DELIVERABLE D.T2.2.1

Piemonte Energy Report Version n°0.1/2019

D.T2.2.1: Deliverable

A.T2.1 State of the art energy report

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1. EXECUTIVE SUMMARY

Piemonte is one of the 20 regions of the country and one of the 21 planning and statistical region of Italy (NUTS2). The second Italian largest region and the fifth considering population, with about 4.4 million of inhabitants. It is located in the northwest of Italy and borders with France from the west and Switzerland from the north (also across the border with the Valle d'Aosta). On the east borders mainly with Lombardia and on the south Liguria.

Main city is Turin, which with its metropolitan area covers about half of the regional population. The region is highly fragmented from an administrative point of view, with the highest number of municipalities at the Italian level 1,197.

The orographic context, with the presence of mountain massifs on three sides and the Po valley in the east, generate a strong territorial heterogeneity, also from the climatic point of view, mainly due to the strong variation of altitude between the different regional areas.

The border position, in the north-west of Italy, makes Piemonte a terminal region from the point of view of national electricity and gas networks (with the development of the main networks to Turin). At the same time, the location of the region makes it a transit corridor for the main networks (both energy and transport) to western and central Europe.

The presence of the area of the Po valley, and the high population and industrial density of the Po valley area, have allowed a much wider development of the infrastructures than in the rest of the country, with the construction of highly interconnected networks.

Piemonte, with all the Po valley, is historically the seat of the Italian productive poles. The region is closely linked to the industrial manufacturing sector and the automotive sector. Over the years, the industrial sector has been very concentrated in the territorial area of the city of Turin, which has led to a strongly centralized demographic structure in the capital and relative outskirts.

In the last decades, from an energetic point of view, the region has undergone profound changes, following a decline in consumption due to the economic crisis and a simultaneous increase in natural gas consumption due to the construction of an indigenous electricity generation park (4,5 GW based mainly on natural gas). The construction of the thermoelectric power plant, mainly operating in a cogeneration, also involved the development of district heating networks serving the regional metropolitan areas.

The historical presence of hydroelectric (2,7 GW + 1 GW of pumped hydro storage) and the recent development of renewable sources, especially solar (1,5 GW), biogas (147 MW) and biomasses (62 MW), allow the coverage of the regional electricity demand (25 TWh). So, the connection with the main interchange points with Switzerland and France means that Piemonte is essentially a region of transit and not of consumption for imported electricity.

The exploitation of biomass in the thermal sector, the development of district heating networks and the production of energy from renewable sources, mean that the coverage of regional final energy consumption (FEC) by renewable energy sources (RES) and derived heat is equal to 24%.

The regional FEC (126 TWh), covered uniformly by the transport, industry and residential sectors (29% each) and services (12%) is however strongly based on the use of fossil fuels, especially natural gas.

From the environmental point of view, this energy demand corresponds to a generation of CO2 of about 26,8 Mt, mainly linked to the transport and industrial sector due to the lower incidence of RES production.

2. INTRODUCTION

2.1. General description of the region

2.1.1 Geographical situation

Piemonte region is situated in the northwest of Italy, it is one of the 20 regions of the country and one of the 21 planning and statistical region of Italy (NUTS2).

Piemonte is the second largest region in Italy, it has an area of 25,387 km², and the fifth considering the population, with 4,404,200 inhabitants.

It consists of 8 Provinces, 1197 municipalities and, concerning the Regional Territorial Plan (PTR), 33 Areas of Territorial Integration (AIT).

The capital of Piemonte is Turin, also representing the biggest city in the region (almost 890 thousand of inhabitants), and the only one in the region with a population greater than 500,000.

