes. Forest management can thus be a method of preserving the functionality of infrastructure such as roads and bridges and a means of protecting villages, hamlets and mountain pastures.

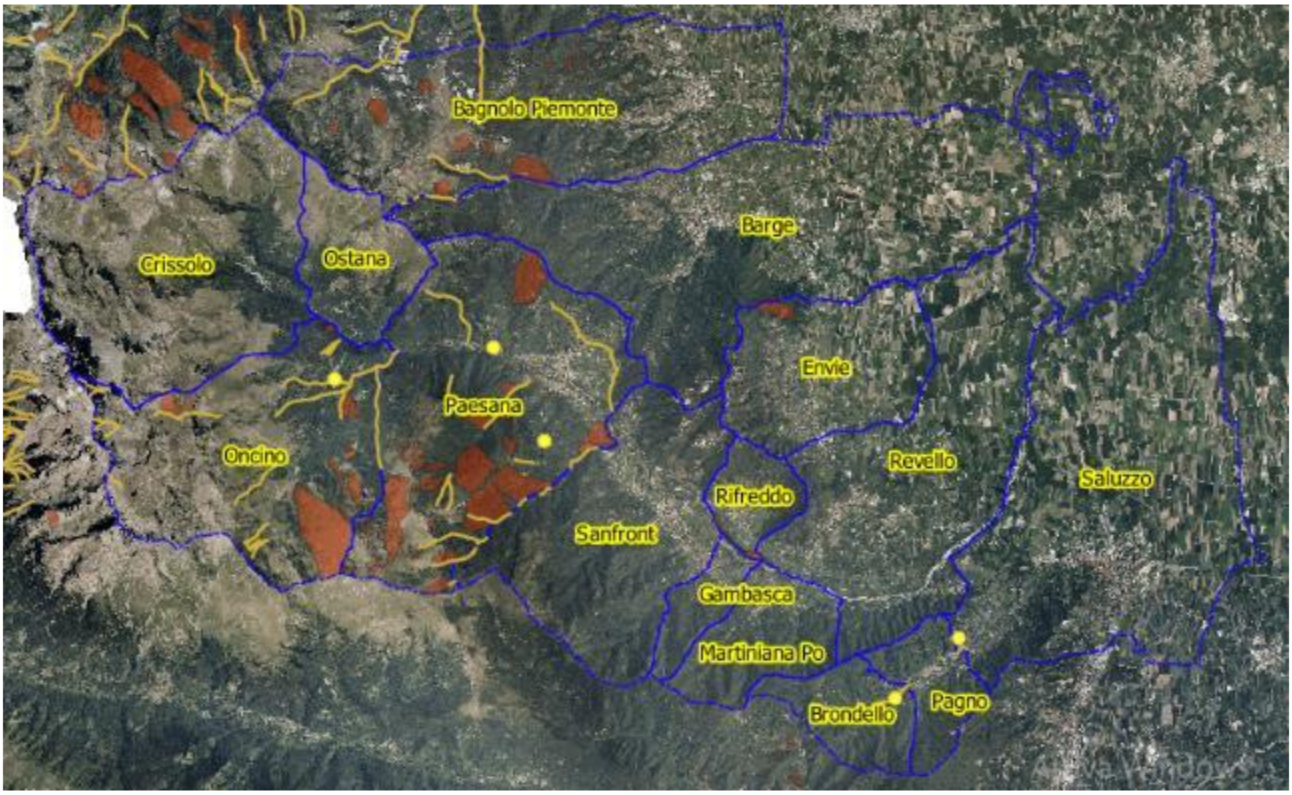


Figure 35: satellite view (AGEA 2018 Orthophoto) showing location of major disruptions reported by the current PAI. Linear instabilities can be distinguished in yellow ochre, point instabilities in yellow, and areal instabilities in brownish.

A multifunctional approach to managing these areas leads not only to increased productivity and value over time, but also generates many possible secondary interests that are not always easy to quantify economically.

As an example, the figure of forest areas falling within 100 m of forest roads and tracks currently present in the area was obtained. From these areas, the possible volume present was estimated by means of the per-hectare values obtained from the surveys carried out in WPC.2. Considering a utilization rate of 70% (in the 30% are considered the processing losses and the average quantities to be released in the forest according to the Reg. For. of the Piedmont Region) and by discarding the valuable assortments (or in any case not aimed at energy production), it is possible to estimate the quantities of wood for energy use easily accessible in the valleys under study.

CATEGORY	AREA (ha)	Average V/ha (m3)	AS-SORTMENT. FOR ENERGY PRODUCTION %	VOLUME AT SOIL (m3)	AVAILABLE VOLUME (m3)
Maple-tree-grassland	1.565,99	403,30	98%	631.570,06	433.257,06
Pioneer and invasion thickets	661,87	154,12	100%	102.009,01	71.406,30
Chestnut groves	4.415,13	402,95	98%	1.779.094,11	1.220.458,56
Beech forests	574,16	459,49	99%	263.820,34	182.827,49
Larch and cembran groves	145,14	425,31	29%	61.728,96	12.530,98
Oak forests	13,04	197,55	75%	2.575,30	1.352,03
Reforestation	196,31	604,78	37%	118.725,18	30.749,82
Robinieti	84,41	133,80	100%	11.294,30	7.906,01
Willow and poplar groves riparian	42,85	146,00	100%	6.255,91	4.379,14
TOT	7.747,23				1.964.867,40

Table 14: Estimated volume available for energy-type assortments in the study area.

6.3.1 ADHERENCE TO GPP (GREEN PUBLIC PROCUREMENT)

Forest area management is currently regulated at the regional level by the Reg. For. of the Piedmont Region, while the use of the resulting biomass is regulated by a set of internationally recognized UNI EN ISO standards. The product derived from biomass turns out to be highly standardized, poorly characterized and, certainly, difficult to track.

GPP (Green Public Procurement) is an environmental policy tool that aims to foster the development of a market for products and services with a reduced environmental impact through the leverage of public demand, contributing, in a decisive way, to the achievement of the objectives of major European strategies such as the Resource Efficiency or Circular Economy strategies.

Public authorities that undertake GPP actions are committed to both rationalizing purchasing and consumption and increasing the environmental quality of their supplies and procurements.

GPP has as among other objectives:

- The reduction of environmental impacts;
- The protection and improvement of enterprise competitiveness;
- The stimulus to innovation;
- The rationalization of public spending;
- The spread of sustainable consumption and purchasing patterns;
- The efficiency and saving of natural resources, especially energy;
- The reduction of waste produced;
- The reduction use of hazardous substances;
- The integration of environmental considerations into other policies of the institution;
- Skill enhancement of public buyers.

Forest certification standards can be divided into three different categories: forest management standards, supply chain certification standards and ecosystem service certification standards.

The first is aimed at those involved in forest management (whether companies, consortia or public agencies) and is designed to ensure that forests are managed in accordance with strict environmental social and economic standards.

The second aims at the traceability of materials from certified forests and is aimed at companies that process wood-derived products throughout the production chain. It therefore interests from the forestry company that performs the utilization up to the second-processing companies of any type (sawmills, furniture factories, producers of biomass, packaging, wood for construction, furniture, paper mills,etc.)

Finally, the third is related to multi-functional forest management, that is, it is not only focused on wood production but considers the positive externalities that forest management produces and is based on the principles of Minimum Environmental Impact, Maximum Permanence, and Transparency.

Figure 36: logos of some of the forest certification protocols.

The two bodies offering these three certifications are PEFC and FSC. The differences between the two bodies are mainly related to the mode of certification. FSC (Forest Stewardship Council) is based on a performance standard that identifies the levels that must be achieved to achieve certification and is internationally applicable and applies in all states where companies or entities decide to adopt the scheme themselves. PEFC (Programme for Endorsement of Forest Certification), on the other hand, is based on system standards, in which no minimum level of achievement is defined but targets and how to achieve them, and is based on national schemes.

In this regard, a PEFC certification group is currently being formed in the territory of the Monviso valleys for all three categories defined above, under the label of Wood of Monviso. This reactivation program of the Wood of Monviso Cluster, in which all possible stakeholders of the local wood supply chain are represented, is included in this project in WPC.1, to which we refer for more details.

Then there are other protocols for certifying the sustainability of wood productions; here we report the Low Carbon Timber (LCT), which originates from the Interreg Alpine Space 2014/2020 CaSCo (Carbon Smart Communities) project and aims to certify the distance traveled by a wood assortment in its production cycle, from harvest to final destination. In this case, easily understandable information is provided to the end consumer, namely the kilometers traveled, which is correlated with the carbon footprint of the product itself.

6.4 Public green management

The study area includes a high number of population centers that have a good area of public land managed as green space. The management of urban public green space, although of secondary importance compared to that of the vast natural areas surrounding the towns, requires certain shrewdness in order to improve and maximize the benefits it brings: in emission control, soil protection, and improvement of air quality, microclimate and livability of the cities.

- In the management of street trees, avoid topping individuals and use more "natural" pruning that does not create stress to the plants themselves and lead them to decay.
- Use pruning residues duly chipped in feeding biomass power plants.
- When planting new areas, use species that are endemic and suitable for the planting elevation.

- Census of greenery for scheduling of green maintenance service, proper planning of new areas, design of upgrading of existing assets, as well as estimation of economic investments needed to maintain and enhance the functionality of the assets themselves.
- Drafting of a municipal green plan for startegic planning of maintenance, replacements with the establishment of best practices for sustainable management of areas and tree stands.

7 EMISSION CONTAINMENT TARGET TO 2050

The 2050 emissions containment goal calls for an 80% decrease in CO_2 emissions by 2050.
The commitment pact to be signed by each municipality includes the following commitments and actions:
"We, Mayors from across Europe, to this end, intensify our climate ambitions and pledge to act at the pace that science dictates, in a common effort to contain climate warming to below 1.5°C-the major ambition of the Paris Agreement.
For years now, cities have been able to turn climate and environmental challenges into opportunities. The time has come to make them the top priority.
As signatories to the Covenant of Mayors-Europe, we are committed to involving everyone in this journey. We will ensure that our policies and programs exclude no person and no place.
The transition to a climate-neutral Europe will impact all sectors of our societies. As local leaders, we must monitor these impacts to ensure equity and inclusion. We can only envision a transition that is equitable, inclusive, and respectful of us, the world's citizens, and our planet's resources.
Our vision is that, by 2050, we will all live in decarbonized and resilient cities with access to affordable, secure and sustainable energy. As part of the Covenant of Mayors-Europe initiative, we will continue to (1) reduce greenhouse gas emissions on our territory, (2) increase resilience and prepare for the negative impacts of climate change, and (3) address energy poverty as one of the key actions to ensure an equitable transition. develop a local climate pact with all stakeholders that will help us achieve our goals.
We are fully aware that all EU member states, regions and cities are at different stages of their own transition, and that they have their own resources to achieve the goals set out in the Paris Agreement. We recognize, once again, our collective responsibility in addressing the climate crisis. The many challenges require a strong policy response at all levels of governance. The Covenant of Mayors-Europe is, first and foremost, a movement of committed Mayors sharing local solutions and inspiring each other with a view to realizing this vision.
We pledge to do our part by taking the following actions:

1. COMMITMENT to setting medium- and long-term goals that are consistent with EU targets and at least as ambitious as our national targets. Our goal is to achieve climate neutrality by 2050. Considering the current climate emergency, we will prioritize climate action and communicate this to our citizens.

2. INVOLVE citizens, businesses, and government at all levels to implement this vision and transform our social and economic systems. We want to develop a local climate pact with all actors who will help us achieve our goals.

3. ACTION, now and together, to get on track and accelerate the necessary transition. We want to develop and implement an action plan to achieve our goals and report on it, by the established deadlines. Our plans will include provisions on climate mitigation and adaptation

4. MAKE NETWORK with fellow mayors and local leaders, in Europe and beyond, to draw inspiration from each other. We will encourage them to join us in the Global Covenant of Mayors movement, wherever they are in the world, if they wish to adhere to the goals and vision described in this document.
We, the signatories of the Covenant of Mayors-Europe, affirm that we can act today (Commitment, Involvement, Action, Networking) to ensure the well-being of future and current generations. We will work together to turn our vision into reality.

We count on the support of our national governments and European institutions in obtaining financial and technical resources, and policies appropriate to the level of our ambitions."

8 MITIGATION ACTIONS

8.1 ACTION SHEETS

The action sheets encapsulate the energy efficiency actions that must necessarily be implemented in order to reduce CO_2 emissions to the environment by 80 percent by 2050.
The cards were organized as follows:

- For the "public, tertiary and residential" sector, 4 different action sheets have been established respectively for
    1. Energy upgrading of buildings
    2. Thermal plant efficiency
    3. Installation of BACS systems
    4. Installation of photovoltaic systems
- For the "public lighting" sector, 1 intervention sheet was established for
    1. Street lighting efficiency
- For the "transportation" sector, 1 intervention sheet was established for.
    1. Transportation sector efficiency

Within each action sheet, the possible actions are specified and the information needed to quantify the output of the intervention at the level of estimated costs for the intervention, primary energy savings (electric or thermal) in MWh/year, and CO_2 reduction in tCO_2/year are made explicit.
In particular, in each sheet, the percentage of primary energy savings (electrical MWh or thermal MWh) is made explicit for each intervention, the cost of the intervention per unit (per kW, CAD, etc...)

depending on the measure considered. The calculation for CO_2 emissions, on the other hand, is given in the following intervention paragraphs since it is a direct consequence of the decrease in primary energy required and, therefore, depends on the extent of the intervention.
In addition, there is a brief description for each tab for each intervention and the monitoring indicators for those specific interventions are specified.

8.1.1 SHEETS FOR THE PUBLIC SECTOR

PUBLIC SECTOR	CARD NO. P1
ENERGY UPGRADING OF BUILDINGS	
Action structure	

DESCRIPTION

The action aims to encourage and incentivize the energy upgrading of the existing residential building stock. For this reason, the public entity intends to become an active player in the process, through the sending of information material to citizens, through the creation of green energy purchasing groups and through the identification of a consortium of operators in the sector capable of providing a turnkey service at advantageous prices. The public body is also keen to encourage the entry of ESCOs to carry out this action, acting as an intermediary between supply and demand.

The interventions are:

- Wall and envelope insulation (insufflation or insulation)
- Replacement of windows and doors
- High-efficiency lighting systems

MONITORING METHOD

The main monitoring method will be pre- and post-intervention energy consumption verification. The systems will be equipped with specific meters: heat meters will have to be installed in the thermal power plants prior to the intervention; for electricity consumption, the meters currently present will be uniti lized until the installation of the quartary open meters.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Insufflation walls	20%	70	€/m2
Insulation walls or attic	25%	100	€/m2
Replacement of windows and doors	13%	700	€/m2
Construction of thermal coat	25%	70	€/m2
High-efficiency lighting systems	50%	53	€/CAD

PUBLIC SECTOR	CARD NO. P2

THERMAL SYSTEM EFFICIENCY

Action structure

DESCRIPTION

The European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role to be played by the public sector with regard to improving energy efficiency. An effective program of rationalization of consumption and energy upgrading of the public building stock must necessarily include the identification and development of integrated solutions to meet energy demand with the lowest consumption of fossil fuels and in the most cost-effective manner. On the basis of the previous Directive, the municipal administration, consistent with the program of maintenance activities, should put in the program of energy upgrading activities by intervening on the thermal power plants of its buildings.

The interventions are:

- Replacement of old boilers in buildings with new boilers, heat pumps, etc.
- Installation of local biomass cogeneration systems
- Installation of geothermal systems on municipal buildings
- Solar thermal for DHW

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;
- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)

Intervention	Saving	Cost	Unit
Boiler replacement with new condensing boiler	5%	80	€/kW
Boiler replacement with heat pump	25%	1600	€/kW
Cogeneration plant	32%	1600	€/kW
Geothermal plant	25%	1000	€/kW
Solar thermal for DHW	5%	5000	€/CAD

PUBLIC SECTOR	CARD NO. P3

BACS SYSTEMS INSTALLATION

Action structure

DESCRIPTION

The action aims to encourage the spread of systems that eliminate thermal waste generated by outdated heating bodies and distribution systems through the installation of thermostatic valves, timers, and weather controllers. The public body plans to become an active player in the change process.

The interventions are:

- Installation of thermostatic valves
- Weather station installation
- BACS systems installation

MONITORING METHOD

he main monitoring method will be energy consumption verification. In addition, other methods of monitoring the action have been identified:

- Direct continuous monitoring of public agency consumption
- Creation of a computerized system where all data concerning the facilities can be brought together.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
BACS systems installation - electricity	15%	25	€/sqm
BACS systems installation - heat	39%	25	€/sqm

PUBLIC SECTOR	CARD NO. P4
INSTALLATION OF PHOTOVOLTAIC SYSTEMS	
Action structure	

DESCRIPTION

The aforementioned European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role that the public sector must play in energy efficiency improvement. All the more so are public buildings that house energy-consuming technological facilities. With regard to the use of renewable energy sources, it is appropriate that the installation on public buildings should prioritize exemplarity in terms of both plant producibility and architectural integration. The Municipal Administration should take steps to ensure that other public stakeholders also include the installation of photovoltaic systems in their programs.

The interventions are:

- Installation of photovoltaic systems

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;

- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Installation of photovoltaic systems	10%	1250	€/kW

8.1.2 BOARDS FOR THE TERTIARY SECTOR

TERTIARY SECTOR	CARD NO. T1

ENERGY UPGRADING OF BUILDINGS
Action structure

DESCRIPTION

The action aims to encourage and incentivize the energy upgrading of the existing residential building stock. For this reason, the public entity intends to become an active player in the process, through the sending of information material to citizens, through the creation of green energy purchasing groups and through the identification of a consortium of operators in the sector capable of providing a turnkey service at advantageous prices. The public body is also keen to encourage the entry of ESCOs to carry out this action, acting as an intermediary between supply and demand.

The interventions are:

- Wall and envelope insulation (insufflation or insulation)
- Replacement of windows and doors
- High-efficiency lighting systems

MONITORING METHOD

The main monitoring method will be pre- and post-intervention energy consumption verification. The systems will not be equipped with specific meters.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Insufflation walls	20%	75	€/m2
Wall insulation	25%	70	€/m2
Replacement of windows and doors	13%	700	€/m2
Construction of thermal coat	25%	100	€/m2
High-efficiency lighting systems	50%	53	€/CAD

TERTIARY SECTOR	CARD NO. T2
THERMAL SYSTEM EFFICIENCY	
Action structure	

DESCRIPTION

The European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role to be played by the public sector with regard to improving energy efficiency. An effective program of rationalization of consumption and energy upgrading of the public building stock must necessarily include the identification and development of integrated solutions to meet energy demand with the lowest consumption of fossil fuels and in the most cost-effective manner. On the basis of the previous Directive, the municipal administration, consistent with the program of maintenance activities, should put in the program of energy upgrading activities by intervening on the thermal power plants of its buildings.

The interventions are:

- Replacement of old boilers in buildings with new boilers, heat pumps, etc.
- Installation of local biomass cogeneration systems
- Installation of geothermal systems on municipal buildings

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;

- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Boiler replacement with heat pump	25%	1600	€/kW
Cogeneration plant	32%	2000	€/kW
Geothermal plant	25%	1000	€/kW

TERTIARY SECTOR	CARD NO. T3

BACS SYSTEMS INSTALLATION

Action structure

DESCRIPTION

The action aims to encourage the spread of systems that eliminate thermal waste generated by outdated heating bodies and distribution systems through the installation of thermostatic valves, timers, and weather controllers. The public body plans to become an active player in the change process.

The interventions are:

- Installation of thermostatic valves
- Weather station installation
- BACS systems installation

MONITORING METHOD

he main monitoring method will be energy consumption verification. In addition, other methods of monitoring the action have been identified:

- Direct continuous monitoring of public agency consumption
- Creation of a computerized system where all data concerning the facilities can be brought together.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
BACS systems installation - electricity	15%	25	€/sqm
BACS systems installation - heat	39%	25	€/sqm

TERTIARY SECTOR	CARD NO. T4
INSTALLATION OF PHOTOVOLTAIC SYSTEMS	
Action structure	

DESCRIPTION

The aforementioned European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role that the public sector must play in energy efficiency improvement. All the more so are public buildings that house energy-consuming technological facilities. With regard to the use of renewable energy sources, it is appropriate that the installation on public buildings should prioritize exemplarity in terms of both plant producibility and architectural integration. The Municipal Administration should take steps to ensure that other public stakeholders also include the installation of photovoltaic systems in their programs.

The interventions are:

- Installation of photovoltaic systems

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;
- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Installation of photovoltaic systems	10%	1250	€/kW

8.1.3 BOARDS FOR THE RESIDENTIAL SECTOR

RESIDENTIAL SECTOR	CARD NO. R1
ENERGY UPGRADING OF BUILDINGS	
Action structure	

DESCRIPTION

The action aims to encourage and incentivize the energy upgrading of the existing residential building stock. For this reason, the public entity intends to become an active player in the process, through the sending of information material to citizens, through the creation of green energy purchasing groups and through the identification of a consortium of operators in the sector capable of providing a turnkey service at advantageous prices. The public body is also keen to encourage the entry of ESCOs to carry out this action, acting as an intermediary between supply and demand.
The interventions are:

- Wall and envelope insulation (insufflation or insulation)
- Replacement of windows and doors
- High-efficiency lighting systems

MONITORING METHOD

The main monitoring method will be pre- and post-intervention energy consumption verification. The systems will not be equipped with specific meters.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Insufflation walls	20%	75	€/m2
Wall insulation	25%	70	€/m2
Replacement of windows and doors	13%	700	€/m2
Construction of thermal coat	25%	100	€/m2
High-efficiency lighting systems	50%	53	€/CAD

RESIDENTIAL SECTOR	CARD NO. R2
THERMAL SYSTEM EFFICIENCY	
Action structure	

DESCRIPTION

The European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role to be played by the public sector with regard to improving energy efficiency. An effective program of rationalization of consumption and energy upgrading of the public building stock must necessarily include the identification and development of integrated solutions to meet energy demand with the lowest consumption of fossil fuels and in the most cost-effective manner. On the basis of the previous Directive, the municipal administration, consistent with the program of maintenance activities, will have to put into the program the activity of energy upgrading by intervening on the thermal power plants of its buildings. The interventions are:

- Replacement of old boilers in buildings with new boilers, heat pumps, etc.
- Installation of local biomass cogeneration systems
- Installation of geothermal systems on municipal buildings

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;

- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Boiler replacement with heat pump	25%	1600	€/kW
Cogeneration plant	32%	2000	€/kW
Geothermal plant	25%	1000	€/kW

RESIDENTIAL SECTOR	CARD NO. R3
BACS SYSTEMS INSTALLATION	
Action structure	

DESCRIPTION

The term BACS, an acronym for Building & Automation Control System, is intended to refer to the set of intelligent automation and control tools that make it possible to "control" and automate certain operations within a building, while enabling a reduction in overall energy consumption.

BACS actively act on energy demand because they adapt the regulation of technological systems according to external climatic conditions, with the aim of optimizing energy consumption without forgetting the comfort of those who actually live or work in the building. The EPBD 2010/31/EU directive aims to encourage the use of BACS control and automation systems.

- Installation of thermostatic valves
- Weather station installation
- BACS systems installation

MONITORING METHOD

he main monitoring method will be energy consumption verification. In addition, other methods of monitoring the action have been identified:

- Direct continuous monitoring of public agency consumption
- Creation of a computerized system where all data concerning the facilities can be brought together.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
BACS systems installation - electricity	39%	25	€/sqm
BACS systems installation - heat	15%	25	€/sqm

RESIDENTIAL SECTOR	CARD NO. R4
INSTALLATION OF PHOTOVOLTAIC SYSTEMS	
Action structure	

DESCRIPTION

The aforementioned European Directive 2006/32/EC on energy end-use efficiency and energy services, in Article 5 called "Energy end-use efficiency in the public sector," makes explicit the exemplary role that the public sector must play in energy efficiency improvement. All the more so are public buildings that house energy-consuming technological facilities. With regard to the use of renewable energy sources, it is appropriate that the installation on public buildings should prioritize exemplarity in terms of both plant producibility and architectural integration. The Municipal Administration should take steps to ensure that other public stakeholders also include the installation of photovoltaic systems in their programs. The interventions are:

- Installation of photovoltaic systems

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification during operation, by the service manager, of individual metered consumption; - Collaboration with the heat management company for real-time monitoring;
- Accounting, year by year, of the decrease in energy consumption due to the 'action carried out;

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Installation of photovoltaic systems	10%	1250	€/kW

8.1.4 PUBLIC LIGHTING BOARDS

PUBLIC LIGHTING SECTOR	CARD NO. I1
PUBLIC LIGHTING EFFICIENCY	
Action structure	

DESCRIPTION

In existing applications there will be a gradual replacement of all installations equipped with old lamps with reduced energy efficiency, with obvious decay of luminous flux over time and high cost of disposal, with others with high efficiency thus achieving excellent results in terms of both savings and illuminance. Further interventions will concern the extraordinary maintenance of electrical lines and switchboards from which it is expected to improve the lighting system a consequent reduction of dispersion and consumption.

The interventions are:

- Replacing traditional lamps with more efficient lamps
- Replacing traditional lamps with LED lamps

MONITORING METHOD

he main monitoring method will be verification of energy consumption in question. In addition, other action monitoring methods are possible such as:

- Verification of consumption by the Technical Department in order to observe the result of the action;
- On-site verification of public service rendered;
- Data collection and processing in order to quantify, year by year, the decrease in energy consumption due to the action taken.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Replacing traditional lamps with LED lamps	50%	53	€/CAD
Replacing traditional lamps with more efficient lamps	45%	50	€/CAD

8.1.5 BOARDS FOR THE TRANSPORTATION SECTOR

TRANSPORT SECTOR	CARD NO. TR1
TRANSPORTATION EFFICIENCY	
Action structure	

DESCRIPTION

In existing applications, there will be a gradual replacement of all diesel and gasoline and natural gas vehicles with electric vehicles. In addition, bicycle use will be encouraged in order to have zero emissions.

The interventions are:

- Replacement of municipal and public vehicles with electric vehicles
- Encouragement of bicycle use
- Incentivizing telecommuting
- Installation of electric charging stations

MONITORING METHOD

The main monitoring method will be the energy consumption audit in question.

- Monitoring will be on consumption resulting from the municipal vehicle fleet
- Develop collaborative relationships with companies in the municipality, in order to know the number of people who annually, take advantage of telecommuting.
- Periodic census of workers using telecommuting.
- Monitoring will be the control of traffic volumes
- The control of energy consumption for recharging,
- The frequency at the points affected by the 'action.

Costs and primary energy savings (%)			
Intervention	Saving	Cost	Unit
Replacement of municipal vehicles with electric vehicles	65%	30000	€/CAD
Encouragement of bicycle use	100%	400	€/CAD
Incentivizing telecommuting	25%	0	€/CAD
Installation of electric charging stations	0	10000	€/CAD

8.1.6 BOARDS FOR THE OTHER SECTOR

COMMON SECTOR.			TAB NO. OTHER1
ENERGY COMMUNITY			
Action structure			
DESCRIPTION In the existing applications, the establishment of the Monviso energy community will be planned. The study for the establishment of the energy community highlighted the problems in establishing the energy community from the thermal point of view. This is because, as the villages are far apart, it is costly and difficult to build a district heating network. For this reason, the energy community considers only the electrical part of energy consumption. So the interventions are: • Establishment of the Monviso energy community. **MONITORING METHOD** The main monitoring method will be verification of electricity consumption and self-consumption in question. In addition, CO_2 emissions will be monitored.			
Costs and primary energy savings (%)			
Intervention	Saving		Unit
Establishment of the energy community	40%		€

8.2 ANALYSIS OF INTERVENTIONS

The treatment of interventions was done differently depending on the data available. In particular, as far as the public sector is concerned, it was possible to carry out the surveys in all the municipalities of interest and it was possible to obtain precise information on the planned interventions, the extent of these and sometimes even the cost. As for the other sectors, tertiary residential transport public lighting and others, there is no detailed information but only data on primary energy consumption and total CO2 emissions for the entire sector as in the table below.

Table 15. Primary energy consumption in MWh per year by tertiary, residential, public lighting, transportation, and other sectors

Sector	FINAL ENERGY CONSUMPTION [MWh].														
	Electricity	Heating/cooling	Fossil fuels							Renewable energy					Total
			Natural gas	Liquid gas	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Vegetable oil	Biofuels	Other biomass	Solar thermal energy	Geothermal energy	
TERTIARY SECTOR	17747		12900	3258											38965
RESIDENTIAL SECTOR	21174		38536	9732								28528	233		113320
PUBLIC LIGHTING SECTOR	2045														2045
TRANSPORT SECTOR					60296	34876									95172
OTHER SECTOR.	4495														4495

For this reason, it was decided to treat these areas by considering consumption totals and not individual municipalities. It was possible to do this and obtain plausible results due to the similar mountainous nature of the villages.
A price list was prepared for sector interventions with the help of national comparison sources, quotes, GSE data and statistics.

As can be seen in the table above, each intervention is associated with a primary energy savings percentage, which represents the percentage of primary energy (in thermal or electrical MWh) that is saved relative to the BEI with the implementation of the intervention. This is then useful for calculating:

1. the tons of CO2 saved
2. The economic savings in euros due to the reduction in consumption and thus the non-purchase of primary thermal or electrical energy

In order to calculate the tons of CO2 equivalent, the values of emission coefficients shown in the table below were adopted.

Emissions saved through the implementation of the intervention were calculated as:

$$\boldsymbol{tCO2eq\ risparmiate} = MWh\ risparmiati * coefficiente\ \boldsymbol{emissivo}\ della\ fonte\ di\ EP$$

Where IPCC coefficients were used as the emission coefficients.

Table 16. Emission coefficients tCO2/MWh

IPCC Emission Factors		
electricity from the grid	0,343	tCO2eq/MWh
photovoltaic	0	tCO2eq/MWh
hydroelectric	0	tCO2eq/MWh
local biomass	0	tCO2eq/MWh
non-local biomass	0,401	tCO2eq/MWh

Instead, in order to calculate the economic savings of the share of primary energy saved, market values for the base year 2018 from bills of the municipality of Bagnolo Piemonte and national sources were used. The prices are listed in the table below:

Table 17. Primary energy prices

Price En EL	€/MWh	164,57
Price En Th	€/MWh	50,76
LPG price	€/MWh	83,17
Diesel price (car)	€/MWh	151
Gasoline price (car)	€/MWh	185

Economic savings were calculated as:

$$\boldsymbol{euro\ risparmiati}\ (€) = MWh\ risparmiati\ (MWh) * prezzo\ energia\ primaria\ (€/MWh\ )$$

8.2.1 INTERVENTIONS FOR THE PUBLIC SECTOR

The interventions for the public sector, as announced earlier, are specific and broken down by municipality since there is a consumption analysis of each public building.
In order to assess the economic impact and the impact on the reduction of primary energy consumption of the interventions, a price list was used for each intervention compiled with the help of national statistics, data from ENEA and GSE, catalogs, quotes and market surveys. In particular, for this section related to the "public," a site visit was made to each municipality with the accompaniment of a technical manager who provided information on the actions the municipality has taken I have plans to take until 2050. These are the actions listed below for each municipality.

Table 18. Price list of interventions for the public sector

Intervention name	Reduced consumption	Cost [€] including installation/labor	Unit
replacement of windows and doors	13%	700	€/sqm
blown-in walls	20%	75	€/sqm
thermal coat	25%	100	€/sqm
LED lighting	50%	53	€/CAD
thermostatic valves	6%	100	€/CAD
boiler replacement			
100 kW	5%	80	€/kW
100 kW pellets	5%	140	€/kW
Heat pump			
5 kW	25%	1600	€/kW
10 kW	25%	1200	€/kW
15 kW	25%	1000	€/kW
cogenerator			
50 kW	32%	2000	€/kW
100 kW	32%	1800	€/kW
200 kW	32%	1150	€/kW
400 kW	32%	750	€/kW
999 kW	32%	670	€/kW
TLR exchanger	5%	20000	€/CAD
	5%	1000	€/kW
solar thermal for DHW	5%	5000	€/CAD
	5%	1100	€/sqm
Replacing radiators	15%	500	€/CAD
Wind power plant	10%	8000	€/CAD
		1300	€/kW
miscellaneous automation	30%	120	€/m2
attic insulation	20%	60	€/m2

Uglass replacement with insulated wall	13%	700	€/sqm
geothermal energy			
20 kW	25%	1000	€/kW
30 kW	25%	933	€/kW
photovoltaic installation	10%	1250	€/kW

In order to facilitate and simplify the reading of the document, it was decided to include a table as follows:

- Column 1: Building code;
- Column 2: name of the building;
- Column 3: Value of current consumption status in MWh/year;
- Column 4: Specific description on the type of consumption ("el"=electric, "th"=thermal);
- Column 5: name of the intervention;
- Column 6: extent of the intervention in m2, m3, units, etc., depending on the nature of the intervention;
- Column 6: extent of the intervention in m2, m3, units, etc., depending on the nature of the intervention (e.g., 98m2 is the area over which the wall insulation intervention is to be carried out);
- Column 7: Unit cost of the intervention;
- Column 8: Total cost of the intervention;
- Column 9: Percentage savings in total primary thermal energy due to the implementation of the intervention;
- Column 10: Primary thermal energy saved by carrying out the intervention in MWh/year;
- Column 11: CO2eq tons of emissions due to heat consumption saved by carrying out the intervention;
- Column 12: Savings in euro/year on purchased primary thermal energy;
- Column 13: Primary electric energy saved by carrying out the intervention in MWh/year;
- Column 14: Percentage savings in total primary thermal energy due to the implementation of the intervention;
- Column 15: CO2eq tons of emissions due to electricity consumption saved by carrying out the intervention;
- Column 16: savings in euro/year on purchased primary electricity;
- Column 17: Primary electric energy saved by carrying out the intervention in MWh/year;
- Column 18: Total cost reduction in euro/year due to interventions;
- Column 19: Total reduction in tons of CO2eq emitted due to interventions

8.2.1.1 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF BAGNOLO

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
  - Piedmont funding call: 100% efficiency upgrading of public lighting.
  - Need for intervention at the gymnasium building.
  - The library is not eligible for intervention since it is a historic building and was already redeveloped in 2000

COD	**Building**	**Current state of consumption**		**Intervention**			**Cost of intervention**		**Thermal and emission reduction and costs**				**Electrical and emission reduction and costs**				Total emission and cost reductions	
	Name	**MWh/year**	**el/th**	Description	Extension	**Unit**	**€/m or CAD**	**€**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**€/year**	**tCO2eq**
1.1	City Hall	98	th	blown-in walls	883	m2	75	66245	20%	20	4	997					997	4
1.1.	City Hall	98	th	thermal coat	98	m2	100	9814	25%	25	5	1247					1247	5
1.1.	City Hall	98	th	Uglass replacement with insulated wall	79	m2	700	54978	13%	13	3	648					648	3
1.1.	City Hall	98	th	thermostatic valves	30	unit	100	3000	6%	6	1	299					299	1
1.2	Nursery School	348	th	TLR exchanger	426	kW	1000	426000	5%	17	4	884					884	4
1.2	Nursery School	348	th	solar thermal for DHW	4	kW	5000	20000	5%	17	4	884					884	4
1.2	Nursery School	348	th	thermal coat	505	m2	70	35318	25%	87	18	4418					4418	18
1.2	Nursery School	348	th	attic insulation	1023	m2	70	71582	25%	87	18	4418					4418	18
1.2	Nursery School	348	th	replacement of windows and doors	52	m2	700	36652	13%	45	9	2297					2297	9
1.2	Nursery School	7	el	LED lighting	40	unit	53	2120					50%	3	2	556	556	2

8.2.1.2 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF BARGE

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
    - Funding from Piedmont region announcement enabled the replacement of 70% of the lighting in the town hall with LED lighting.
    - Funding for energy upgrading of school buildings.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2 eq
2.1	City Hall	43	el	LED lighting	50	unit	53	2650					50%	22	11	3551	3551	11
2.1	City Hall	100	th	thermal coat	1564	m2	100	156447	25%	25	5	1266					1266	5
2.5	Primary School Capital	68	th	thermal coat				56000	25%	17	3	860					860	3
2.5	Primary School Capital	68	th	controlled mechanical ventilation				70000	5%	3	1	172					172	1
2.7	Kindergarten Principal	193	th	heat generator installation				30000									0	0
2.7	Kindergarten Principal	193	th	thermal coat				34000	25%	48	10	2450					2450	10
2.7	Kindergarten Principal	193	th	replacement of windows and doors				66500	13%	25	5	1274					1274	5
2.9	Cruise School	82	th	thermal coat				11200	25%	21	4	1047					1047	4
2.9	Cruise School	82	th	thermostatic valves + boiler replacement				30000	5%	4	1	209					209	1
2.9	Cruise School	82	th	replacement of windows and doors				55500	13%	11	2	544					544	2
2.10	Sports hall	9	th	Replacement of heat generators with condensing boilers				65000	5%	0	0	23					23	0
2.10	Sports hall	9	th	replacement of windows and doors				35000	13%	1	0	59					59	0
2.10	Sports hall	9	th	thermal coat				250000	25%	2	0	114					114	0

8.2.1.3 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF BRONDELLO

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2 eq	€/year	%	MWh/year	tCO2 eq	€/year	€/year	tCO2 eq
3.1	City Hall	21	th	Replacement of windows and doors	25	m2	700	17500	13 %	3	1	136					136	1
3.1	City Hall	3	el	LED lighting	4	kW	53	212					50 %	1	2	239	239	2
3.1	City Hall	21	th	Boiler replacement	24	kW	80	1920	30 %	6	1	313					313	1
3.1	City Hall	21	th	Electricity columns	2	pedestals		0									0	0
3.2	Outpatient Clinic-Archive	1	th	Insulations	350	m2	125	43750	5%	0	0	3					3	0
3.2	Outpatient Clinic-Archive	0	el	LED lighting	3	kW	53	159	50 %	0	0	6					6	0
3.5	Gymnasium	3	th	Replacement of windows and doors	80	m2	700	56000	13 %	0	0	17					17	0
3.5	Gymnasium	3	th	Coat insulation	600	m2	125	75000	5%	0	0	7					7	0
3.5	Gymnasium	3	el	LED lighting	5	kW	53	265					50 %	1	0	237	237	0
3.5	Gymnasium	3	th	Boiler replacement	115	kW	80	9200	30 %	1	0	40					40	0
3.6	Former municipal headquarters	24	th	Replacement of windows and doors	35	m2	700	24500	13 %	3	1	158					158	1
3.6	Former municipal headquarters	24	th	Insulations	118	m2	125	14764,3744	5%	1	0	61					61	0
3.6	Former municipal headquarters	0	el	LED lighting	2	kW	53	106					50 %	0	0	16	16	0
3.6	Former municipal headquarters	24	th	Boiler replacement	34	kW	80	2752	30 %	7	1	365					365	1
3.9	Multipurpose center	0	th	Boiler replacement	81	kW	80	6480	30 %	0	0	2					2	0

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

8.2.1.4 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF CRISSOLO

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
  - Contribution from the state under the Law for Efficiency (Paragraph 29 Law 160/2019) with 50,000 euros: with this contribution, the municipality of Crissolo decided to replace the old oil-fired boiler in the town hall with two new oil-fired condensing boilers.
  - State grants: contributions to replace radiators in city hall, insulation of exterior walls, replacement of windows and doors, and attic insulation.

COD	**Building**	**Current state of consumption**		**Intervention**			**Cost of intervention**		**Thermal and emission reduction and costs**				**Electrical and emission reduction and costs**				Total emission and cost reductions	
	Name	**MWh/year**	**el/th**	Description	Extension	**Unit**	**€/m or CAD**	**€**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**€/year**	**tCO2 eq**
4.1	City Hall	37	th	boiler replacement	29	kW	125	3625	5%	2	0	93					93	0
4.1	City Hall	37	th	replacement radiators	16	unit	500	8000	15%	5	1	279					279	1
4.1	City Hall	37	th	wall insulation	412	m2	70	28823	25%	9	2	464					464	2
4.1	City Hall	37	th	loft insulation	778	m2	70	54488	25%	9	2	464					464	2
4.1	City Hall	37	th	replacement of windows and doors	29	m2	700	19992	13%	5	1	241					241	1
RES_4.1	Wind Power City Hall	73	el	wind farm	6	kW	1250	7500					13%	9,64	14	489	489	14

8.2.1.5 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF GAMBASCA

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO_2eq	€/year	%	MWh/year	tCO_2eq	€/year	€/year	tCO_2 eq
6.1	City Hall	46	th	Replacement of windows and doors	25	m2	700	17500	13%	6	1	303					303	1
6.1	City Hall	46	th	Thermal coat	226	m2	125	28250	25%	11	2	582					582	2
6.1	City Hall	6	el	Lighting	50	bulbs	15	750					0,5	3	0	519	519	0
6.1	City Hall	46	th	Boiler replacement	32	kW	80	2560	0,3	14	3	699					699	3
6.7	Multipurpose center	22	th	Replacement of windows and doors	35	m2	700	24500	13%	3	1	145					145	1
6.7	Multipurpose center	22	th	Wall insulation	108	m2	125	13519,7033	5%	1	0	56					56	0
6.7	Multipurpose center	3	el	LED lighting	5	kW	53	265					50%	1	2	243	243	2
6.7	Multipurpose center	22	th	Boiler replacement	32	kW	80	2520	30%	7	1	334					334	1

8.2.1.6 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF MARTINIANA PO

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
  - The installation of the heat pump in the municipal offices is aimed at using the power generation of the photovoltaic system installed very recently on the roof (6 kW power).
  - The installation of photovoltaics and heat pump is aimed at energy efficiency of the heating system.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2 eq
7.1	City Hall	0,422	el	installation of photovoltaic panels	6	kW	1250	7500					10%	0	1	7	7	1
7.1	City Hall	30,55	th	heat pump					25%	8	2	388					388	2
7.2	Elementary school	6	el	installation of photovoltaic panels	12	kW	1250	15000					10%	1	0	99	99	0
7.2	Elementary school	25	th	boiler replacement					30%	8	2	381					381	2
7.3	Kindergarten	37	th	boiler replacement					30%	11	2	563					563	2

8.2.1.7 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF OSTANA

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
  - Growth Decree for funding: replacement of fixtures at City Hall (old fixtures were from the 1980s).
  - Township project: boiler replacement and wall insulation.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2 eq
9.1	City Hall	59,35	th	boiler replacement	50	kW	125	6250	5%	3	1	151						
9.1	City Hall	59,35	th	replacement of windows and doors	29	m2	700	19992	13%	8	2	392					392	2
9.1	City Hall	59,35	th	thermal coat	278	m2	100	27789	25%	15	3	753					753	3
9.8	Lou Puotoun	43,92	th	boiler replacement with heat pump	30	kW	1000	30000	25%	11	2	557					557	2

8.2.1.8 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF PAGNO

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2 eq
11.1	City Hall	53	th	replacement of windows and doors	30	m2	700	21000	13%	7	1	349					349	1
11.1	City Hall	53	th	thermal coat roof	300	m2	70	21000	25%	13	3	672					672	3
11.1	City Hall	53	th	boiler replacement	45	kW	80	3600	30%	16	3	806					806	3
11.3	Brothe-rhood	68	th	boiler replacement with heat pump	55	kW	1000	55000	25%	17	3	861					861	3
11.3	Brothe-rhood	68	th	building energy upgrading	400	m2	70	28000	15%	10	2	517					517	2

8.2.1.9 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF PAESANA

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
    - Region call: for 100% public lighting.
    - Interventions for City Hall: old building with need for replacement of windows and doors and central heating unit with a new condensing boiler.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	MWh/year	el/th	Description	Extension	Unit	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2 eq
10.1	City Hall	36	th	replacement of windows and doors	35	m2	700	24500	13%	5	1	237					237	1
10.1	City Hall	36	th	boiler replacement	25	kW	80		30%	11	2	546					546	2
10.5	Elementary school	239	th	thermal coat	1600	m2	100	160000	25%	60	12	3032					3032	12

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

8.2.1.10 PUBLIC SECTOR INTERVENTIONS MUNICIPALITY OF SANFRONT

- Origin of thermal consumption data: Siatel.
- Origin of electricity consumption data: E-distribution.
- Rationale for the intervention choices made:
    - MIUR call for proposals: efficiency upgrading Marconi Boero school (replacement of central heating unit with burner then condensing).
    - National Milleproroghe calls, BIM grants: efficiency upgrading of City Hall building (replacement of windows and doors with low-emissivity shading glass, 16 cm fiber attic insulation, new central condensing boiler with external methane sensor).
    - 50,000 grant for energy efficiency projects.

COD	Building	Current state of consumption		Intervention			Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
	Name	**MWh/year**	**el/th**	Description	Extension	**Unit**	**€/m or CAD**	**€**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**%**	**MWh/year**	**tCO2eq**	**€/year**	**€/year**	**tCO2 eq**
14.2	City Hall	69	th	replacement of windows and doors	25	m2	700	17500	13%	9	2	455					455	2
14.2	City Hall	69	th	thermal coat	300	m2	100	30000	25%	17	3	875					875	3
14.2	City Hall	69	th	boiler replacement	57	kW	80	4560	30%	21	4	1050					1050	4
14.4	Marconi Boer School	797	th	boiler replacement	420	kW	80	33600	30%	239	48	12130					12130	48
14.3	Community center	5	th	boiler replacement	27	kW	80	2160	30%	1	0	72					72	0
14.6	Sports facilities	17	el	LED lighting									40%	7	2	1105	1105	2

8.2.2 INTERVENTIONS FOR THE TERTIARY, RESIDENTIAL AND OTHER SECTORS

For the tertiary, residential and other sectors, not having specific data, the following assumptions were made:

- For the thermal coat intervention, the number of people per dwelling was estimated through the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the average number of dwellings. The percentage of buildings that will have thermal insulation applied to the walls of the dwellings by 2050 will be 70%, and it was estimated that for each building the average area to which the intervention is applied is 240 m2.

- For the wall blower intervention, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the average number of dwellings. The percentage of buildings that will do the intervention in 2050 will be 20 percent, and it was estimated that for each building the average area to which it is applied is 240 m2.

- For the window replacement intervention, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the number of dwellings. The percentage of buildings that will do the housing intervention in 2050 will be 75%, and it was estimated that the average area to which it is applied is 15 m2 per building.

- For the high-efficiency lighting intervention, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the number of dwellings. The percentage of buildings that will do the intervention in 2050 will be 100 percent, and it was estimated that for each building the extent to which it is applied is 10 lighting points per house.

- For the intervention of installing a microcogenerator, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the number of dwellings. The percentage of buildings that will do the intervention in 2050 will be 5 percent, and it was estimated that for each building the extension is one 20 kW cogenerator (small size) according to project data already executed.

- For the intervention of installing a heat pump, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the number of dwellings. The percentage of buildings that will do the intervention in 2050 will be 50 percent, and it was estimated that for each building the extension is one heat pump of 8 kW (small size) according to project data already executed.

- For the geothermal system installation intervention, the number of people per dwelling was estimated due to the number of total inhabitants, and then dividing the number of inhabitants by the number of people per dwelling gives the number of dwellings. The percentage of buildings that will do the intervention in 2050 will be 10% and it was estimated that for each building the extension of a geothermal system of 12 kW (small size) according to data projects already executed.

The price list in the table below was used to estimate primary energy and emission savings and intervention costs.

Table 19. Price list of tertiary sector interventions

Intervention name	Reduced consumption	Cost [€] including installation/labor	Unit
replacement of windows and doors	13%	700	€/sqm
blown-in walls	20%	75	€/sqm
thermal coat	25%	100	€/sqm
high-efficiency lighting	50%	53	€/CAD
LED lighting	50%	53	€/CAD
PV installation	10%	1250	€/kW
installation of thermal BACS systems	39%	25	€/sqm
BACS electrical systems installation	15%	25	€/sqm
Heat pump			
5 kW	25%	1600	€/kW
10 kW	25%	1200	€/kW
15 kW	25%	1000	€/kW
cogenerator			
50 kW	32%	2000	€/kW
100 kW	32%	1800	€/kW
200 kW	32%	1150	€/kW
400 kW	32%	750	€/kW
999 kW	32%	670	€/kW
geothermal energy			
20 kW	25%	1000	€/kW
30 kW	25%	933	€/kW

Now, using the coefficients given in the price list, the cost of each intervention, the primary energy reduction of each intervention, and the reduction of CO_2eq emissions were estimated.

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

GreenChainSAW4Life

COD	Name	Current state of consumption		Intervention		Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
		MWh/year	el/th	Description	Extension	€/m or CAD	€	%	MWh/year	tCO2 eq	€/year	%	MWh/year	tCO2 eq	€/year	€/year	tCO2eq
TERTIARY SECTOR, RESIDENTIAL, OTHER																	
TER	Tertiary + residential + other	61928	th	thermal coat	873768	100	87376800	25%	10837	2189	550106					550106	2189
TER	Tertiary + residential + other	61928	th	blown-in walls	249648	75	18723600	20%	2477	500	125739					125739	500
TER	Tertiary + residential + other	61928	th	replacement of windows and doors	58511	700	40957875	13%	6038	1220	306488					306488	1220
TER	Tertiary + residential + other	43416	el	high-efficiency lighting	52010	53	2756530					50%	21708	5769	3572486	3572486	7446
TER	Tertiary + residential + other	61928	th	cogenerator	10402	2000	20804000	35%	1084	219	55011					55011	219
TER	Tertiary + residential + other	61928	th	heat pump	20804	1600	33286400	25%	7741	4544	392933					392933	4544
TER	Tertiary + residential + other	61928	th	geothermal	6241	1000	6241200	30%	1858	375	94304					94304	375
TER	Tertiary + residential + other	61928	th	installation of thermal BACS systems	8483	25	212082	39%	24152	4879	1225951					1225951	4879
TER	Tertiary + residential + other	43416	el	BACS electrical systems installation	5947	25	148685					15%	6512	2234	1071746	1071746	2234
TER	Tertiary + residential + other	43416	el	PV installation	21064	0	0					10%	3907	1340	643047	643047	1340

Implementation of this intervention leads to a decrease in CO_2 emissions of about 70 percent for the tertiary sector, residential or otherwise.

8.2.3 INTERVENTIONS FOR THE PUBLIC LIGHTING SECTOR

With regard to the "public lighting" sector, lighting efficiency was considered in all 10 countries mentioned above that adhere to the Covenant of Mayors.
The price list for interventions on the "public lighting" sector is presented here.

Table 20. Public lighting price list

Intervention name	Reduced consumption	Cost [€] including installation/labor	Unit
LED lighting	50%	53	€/CAD

To calculate the tons of CO_2 equivalent saved by the lighting sector, the total consumption of primary electrical energy (2045000 kWh) is divided by the annual hours of operation (3650 h assuming the lighting of public lighting is turned on 8-10 hours per day). From this division, the installed power (560 kW) is obtained, and knowing the average power of an LED lamp for public lighting (0.6 kW), dividing the total installed power by the average power of each lamp gives the number of lamps (about 933). For the calculation of tons of CO_2 equivalent saved, it is considered that all lamps are replaced with LED lighting lamps. The replacement of LED lamps results in a 50% decrease in emissions. Although this, does not reach 80% of the emission reduction, together with the intervention in "other" of the establishment of the energy community, this will easily reach the value of 80%.

Figure 37. Savings from public lighting interventions.

COD	Name	Current state of consumption		Intervention		Cost of intervention		Thermal and emission reduction and costs				Electrical and emission reduction and costs				Total emission and cost reductions	
		MWh/year	el/th	Description	Extension	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2eq
PUBLIC LIGHTING SECTOR																	
IP	Public lighting	2045	el	LED lighting	900	53	47700					50%	1022,5	526,0763	168272,8	168272	351

8.2.4 INTERVENTION FOR THE TRANSPORTATION SECTOR

For interventions in the transportation sector, multiple actions were assumed to make the sector more efficient. The presented price list also includes the possible types of interventions.

Table 21. Price list for interventions in the transportation sector

Intervention name	Reduced consu-mption	Cost [€] including installation/labor	Unit
replacement of vehicles with electric vehicles	100%	30000	€/CAD
telecommuting incentive	15%	0	€
bicycle use incentive	100%	400	€/CAD
electric column installation	-	10000	€/CAD

In order to estimate the percentage of annual CO2 reduction, the following assumptions were made:

- For the intervention to replace municipal and private vehicles with electric cars, it is estimated that 80 percent of cars on the road in 2050 will be electric. Thus, multiplying the total number of cars by the percentage of electric cars in 2050 gives the number of electric cars in 2050. To calculate the tons of CO2 equivalent saved by switching to electric cars, one multiplies the MWh of thermal energy saved by the emission coefficients of gasoline and diesel by estimating, thanks to numerical proportions made on real data, that 20 percent of cars will be gasoline and the remaining 80 percent will be diesel. To calculate the economic savings in euros, the assumption that 20 percent of cars are gasoline and 80 percent are diesel is maintained.

- For the encouragement of bicycle use, it is estimated that by 2050 the segment of the population that will use bicycles to get around will be 5 percent. The estimate is so pessimistic since, being mountainous countries, the roads are not flat and bicycle use is unrealistic.

- For the installation of electric charging columns, it is estimated that 2 columns will be installed for each country approximately.

- For the incentive of telecommuting, it is estimated that 45 percent of the population will work from home in 2050 due to the expansion of internet connection even in small towns.

COD	Name	Current state of consumption	Intervention	Cost of intervention	Thermal and emission reduction and costs	Electrical and emission reduction and costs	Total emission and cost reductions	

		MWh/year	el/th	Description	Extension	€/m or CAD	€	%	MWh/year	tCO2eq	€/year	%	MWh/year	tCO2eq	€/year	€/year	tCO2eq
TRANSP	Transportation sector	95172	th	Replacement of municipal and private vehicles with electric vehicles	16717	30000	501504000	70%	53296	15216	8410159	0				8410159	10766
TRANSP	Transportation sector	95172	th	bicycle use incentive	1040	400	416080	100%	4759	1253	750907	0				750907	961
TRANSP	Transportation sector	95172	th	installation of electric charging stations	20	10000	200000	0%	0	0	0	0				0	0
TRANSP	Transportation sector	95172	th	telecommuting incentive	938	0	0	25%	23793	6267	3754535	0				3754535	4806

These interventions achieve an 80% reduction in emissions from the transportation sector.

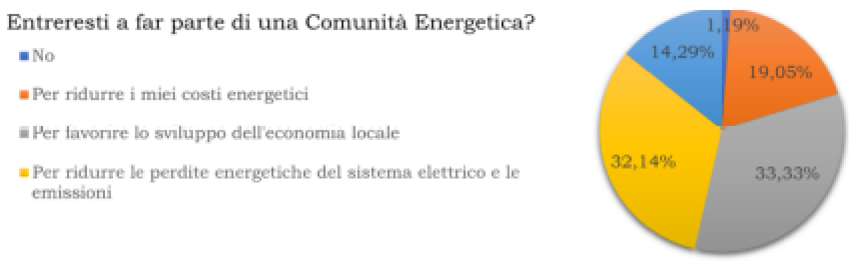
8.2.5 ADDITIONAL INTERVENTIONS FOR THE PUBLIC

The intervention consists of the establishment of the Monviso Energy Community. In order to reduce local CO2 emissions, the plan is to formalize a Renewable Energy Community, connected more or less to the wood supply chain. In addition to assessing the conformation of an ERC, the plan would map the energy consumption of the area and the current estimate of energy use from renewable sources. Following the mapping of consumption in the territory, a strategy for energy efficiency and widespread generation of low-emission energy will be planned. By selecting the best available technologies for biomass heating and microcogeneration, the conformation of the CER itself will be evaluated. Upon confirmation of the "Energy and ERC" plan, of the 14 municipalities participating in LIFE only10 have confirmed and intended to implement local changes for community implementation. At the end of January 2020, as previously mentioned, the signing of the expressions of interest of the remaining 10 mayors was confirmed. The event is also to be considered relevant from a regional and national perspective. The topic of ERCs in Piedmont, and lately in Italy as well, is attracting great interest. Before contextualizing the pragmatism of the initiative, a decisive search for the buildings that would first be part of this project was necessary. Given the lockdown context with which the initiative had to interface in 2020, private buildings were momentarily excluded. The only buildings that entered the LIFE estimation scenario were municipal-owned buildings. Once this estimation and preliminary design phase is completed, it will be possible to organize citizen outreach campaigns to expand the pool of collective consumers. Also in January 2020, in conjunction with the presentation of the GCS4L project, a questionnaire was conducted to understand the level of local sensitivity to the CER issue and what the actual local knowledge of this new configuration was. The questionnaire was presented on January 31, 2020 in Paesana during the regional conference "Forest, Wood and Energy" with 65 individuals in attendance. It proposed the following questions and answers.

- Sei a favore dello sviluppo della gestione forestale e della filiera legno?
  - A No
  - B Non mi interessa
  - C Si, a prescindere da come viene portata avanti
  - D Si, solo se condotta con criterio e pianificazione
- Quali dovrebbero essere gli obiettivi prioritari della gestione forestale delle valli Po, Bronda e Infernotto?
  - A Vendita del legname al miglior prezzo
  - B Valorizzazione paesaggistica, storica, ricreativa e culturale
  - C Gestione del territorio, dei dissesti e del rischio incendio
  - D Contrasto ai cambiamenti climatici
  - E Creazione di occupazione sul territorio
  - F Incremento della biodiversità
- La filiera legno è un settore che potrà assumere in futuro una maggiore rilevanza nell'area?
  - A No, rimarrà un settore marginale
  - B Può crescere, ma l'interesse per questo settore rimarrà basso
  - C è un settore molto promettente che può diventare di rilievo
  - D Assolutamente sì, mi aspetto che diventi la principale attività occupazionale dell'area
- Saresti disposto a pagare leggermente di più (<10%) per utilizzare legno locale per edilizia o energia?
  - A No, lo acquisterei solo se mi costasse come i materiali che acquisto ora
  - B Si, se sono certo del vantaggio per la migliore gestione del territorio e diminuire il rischio
  - C Si, se sono certo del vantaggio per l'economia locale
  - D Si, se sono certo che migliori la fornitura di altri servizi
  - E Pagherei anche più del 10%
- Ti interesserebbe usare legno locale come materiale per la costruzione e l'arredamento della tua abitazione?
  - A No, costerebbe troppo
  - B Si, ma solo per elementi di arredo
  - C No, non mi fido/ non è sicuro
  - D Si, anche nella struttura dell'abitazione
- Al fine di ridurre le emissioni, a quale sistema di riscaldamento saresti disposto a passare?
  - A Stufa a legna
  - B Caldaia a cippato
  - C Teleriscaldamento
  - D Pompa di calore elettrica
  - E Caldaie a alte prestazioni alimentata a combustibili fossili
- Come reagiresti se fossero installate delle caldaie o cogeneratori a biomassa forestale?
  - A Mi è indifferente
  - B Negativamente, sono contrario
  - C Positivamente, se l'impianto è dimensionato sui reali bisogni di energia
  - D Positivamente, se l'impianto è dotato di adeguati filtri
  - E Positivamente, se l'impianto è alimentato con legno di qualità e origine locale
- Entreresti a far parte di una comunità energetica locale?
  - A No
  - B Per ridurre i miei costi energetici
  - C Per favorire lo sviluppo dell'economia locale
  - D Per ridurre le perdite energetiche del sistema elettrico e le emissioni
  - E Al momento non so valutare
- Ci sono altri temi, non trattati nella giornata odierna, che vorresti fossero affrontati dal progetto?
- Dati generali
  - Comune di residenza
  - Età
  - Sesso
  - Occupazione
  - Titolo di studio
- Con che frequenza visita le valli Po, Bronda e Infernotto?
  - A Oggi è la prima volta
  - B Saltuariamente
  - C Regolarmente
  - D Sempre

The profile of the average user present was:

While in a general sense an optimistic view of the EC emerged:



Thanks to this event, the following project governance was confirmed as well as the buildings that will be part of this research phase. In addition to the municipal buildings, the Bacino Imbrifero Locale del Po with its hydroelectric power plant located in Paesana and the Unione Montana Monviso with its offices also located in the municipality of Paesana applied for interest.

Figure 38. Outline of the governance of the Monviso community

Comune/Ente	Numero POD edifici	Numero POD per Illuminazione Pub
Bagnolo	23	60
Barge	27	79
Brondello	6	39
Crissolo	8	10
Gambasca	6	18
Martiniana Po	7	Non definito
Ostana	7	Non definito
Paesana	18	56
Pagno	3	200
Sanfront	14	3
U.M. Monviso	1	

The current governance of the project stipulates that the 10 entities are represented by a Lead Partner. In this case, the representative is the Municipality of Ostana. The Lead Partner has exclusive authority to represent all the buildings in question and, in the case of representative events or contacts with national authorities, is responsible for transferring the acquisition of information to all other entities. The following pages tabulate the buildings for which all the data examined were collected and processed. For each building, the lease address is presented but not the POD or PDR code for privacy reasons.

BAGNOLO PIEMONTE

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	60 POD
MUNICIPIO	Piazza Divisione Alpina Cuneense 5		
SCUOLA MATERNA	Via De Gasperi 5		
PALESTRA	Via Roma 2		
SCUOLA PRIMARIA	Via Don Milani 9		
SCUOLE MEDIE	Via Confraternita 42, Via Santa Barbara		
BIBLIOTECA	Corso Malingri 22		
ARCHIVIO STORICO	Corso Malingri 22		
TORRE STORICA	Via Barrata		
BOLLATRICE	Via Cave		
BOLLATRICE CAVE 2	Via Cave		
LOCALI EX PESO	Via Einaudi 4		
CIMITERO CAPOLUOGO	Viale Rimembranza 8		
CIMITERO FRAZ.VILLAR	Via Cave 295		
CIMITERO VILLARETTO	Piazza San Giovanni		
MAGAZZINO 1	Via Scuole Nuove 24		
MAGAZZINO 2	Via Cavour 104		
PESO PUBBLICO	Via Cave 8		
SALA CONFERENZE	Corso Malingri 22		
SCUOLA ELEMENTARE VILLARETTO	Via Villaretto 60		
EX MUNICIPIO	Corso Malingri 22		
LOCALI EX PROLOCO	Via Cavour 19		
TEATRO SILVIO PELLICO	Corso Marconi 1		
PIAZZA MERCATO	Piazza San Pietro		
PARCHI E GIARDINI	Via Don Bertero		

BARGE

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	79 POD
MUNICIPIO	Piazza Giuseppe Garibaldi 11		
BIBLIOTECA	Via Monviso 1		
SCUOLA PRIMARIA CAPOLUOGO	Viale Mazzini 2		
SCUOLA SECONDARIA	Via Cottolengo 2		
SCUOLA MATERNA CAPOLUOGO	Via Cavallotta sn, Via Campo Sportivo 20		
SCUOLA SAN MARTINO	Via Crocetta 2		
SCUOLA PRIMARIA CROCERA	Via Cuneo		
IMPIANTI SPORTIVI	Via Azienda Moschetti		
MAGAZZINO COMUNALE	Piazza Garibaldi 11		
CASERMA VIGILI DEL FUOCO	Via Fiorita, 32		
EX OFFICINA FERROVIARIA	Via Assarti sn		
ELISUPERFICIE	Piazza Stazione 4 A		
PRESIDIO SOCIALE	Via Ospedale		
PESO PUBBLICO	Piazza statuto		
LAGHETTO PESCATORI	Via Gabiola		
CIMITERO	Via San Martino 58		
SIRENA PARROCCHIALE	Largo Cesare Battisti		
AREA MERCATO	Via Balangera		
ALA MERCATALE	Piazza Garibaldi 3		
CENTRO SOCIALE	Via Dana Borga 1		
TETTOIA CENTRO SOCIALE	Via Agnes Robert		
RIPETITORE RADIO	Via Combe		
SPOGLIATOIO CROCERA	Via Cuneo		
IRRIGAZIONE AIUOLE	Viale Mazzini		
IRRIGAZIONE AIUOLE	Viale Stazione 38		
PESO PUBBLICO SAN MARTINO	Via San Martino		
CIMITERO UFFICIO	Via San Martino		
SEMAFORO	Via Carle		
UNITRE	Piazza San Giovanni 1		
ASSOCIAZIONI	Via Cavallotta		
PARTI COMUNI	Piazza Stazione 6		
UNITÀ ABITATIVA	Piazza Stazione sn		

BRONDELLO

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	39 POD
MUNICIPIO	Via Provinciale 13		
AMBULATORIO - ARCHIVIO	Via Villa 9		
BRUCIATORI - CT	Via Villa 20		
CAMERA MORTUARIA	Via Villa		
PALESTRA	Via Villa 9		
EX SEDE COMUNALE	Via Villa 23		
RIPETITORE UMM	Via Rossi		
ALLOGGIO COMUNALE	Via Villa 6		
CENTRO POLIFUNZIONALE	Via Villa 9		

CRISSOLO

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	10 POD
MUNICIPIO	corso Umberto I, 39		
CIMITERO	Frazione Serre		
EX MULINO	Via Ruata 1		
AUTORIMESSA	Piazza Umberto I 190		
SALA POLIVALENTE	Piazza della Seggiovia Crissolo		
WC SEGGIOVIA	via ruata 48b		
TELECAMERE	Via Provinciale, 2bis		
RIPETITORE	Via Ruata, Snc		
CENTRALINA	Frazione Serre		

GAMBASCA

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	18 POD
MUNICIPIO	via Roma 6		
CIMITERO	Via Martiniana Po Snc		
MAGAZZINO PC	Via Picat 9t		
MAGAZZINO COMUNALE	Via Picat 9		
AREA MERCATALE	Piazza Gauthier Snc		
LUCE SCALE ED. RES.	Via Picat 9t		

MARTINIANA PO

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	Non definito
MUNICIPIO+FARMACIA	Via Roma 29		
SCUOLA ELEMENTARE	Via Roma sn		
SCUOLA MATERNA	Via Roma sn		
UFFICIO POSTALE	Via Roma 20		
PALESTRA	Via Roma 19		
SALA CONVEGNI	Via Roma 13		
ALTRI USI	Via Roma		

OSTANA

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	Non Definito
MUNICIPIO + MUSEO	Via Roma 50		
CASE POPOLARI VALENTIN	Via Roma		
CENTRO BENESSERE	Capoluogo Villa 35		
AUTORIMESSE + PORTA DEL MONVISO	Capoluogo Villa 18/B		
RIFUGIO LA GALABERNA	Capoluogo Villa 18/A		
AUTORIMESSA	Piazza Caduti per la Libertà 49		
LOU PURTOUN	Localita' Sant'antonio 60/A		

PAESANA

NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	56 POD
MUNICIPIO	Via Nazionale		
MUNICIPIO	Via Reinaud 16		
MUNICIPIO	Via Roma 9		
SCUOLA SECONDARIA	Piazza Vittorio Veneto 24		
SCUOLA PRIMARIA	Via Roma 59		
SCUOLA MATERNA	Via Barge 6		
EDIFICIO 1	Località Occa Giardini		
EDIFICIO 2	Via Roma 36		
EDIFICIO 3	Via Roma 34		
EDIFICIO 4	Via Barge 6		
EDIFICIO 5	Via Barge 4		
EDIFICIO 6	Via Barge 4		
EDIFICIO 7	Piazza Vittorio Veneto 24		
EDIFICIO 8	Frz Calcinere Inferiore		
IMPIANTI SPORTIVI	Via Nazionale 2		
EDIFICIO 9	Borgata Giors Mad Orient		
EDIFICIO 10	Via Barge 6		
SEDE UNIONE MONVISO	Via Santa Croce 4		

PAGNO

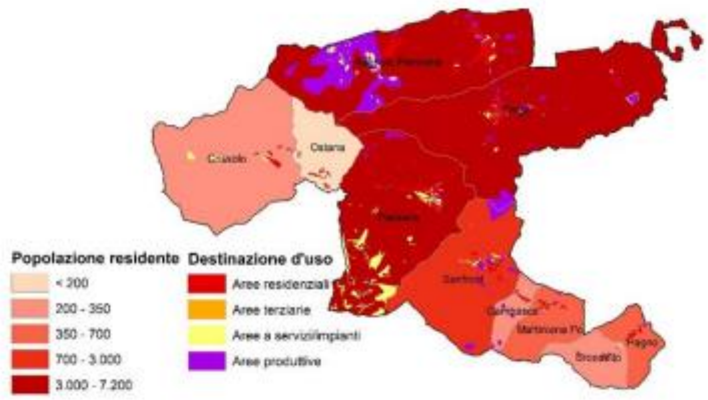
NOME EDIFICIO	INDIRIZZO	ILLUMINAZIONE PUBBLICA	200 punti luce
MUNICIPIO	Via Roma 3		
EDIFICIO PROPRIETA' COMUNALE	Via Caduti Liberazione 3		

SANFRONT			
NOME EDIFICIO	**INDIRIZZO**	**ILLUMINAZIONE PUBBLICA**	**3 POD**
MUSEO BALMA BOVES	Via dei Fiori sn		
MUNICIPIO	Piazza Statuto 2		
SEDE ALPINI+CENTROSOCIALE	Via dei Bianchi 1		
SCUOLA CAP	Corso Marconi sn		
AREA ARTIGINALE	Via Valle Po sn		
IMPIANTI SPORTIVI	Via Montebracco sn		
DISSUASORE	Piazza Ferrero sn		
CHIESA FRAZIONALE E GIOCO BOCCE	Via San Chiaffredo Bollano sn		
PESO E SEMAFORO	Via Valle Po sn		
EX ASILO	Via Trieste 21		
CIMITERO CAP.	Via Robella sn		
EX CINEMA	Piazza Statuto 27		
CENTRO SOCIALE			
MAGAZZINO COMUNALE	Via Vecchia sn		
CIMITERO ROCCHETTA	Via Rocchetta sn		

8.2.5.1 SPATIAL FRAMING OF THE ENERGY COMMUNITY

SPATIAL DEVELOPMENT

Figure 39. - Map on the distribution of population and land use in the Monviso area.

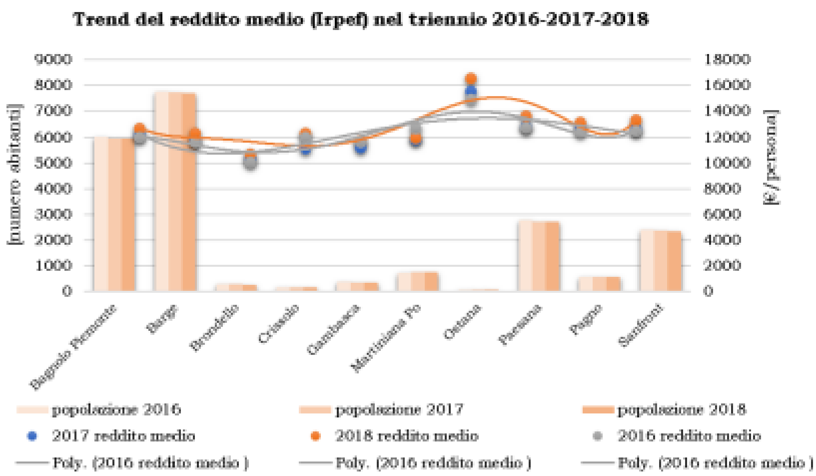


Economically, and according to IRES reports, the Monviso, Po Valley and Infernotto area is strongly characterized by the agricultural sector and fruit cultivation (apples). Statistics note that livestock farming also plays a central role in the local economy, especially Fassona-type cattle farms. In the secondary sector, two manufacturing industry activities are most prevalent: paper mills and furniture factories. Woodworking for the production of furniture is the sector in which there is the greatest specialization, and we can speak of a true wood district stretching from Saluzzo to Crissolo. Not surprisingly, at the beginning of 2016, an agreement was signed in Saluzzo to create the "Saluzzo and Monviso Valleys Wood Cluster." The project leader was the City of Saluzzo. The project had the support of 16 entities: from the Monviso Mountain Unions to nearby schools (Afp of Dronero, Apm, Denina Institute and Soleri-Bertoni High School in Saluzzo) to the Po River Basin Consortium. The construction sector also seems to still have some importance, as does the mining of the local stone, slangily called "Luserna stone." In the tertiary and service sector, unique and undisputed is the activity related to alpine tourism. The Monviso Nature Park is an unmissable destination for ski mountaineering and exploratory trekking activities. Although the sector arranges facilities for winter and summer hospitality, we see in a phase of adjusting them. As far as forestry is concerned, the activity has long been shelved but, thanks to targeted projects in the area, it has been making a comeback for the past few years, driven mainly by the Ostanese municipality. For future growth, it does not appear that the scale of priorities is directed toward specific goals, but there is an increased focus on the tourism and hospitality sector. In this regard, the promotion of tourism around Monviso with the enhancement of bicycle routes should be noted.

Dati ISTAT 2019	Numero famiglie	Età media
BAGNOLO	2555	44,8
BARGE	3171	44,3
BRONDELLO	142	47,9
CRISSOLO	108	50
GAMBASCA	165	45,3
MARTINIANA PO	329	46,6
OSTANA	54	51,7
PAESANA	1373	49
PAGNO	264	45,9
SANFRONT	1058	47,1

DATI ISTAT 2019	2016 Reddito medio [€/persona]	2017 Reddito medio [€/persona]	2018 Reddito medio [€/persona]
BAGNOLO	12017,23	12230,64	12722,74
BARGE	11690,38	11778,79	12330,91
BRONDELLO	10110,53	10349,00	10754,82
CRISSOLO	12064,03	11171,95	12364,69
GAMBASCA	11661,20	11217,42	11787,03
MARTINIANA PO	12695,06	11860,79	11947,06
OSTANA	14973,17	15588,63	16558,84
PAESANA	12788,31	12877,40	13678,51
PAGNO	12499,75	12759,21	13152,30
SANFRONT	12524,85	12679,16	13371,81
MEDIA	12302,45	12251,30	12866,87

Figure 40. Average person income of the constituent countries of the energy community.



Local average income values refer to ISTAT 2019 data. ISTAT itself states that it acquired the data from the tax returns of the MEF - Department of Finance. The statistical basis takes into account

the Income, Irap and VAT declaration forms for all types of taxpayers; for individuals only, the 730 and CU (Single Certification) forms are also processed. To best frame the local economy, we need to check its contextualization at the national level. The MEF itself states as of 2019 that the income class between 12,000 and 15,000 euros covers 7.84 percent of national taxpayers. The largest percentage of Italian taxpayers enter an income class between 20,000 and 26,000 euros; this category alone covers 15.77 percent of the Italian population. So the Monviso area cannot be classified as an economically affluent area. However, it must be considered that in the statistics about 30% of the resident population is over 60 years old, thus with retirement income lowering the average values of total income. The percentage of retirement income compared to overall income for each municipality can be viewed below.
For the local building stock, the reference database for the analysis was the BDTRE, updated to 2019, of the Piedmont Region Geoportal. In the following image we can see the distribution of buildings. The highest density coincides with the historic centers of the small towns.

Figure 41. Monviso area buildings

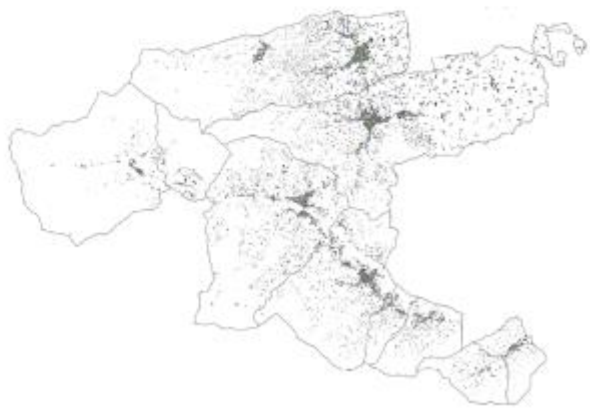
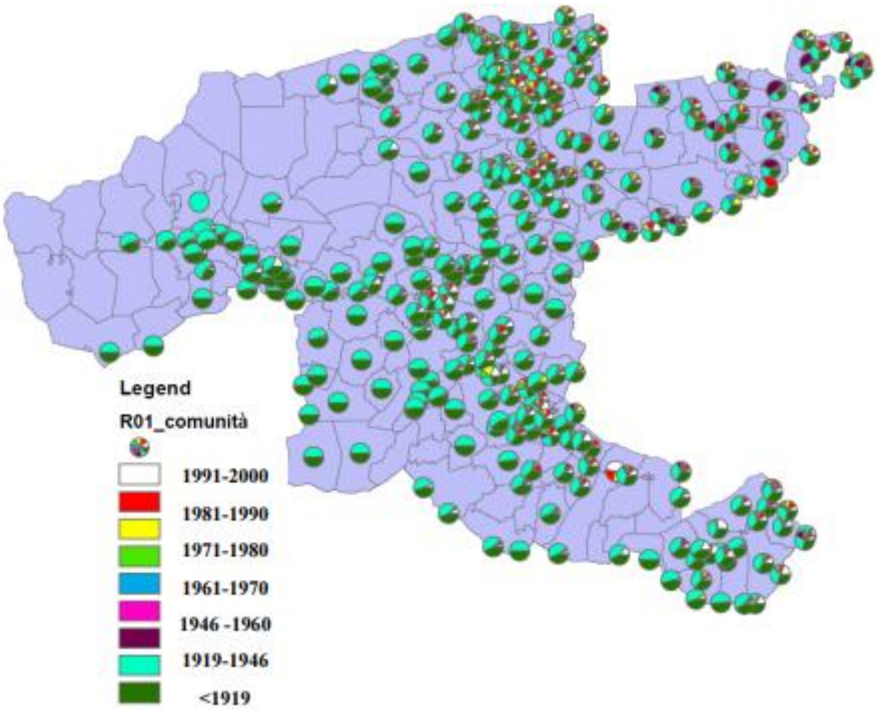


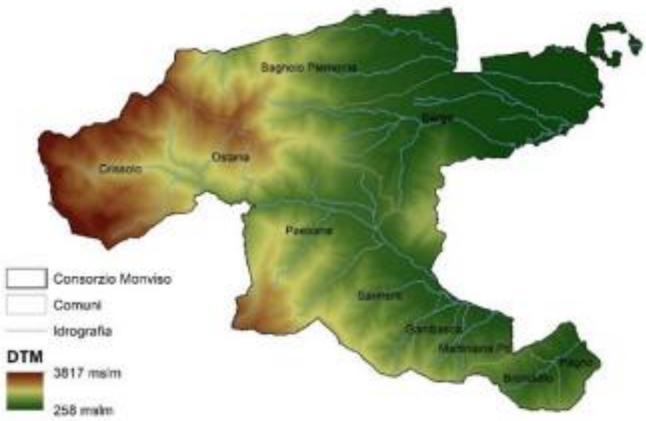
Figure 42. Buildings constitution map



The housing stock is not very recent, with the majority of buildings having been constructed between shortly before World War I. This peculiarity is accentuated in the historic centers of the municipalities of Crissolo, Paesana, and the rural areas of the other municipalities. The analysis of the buildings is crucial for the choice of energy technologies to be applied in the future CER as well as for energy efficiency choices. The technologies should be efficient but at the same time should not compromise the precarious structure of older buildings.

MORPHOLOGY OF THE TERRITORY

Figure 43. Othermetric map Monviso area.

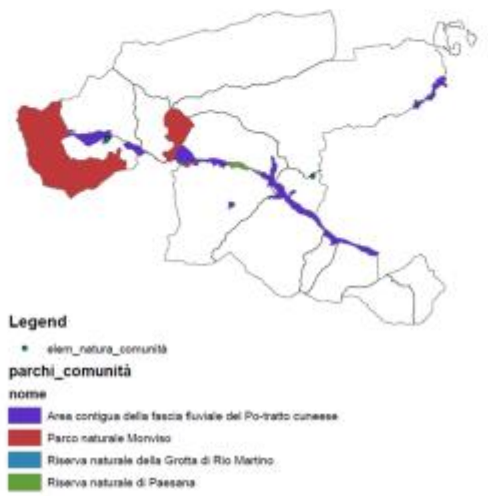


The territory under consideration is located in the Cottian Alps plexus, at the northern edge of the Province of Cuneo. It is bordered to the south by Val Varaita, to the west by France, to the north by Val Pellice in the province of Turin, and to the east by the Po plain. It is a mountainous territory even though the municipalities of Barge and Bagnolo are located on a strip of lowland territory, thus excluded from the limits of administrative competence of the Mountain Communities, but included in the analysis of the present one. At a general level, the territory sees the presence of 20952 inhabitants (as of January 1, 2018) and a total area of 347.18 sq. km. The average altitude is around 651 m.a.s.l.

Figure 44. Map of the area above 600 m above sea level showing the location of Mount Viso and Mount Bracco.

Figure 45. Map and geographical designation of local valleys.

Figure 46. Map of the protected area of Monviso Nature Park showing the



As is clearly visible in Figure 31, the area is morphologically made up of the combination of several Valleys. The valleys are distinguished into:

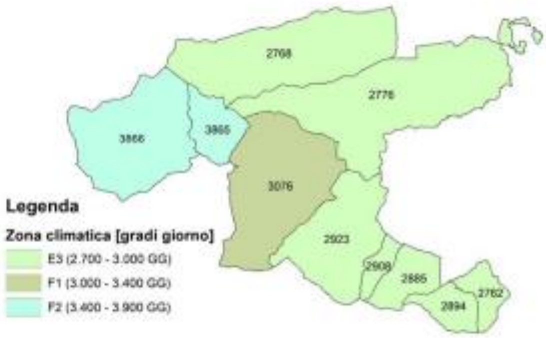
- Val Bronda, bordered to the south by the territory of the Val Varaita Mountain Community and includes the municipalities of Pagno and Brondello.
- Po Valley that from Monviso (m 3848) and the border ridge with Queyras (France), descends to the plain. The territory is very varied, passing from high-altitude views to mid-mountain environments. The Po Valley as a whole affects the municipalities of: Crissolo, Ostana, Oncino, Paesana, Sanfront, Gambasca and Martiniana Po.
- Mount Bracco massif, whose peak culminates at m 1306, rises between the border of Paesana and Barge. It towers over the plain appearing detached from the overall design of the Valleys. Mount Bracco partially affects the territory of Paesana, Sanfront and Barge.
- Infernotto Valley forms a deep furrow north of the Po Valley. It originates from the Punta d'Ostanetta (m 2,375) and extends to the village of Barge. Administratively, the right slope falls in the municipality of Barge, while the left slope falls mainly in the municipality of Bagnolo.
- Grana stream overlooks the municipality of Bagnolo and forms the watershed with the Pellice stream basin.
- the Po riverbed by encompassing the floodplain stretches of the Infernotto stream, which in Barge is named Ghiandone, and the Grana stream, which flows into the Po at Staffarda Abbey. The wide plain territory, structured on several terraces, is subjected to intense and rational agricultural use with orchards, forage crops and poplar groves. Administratively, the plain falls on part of the municipal territories of Barge and Bagnolo.

Dati ISTAT 2019	Popolazione 01/01/2018	Superficie [kmq]	zona sismica	zona climatica	GG	altitudine [mslm]
BAGNOLO	5969	63,25	3S	E	2768	365
BARGE	7699	81,99	3S	E	2776	372
BRONDELLO	275	10,12	3S	E	2894	467
CRISSOLO	162	52,05	3S	F	3866	1318
GAMBASCA	358	5,74	3S	E	2908	478
MARTINIANA PO	761	13,28	3S	E	2885	460
OSTANA	81	14,09	3S	F	3865	1250
PAESANA	2724	58,27	3S	F	3076	614
PAGNO	569	8,68	3S	E	2762	362
SANFRONT	2354	39,71	3S	E	2923	490

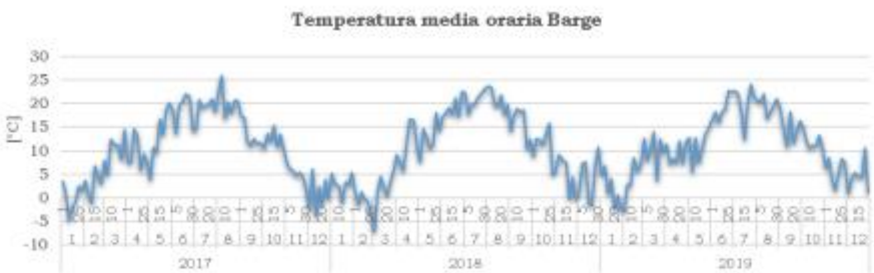
CLIMATE DATA.

By accessing Arpa Piedmont databases, it was possible to assess the climate scenario of the Valley. Arpa monitoring stations are located at three points in the valley: at Barge, Crissolo Po, and Paesana Erasca. From the analysis of degree days, the area is predominantly under class E, except for three municipalities such as Ostana, Paesana and Crissolo which are in class F. The Day Degrees presented here refer to Tab A attached to Presidential Decree 412/93, updated to 2018.

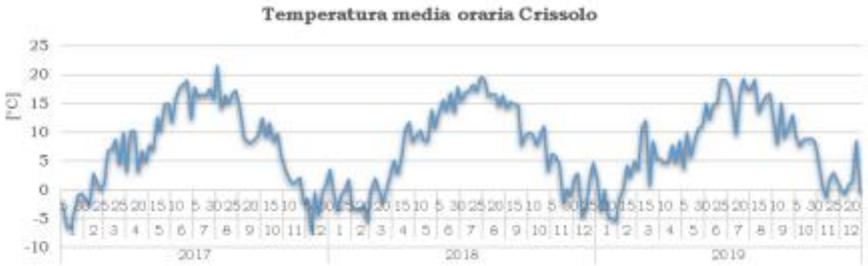
Figure 47. Map of municipal degree days.



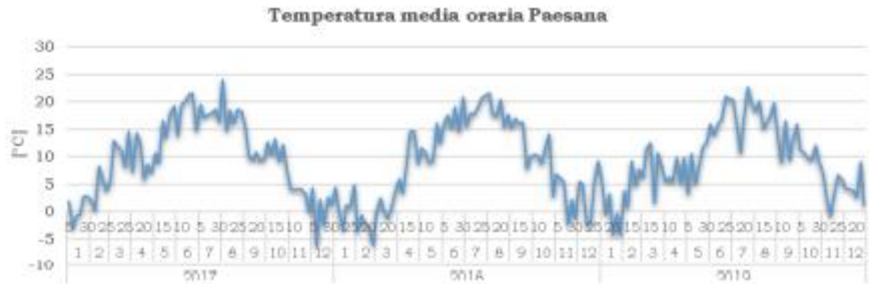
Hourly outdoor temperature data taken in Barge by Arpa Piemonte are graphed as follows:



From Crissolo, the hourly outdoor temperature data are slightly lower than from Barge, their trend is as follows:

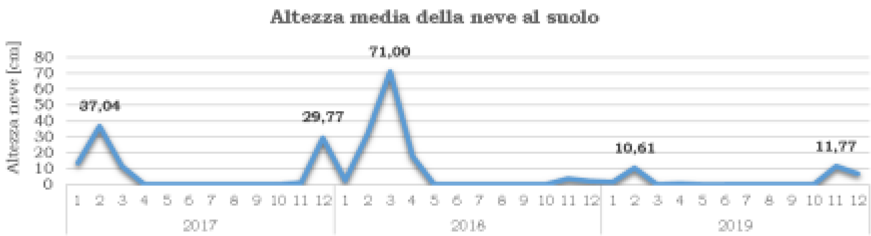


The last sampling point of Arpa Piemonte is in Paesana. The outdoor temperature recorded with hourly time step is as follows:



We can see that the temperatures recorded in the three municipalities are very similar in both trend and values. For modeling purposes, especially forecasting, it was decided not to calculate an average temperature between the three points but to group the municipalities into three zones and assign a reference ARPA station to each zone. The measurements from the ARPA station in Barge were the reference for the loads in Bagnolo Piemonte and Barge. The ARPA measurements from Crissolo were the reference for Crissolo and Ostana. Finally, ARPA measurements from Paesana were reference for the remaining area: Paesana, Brondello, Gambasca, Martiniana Po, Pagno, and Sanfront.

AVERAGE ANNUAL SNOWFALL HEIGHT



The graph under consideration shows ARPA Piedmont data collected at the Paesana Erasca meteo-rological station. The average monthly values of snowfall [cm/month] are shown; the data will then be useful for subsequent calculations of energy production from photovoltaics. The Po Valley falls in the rainfall regime zone defined as Prealpine type B in which there is a maximum precipitation in winter, main minimum in spring and secondary minimum in autumn. The presence of the Monviso massif at the head of the valley blocks the moist currents coming from the plain, favoring high precipitation that is around 30 cm, with peaks in the Infernotto Valley.

8.2.5.2 ENERGY AND EMISSION BALANCE

After the introductory phase on the methodology, it is possible to forward us to the details of the processing carried out. This chapter will present the output sheets generated for each municipality after acquiring the necessary data. The cataloging is divided into three outputs: the definition analyses that show the trends of the global loads of all municipal buildings in that territory; the resource analyses that explain the differences between the energy supply resources; and the numerical analyses that summarize with a single data the average electrical and thermal consumption of the building plexus. Upon completion of the municipal sheets, the data will be compared in parallel to better verify the different energy demand positions of each municipal area.

Thermal forecasting model

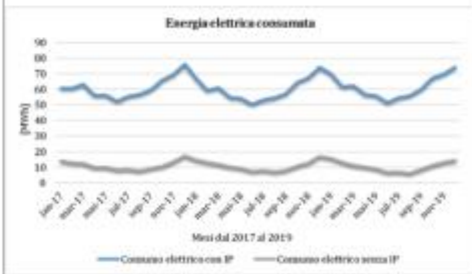
Thermal consumption of natural gas is the consumption that most led to transmission gaps. Thermal values of other sources such as pellets, LPG or diesel fuel were collected from the annual invoices stipulated between supplier and PA. These are values for which the monthly detail is missing a priori. To complete the missing values for natural gas, a graphical interpolation formula was implemented, dependent on the outdoor temperature recorded by ARPA stations.

$$Cosnumo\ mensile\ [Sm3] = \frac{Temperatura\ esterna\ effettiva\ [°C]}{(Temperatura\ di\ riferimento\ [°C]\ ) * (Consumo\ mensile\ di\ riferimentio\ [Sm3])}$$

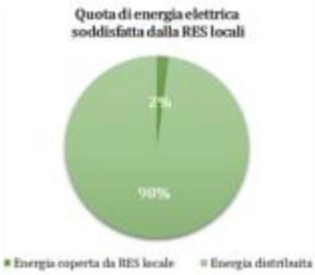
Bagnolo Piemonte

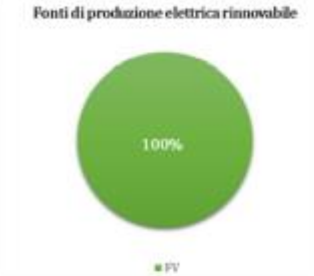
Dati generali			
Popolazione	5972	Punti POD considerati	81 di cui 60 IP
Superficie [kmq]	63,1	Edifici riscaldati	12

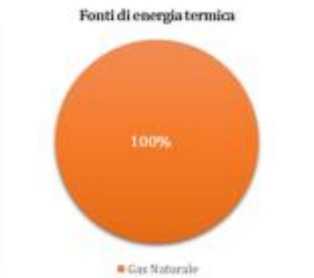
Output analisi dei dati comunali



Output analisi delle risorse







Output numerici

Energia elettrica mediamente consumata in un anno:

710,25 MWh

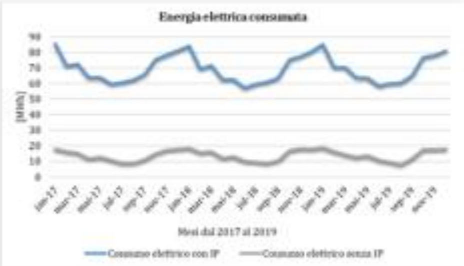
Energia termica mediamente consumata in un anno:

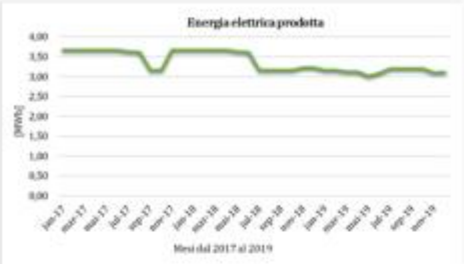
858,75 MWh

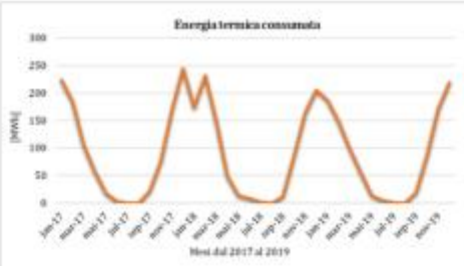
Barge

Dati generali			
Popolazione	7549	Punti POD considerati	106 di cui 76 IP
Superficie [kmq]	81,99	Edifici riscaldati	16

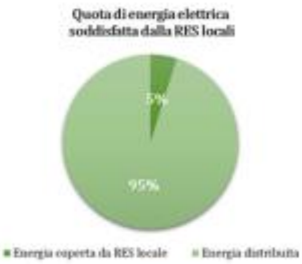
Output analisi dei dati comunali

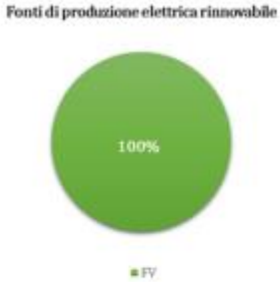


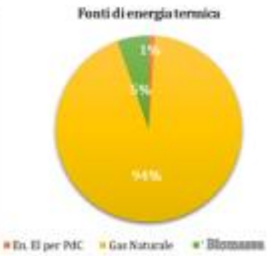




Output analisi delle risorse







Output numerici

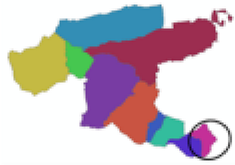
Energia elettrica mediamente consumata in un anno:

832,66 MWh

Energia termica mediamente consumata in un anno:

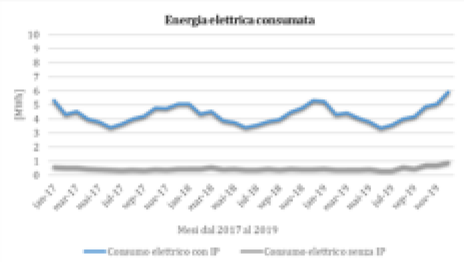
1069,33 MWh

Brondello

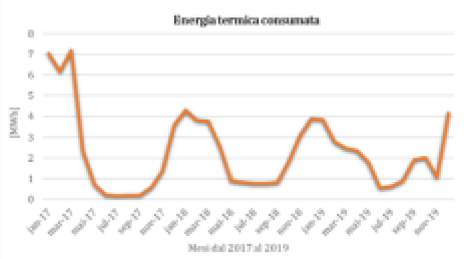


Dati generali			
Popolazione	279	Punti POD considerati	45 di cui 39 IP
Superficie [kmq]	10,12	Edifici riscaldati	6

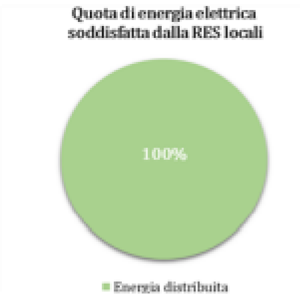
Output analisi dei dati comunali



Non hanno impianti di fonti rinnovabili installati



Output analisi delle risorse



Output numerici

Energia elettrica mediamente consumata in un anno:

51,73 MWh

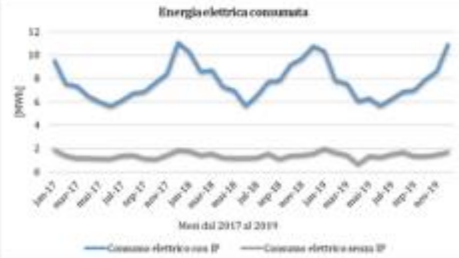
Energia termica mediamente consumata in un anno:

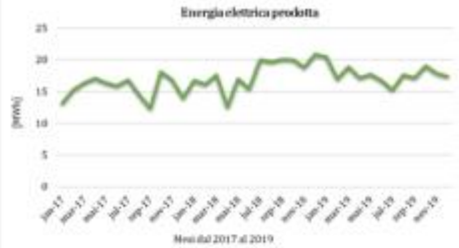
27,24 MWh

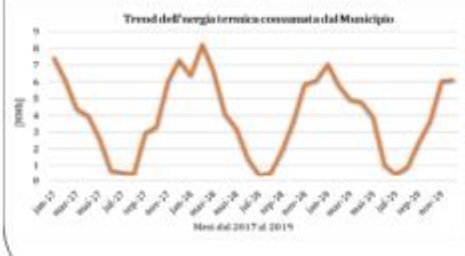
Crissolo

Dati generali			
Popolazione	158	Punti POD considerati	18 di cui 10 IP
Superficie [kmq]	52	Edifici riscaldati	1

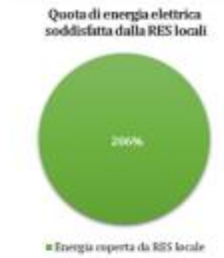
Output analisi dei dati comunali

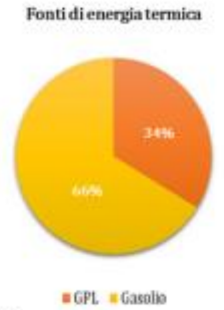






Output analisi delle risorse





Output numerici

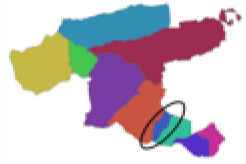
Energia elettrica mediamente consumata in un anno:

99,63 MWh

Energia termica mediamente consumata in un anno:

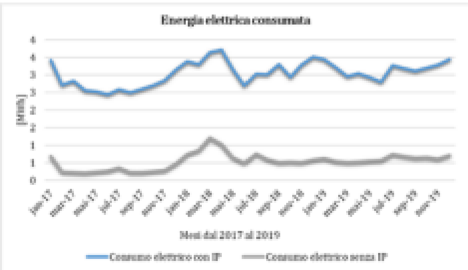
36,06 MWh

Gambasca



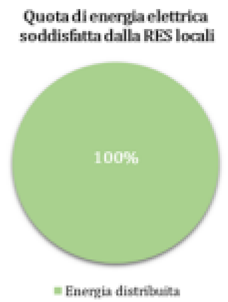
Dati generali			
Popolazione	341	Punti POD considerati	24 di cui 18 IP
Superficie [kmq]	5,74	Edifici riscaldati	1

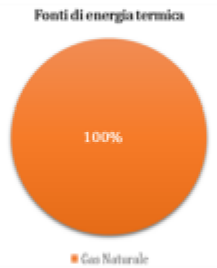
Output analisi dei dati comunali



Non hanno impianti di fonti rinnovabili installati

Output analisi delle risorse





Output numerici

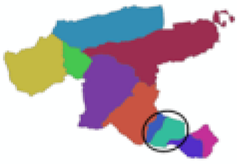
Energia elettrica mediamente consumata in un anno:

36,56 MWh

Energia termica mediamente consumata in un anno:

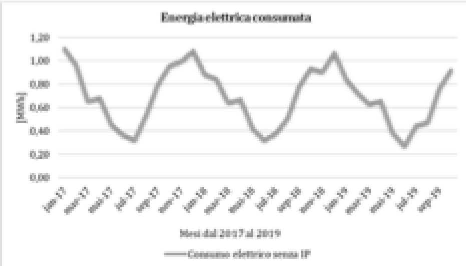
43,60 MWh

Martiniana Po



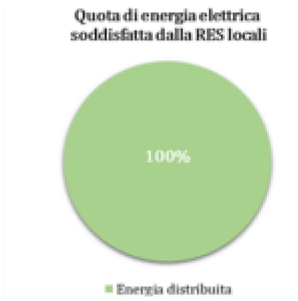
Dati generali			
Popolazione	770	Punti POD considerati	3
Superficie [kmq]	13	Edifici riscaldati	7

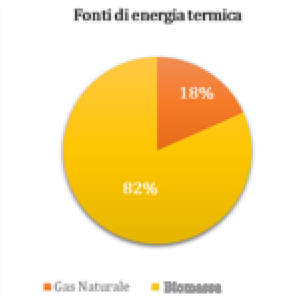
Output analisi dei dati comunali



Non hanno impianti di fonti rinnovabili installati

Output analisi delle risorse





Output numerici

Energia elettrica mediamente consumata in un anno:

8,45 MWh

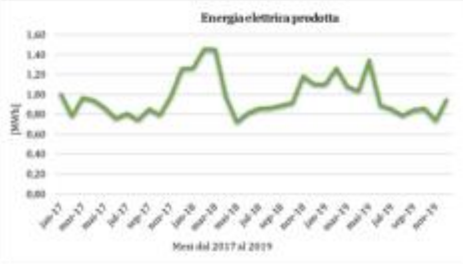
Energia termica mediamente consumata in un anno:

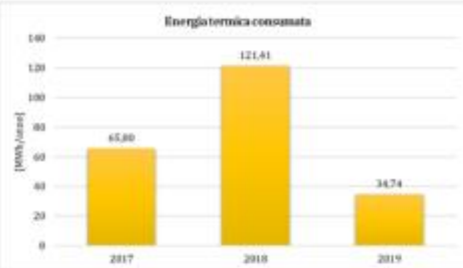
206,20 MWh

Ostana

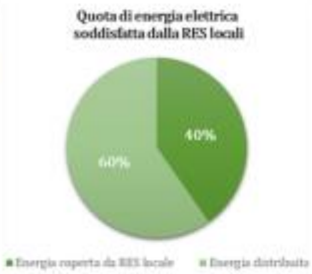
Dati generali			
Popolazione	89	Punti POD considerati	5 di cui 1 IP
Superficie [kmq]	19.98	Edifici riscaldati	3

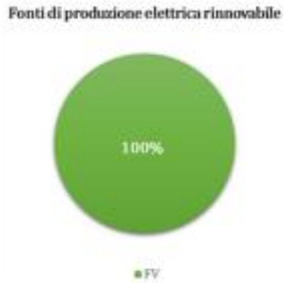
Output analisi dei dati comunali

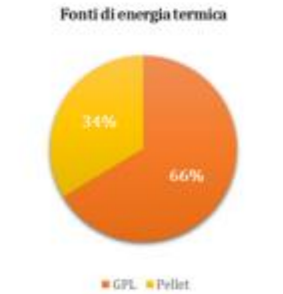




Output analisi delle risorse







Output numerici

Energia elettrica mediamente consumata in un anno:

23,09 MWh

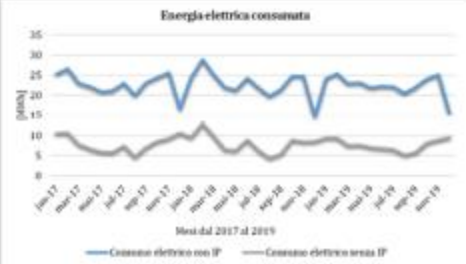
Energia termica mediamente consumata in un anno:

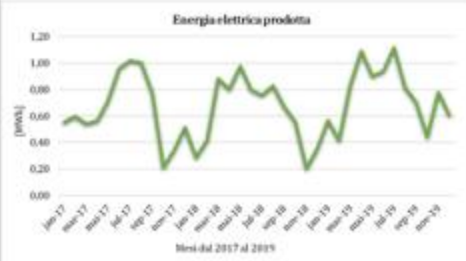
73,98 MWh

Paesana

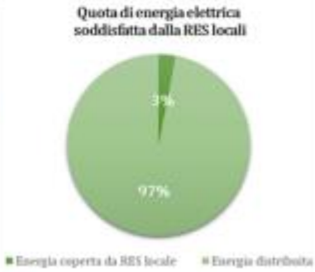
Dati generali			
Popolazione	2733	Punti POD considerati	72 di cui 56 IP
Superficie [kmq]	58,1	Edifici riscaldati	3

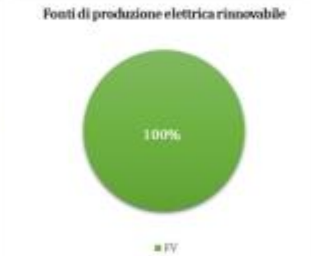
Output analisi dei dati comunali

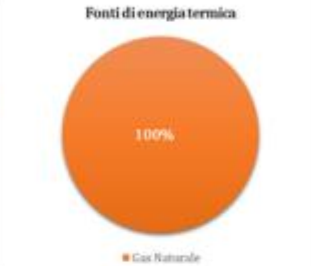




Output analisi delle risorse







Output numerici

Energia elettrica mediamente consumata in un anno:

271, 68 MWh

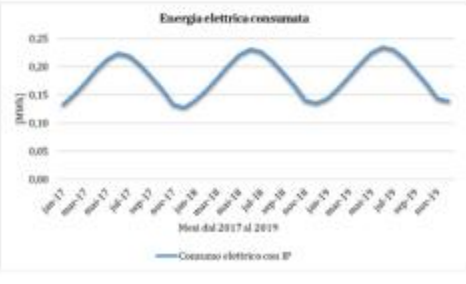
Energia termica mediamente consumata in un anno:

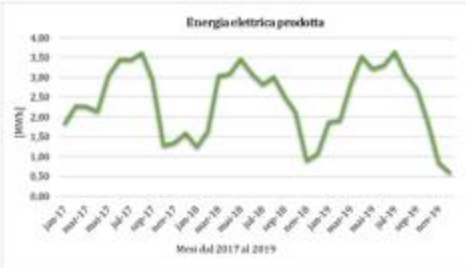
378, 20 MWh

Pagno

Dati generali			
Popolazione	583	Punti POD considerati	200 IP modellizzato
Superficie [kmq]	8,4	Edifici riscaldati	1

Output analisi dei dati comunali

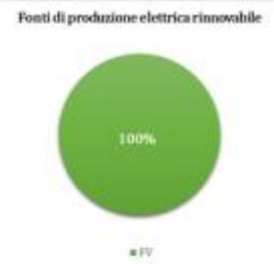


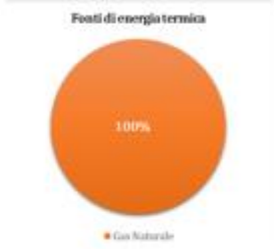


Output analisi delle risorse

L'energia elettrica necessaria all'illuminazione pubblica è fornita **100%** dall'ente distributore locale.

La quota prodotta dai pannelli fotovoltaici è utilizzata direttamente dagli edifici su cui sono stati installati. Per i suddetti edifici non sono noti i consumi





Output numerici

Energia elettrica mediamente consumata in un anno:

2,98 MWh

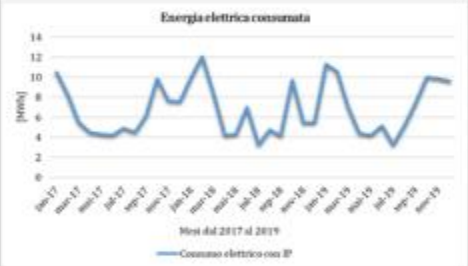
Energia termica mediamente consumata in un anno:

55,95 MWh

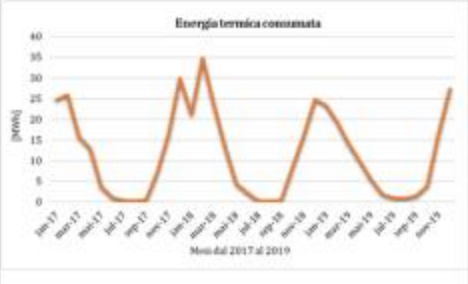
Sanfront

Dati generali			
Popolazione	2381	Punti POD considerati	17 di cui 3 IP
Superficie [kmq]	39,7	Edifici riscaldati	4

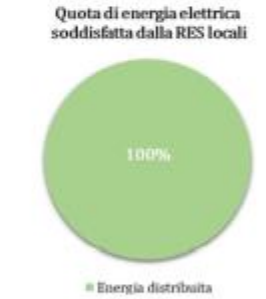
Output analisi dei dati comunali

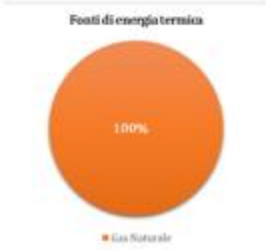


Non hanno impianti di fonti rinnovabili installati



Output analisi delle risorse





Output numerici

Energia elettrica mediamente consumata in un anno:

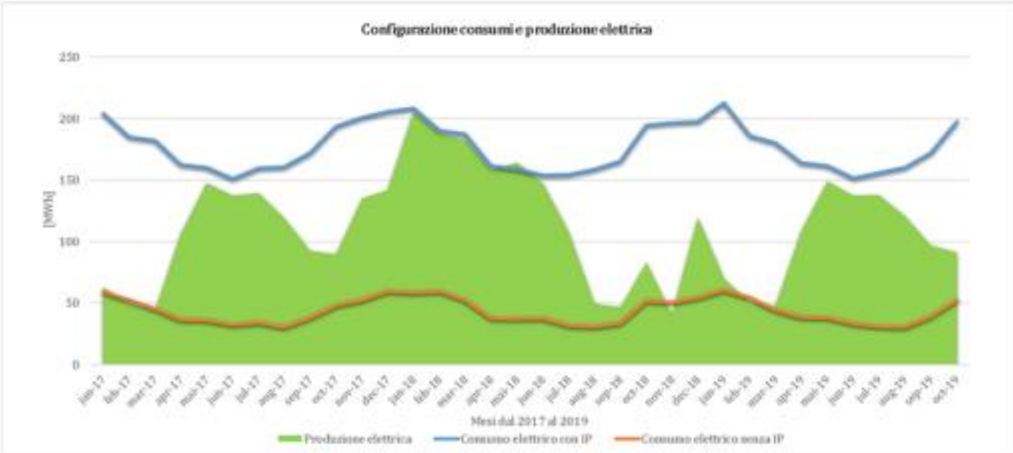
81,39 MWh

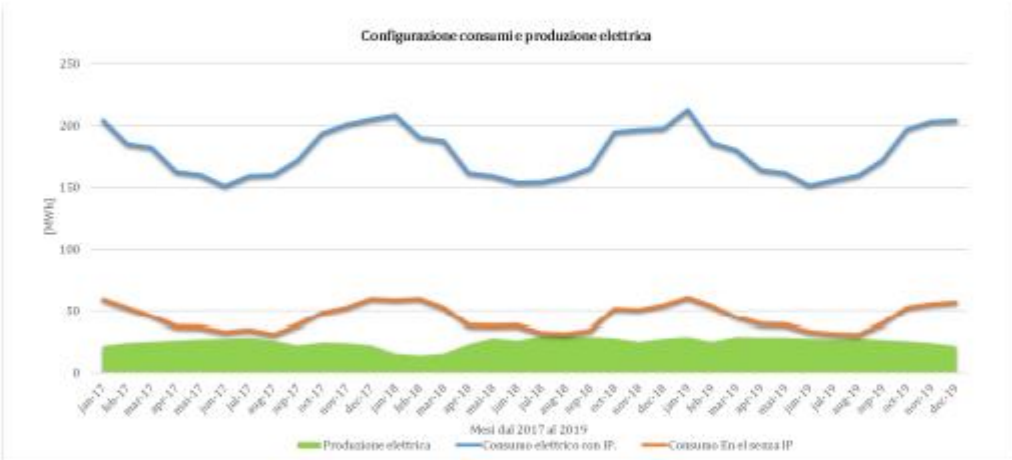
Energia termica mediamente consumata in un anno:

138 MWh

Comunità Monviso

Dati generali			
Popolazione	20644	Punti POD considerati	579 di cui 455 IP
Superficie [kmq]	347,2	Edifici riscaldati	54





General sheets cannot be useful unless viewed globally and compared. In practice, because of the way Italian regulations are structured, one cannot speak at the moment of a single Monviso ERC, but of several municipal aggregates headed by administrative body with the sole legal status. Despite this, regulations are constantly changing, and already in the Piedmont regional regulations, the ERC must be subject to the same TA cabin. In the overall balance between required electricity needs and current production, we have a scenario where BIM's electricity production is an integral part of the balance. Indeed, the production of the hydroelectric power plant cannot go unnoticed. It is a facility located on the Rio Laità, on the border between the municipalities of Paesana and Ostana. The plant has an installed capacity of more than 70 kWp, with an elevation drop of 400 m and a maximum concession flow rate of 22 liters/second. Its average annual producibility is 330 MWh.

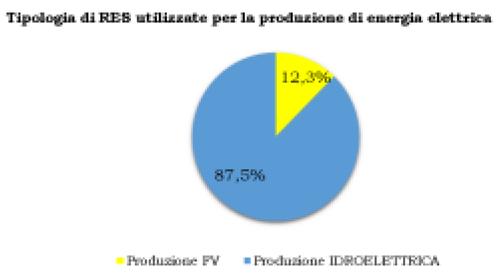
Figure 48. Image hydroelectric power plant operated by BIM.

The peak power currently installed in the municipalities is presented in the Table below. From the Atlaimpianti portal, each individual plant's contract with the GSE was verified. All the plants in our review are currently incentivized by the GSE.

Figure 49. Installed powers

COMUNE	EDIFICIO	INDIRIZZO	CONTRATTO CON GSE	POT [kW]
BAGNOLO	Scuola Elementare Nuova	via don milani 9	SSP	20
BARGE	Scuola Materna Capoluogo	via c.po sportivo 20	CE	5,5
BARGE	Scuola Materna E Primaria San Martino	via crocetta 2	CE	10
BARGE	Scuola Primaria Crocera	via cuneo	CE	3,96
BARGE	Impianti Sportivi	via azienda moschetti 5	CE	17,64
CRISSOLO	Fotovoltaico Isolato	via ruata 1	SSP	20
CRISSOLO	Centralina Idroelettrica Isolata	frazione serre	RID	18
OSTANA	Autorimessa	piazza caduti per la libertà	SSP + CE	8,28
PAESANA	Scuola Infnazia	via reinaud	SSP	10
PAGNO	Scuola Infanzia	via caduti	SSP	9,8
PAGNO	Mercato Coperto	piazza mercato	SSP	17,3

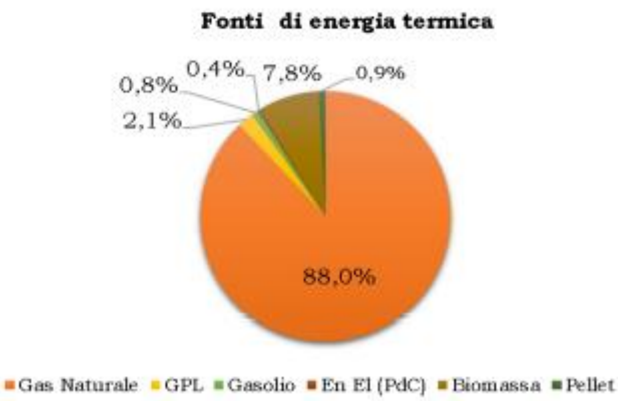
We can summarize all the data previously described through graphical structures.



From the thermal point of view, on the other hand, the overall balance of Monviso is shown below.

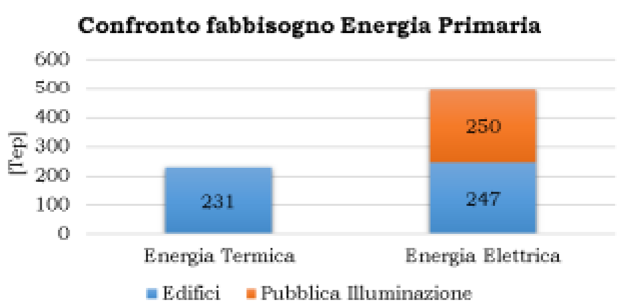
In winter, thermal energy demand touches as high as 638 MWh, values that are not comparable with electric energy demands. In the resource plan, thermal demand presents a more colorful scenario. The largest supply is covered by natural gas, however, we must recognize the strong deficiency of RES on the thermal side. We can speak of renewable supplies only in the case of district heating systems. TLR structures are present in Barge and Martiniana Po (both managed by Comat Energia s.r.l. - EDISON S.p.a. group. - but both networks are excluded from ARERA regulation.) All remaining thermal demand is, de facto, provided by fossil sources. The following graph clarifies the distribution of resources in percentages.

Figure 50. Percentage distribution of local thermal resources.



At the level of consumption, it is clear that thermal consumption is definitely more relevant than electrical. But, given the different nature of the resources involved, we must distinguish the actual primary energy demand, expressed in TEP, that such consumption sees involved. The conversion parameters of FIRE (Italian Foundation for the Rational Use of Energy) were applied to convert the values to TEP. The conversion coefficients adopted by FIRE are based on what is provided in point 13 of the MiSE circular of December 18, 2014.

Figure 51. - Comparison of thermal and electrical primary energy.



From the comparison examined, the starting situation appears to be overturned. The primary energy on the electric side exceeds the thermal primary energy by 16 units, and if we were to consider at that share the electric energy required for street lighting alone this disparity increases. This scenario, apparently, should not be labeled as unexpected. Almost all electricity is supplied by the national grid and FIRE parameters are very stringent on this form of supply. In fact, to electricity, whether supplied from the grid or supplied by photovoltaics, FIRE assigns a conversion of 0.187 [toe/MWh] while for a thermal source such as natural gas the parameter changes to 0.000861 [toe/MWh]. Once we have determined the primary energy demand, we need to proceed with comparisons between municipalities in the ERC and point to the numerical values.

EMISSION BALANCE

The LIFE project involving the Monviso area explicitly aims to reduce CO2 emissions by 80 percent by 2050.

Emissive sources are divided into fossil and renewable. For each source, the plan is to apply a standard formulation:

$$Emissione\ [tCO2eq.] = Fattore\ di\ Emissione\ \left[\frac{tCO2eq}{MWh}\right] * Consumo\ energetico\ [MWh]^{2}$$

Emission factors are tabulated according to IPCC recommended values.

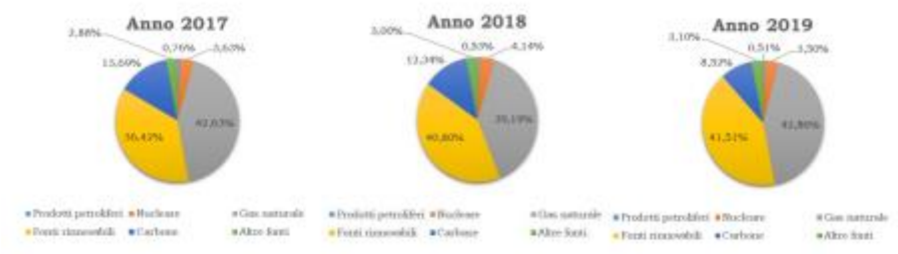
The IPCC is the acronym for an intergovernmental body that periodically reports on global climate change. The body estimates the emissive factors of a resource based on the scientific reports inherent in that resource and normalizes that result based on global climate change. The value will always be lower than a value estimated using LCA methodology, but it is necessary to compare both to avoid one-size-fits-all knowledge of pollutant impacts. The database values used are updated to the 2018 PAES Template and can be summarized in the following table:

METODO	UNITÀ DI MISURA	TIPOLOGIA DI RISORSA	VALORE
LCA	tCO2eq/kWh	Batteria Li-ion	0,089
	tCO2eq/MWh	Energia Elettrica della rete nazionale	0,708
	tCO2eq/MWh	Energia elettrica di FV	0,050
	tCO2eq/MWh	Biomassa locale	0,002
	tCO2eq/MWh	Biomassa non locale	0,405
	tCO2eq/MWh	Gas Naturale	0,237
	tCO2eq/MWh	Gasolio	0,307
	tCO2eq/MWh	GPL	n.a.
	tCO2eq/MWh	Pellet	n.a.
IPCC	tCO2eq/kWh	Batteria Li-ion	0,00
	tCO2eq/MWh	Energia Elettrica della rete nazionale	0,343
	tCO2eq/MWh	Energia elettrica di FV	0,00
	tCO2eq/MWh	Biomassa locale	0,00
	tCO2eq/MWh	Biomassa non locale	0,401
	tCO2eq/MWh	Gas Naturale	0,202
	tCO2eq/MWh	Gasolio	0,268
	tCO2eq/MWh	GPL	0,227
	tCO2eq/MWh	Pellet	0,367

For electricity, emission calculations require a separation of resources. To date, 7 percent of total municipal consumption is covered by PVs.

Emissions from CO2, in parallel with primary energy consumption, see electrical resources excel. Given the fossil-intensive nature with which the same is generated in Italy, such an output should not be surprising. The reality of the facts also prompted an analysis of the types and percentages of resources with which electricity supply was secured from the local distributor (EDistribuzione) over the three years.

Figure 52. Percentage composition of electric resources used by the local distributor from 2017 to 2019.



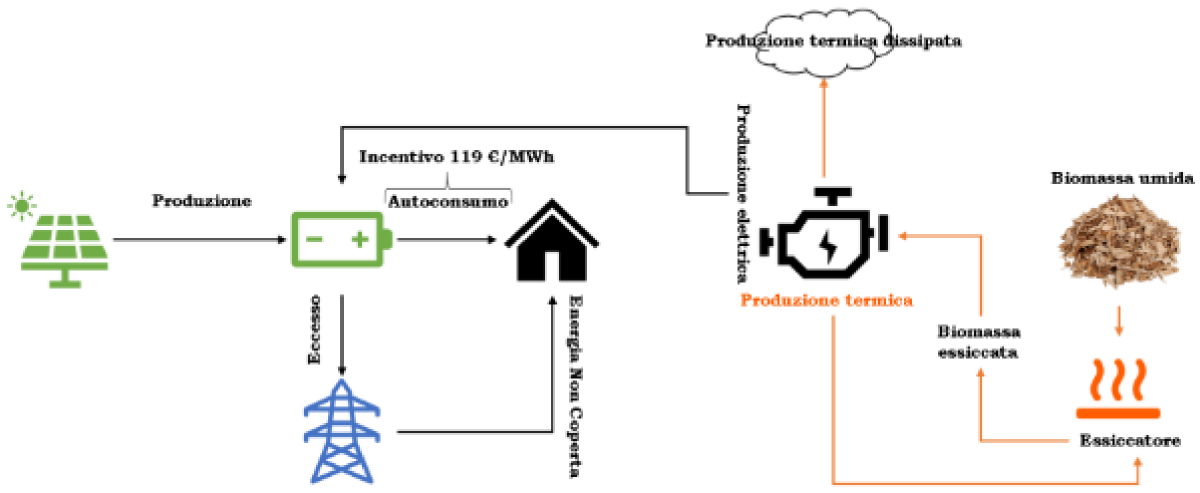
The result sees almost equal use of renewable resources and natural gas, the percentage of coal used is small but given its high emission value it affects the overall outcome of tons of CO2 equivalent produced. The distribution of natural gas in Italy sees, due to its complexity, an inefficient and high-emissive production process but despite this aspect it is exploited by the entire population and is perceived as a strongly ecological resource compared to biomass.

8.2.5.3 PROPOSED SCENARIO FOR THE ENERGY COMMUNITY

After data analysis, the proposed community scenario assumes that the latter is as described by the national RED II Energy Community legislation where old photovoltaic and hydro are not considered to be the subject of incentive for the electricity consumed by the ERC. The establishment of the community also aims for a decrease in annual CO2 emissions and thus the establishment of a scenario that is able to achieve a significant decrease in emissions.
After evaluating several possible scenarios, it was concluded that the scenario that allows up to 35 percent reduction in emissions is structured as follows:

- 100 kWp of new photovoltaics (in addition to the one already installed);
- 90 kWh lithium battery;
- 50 kWel of CHP;

Figure 53. Outline of the Monviso energy community scenario



With this configuration, considering a total community electricity consumption of 2706106 kWh/year. This scenario guarantees an electrical production from renewable sources of 1464462 kWh/year, a self-consumption of 86% and a percentage of self-consumed REN of total consumption of 42%. The emission reduction is around 30%.

9 CONCLUSIONS

In conclusion, considering all the assumed interventions, a reduction in consumption in the public sector of 50 percent and in the private sector of 70 percent is calculated. Then considering the savings on primary energy and assuming that the emission coefficient of electricity and heats taken from the grid will be halved in 2050 due to the takeover on the grid of renewable methods of primary energy production, implementing all the interventions described in the paper in the various sectors, a total CO_2 emission reduction of 80% is achieved.