Figure 1 Piemonte region

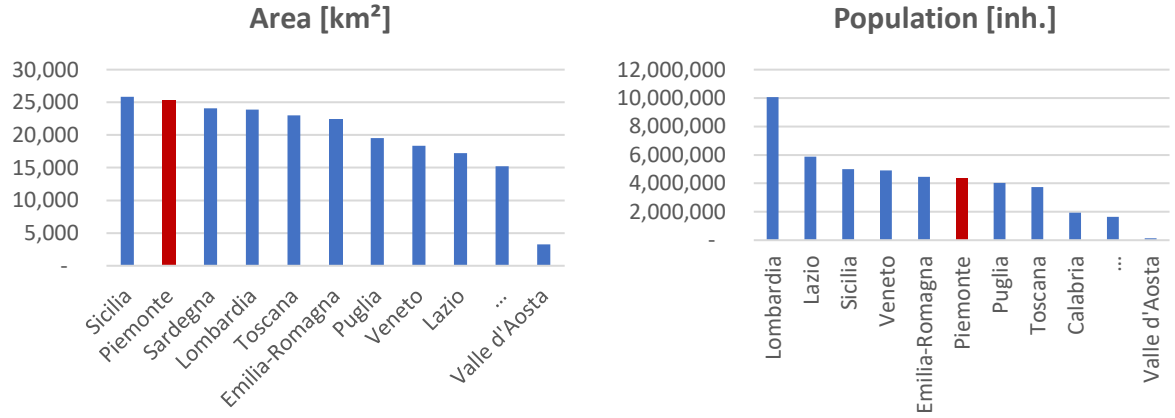


Figure 2 Area and population | Comparing with national data

Piemonte is surrounded on three sides by the Alps and by the Po valley on the last side. So, the geography of Piemonte is variable both from an orographic and climatic point of view, 43.3% is mountainous, along with extensive areas of hills (30.3%) and plains (26.4%).

Considering climate condition, the municipalities are in a wide range of altitude, from 70 MASL to 2039 MASL with the municipality of Sestriere (5165 Degree Days). Due to the orographic conditions and the different altitude, the temperature and the precipitations can vary moving from the Po valley towards the mountain municipalities. In the figure below the visualization of the isotherm and isohyets shows the high climatic variability of the regional territory.

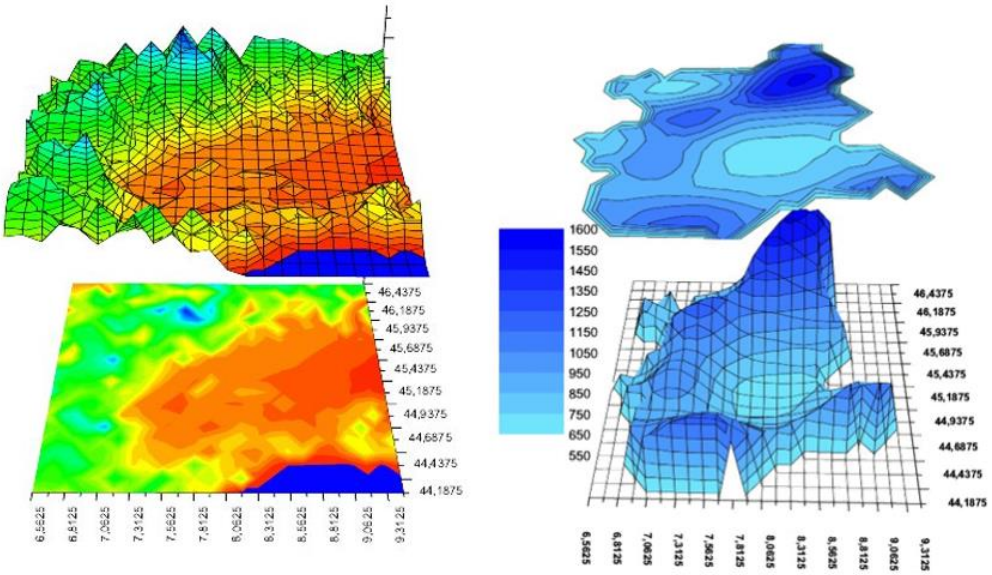


Figure 3 Climate data | Isotherm and isohyets | source: ARPA

2.1.2 Settlement structure

With 172 inhabitants/km² Piemonte is the 9th region in Italy, with a higher population density in the Turin metropolitan area and reduced in the other regional areas characterized by mountain and agricultural contexts. Almost ¼ of the population is in the city of Turin and ½ is in the Province of Turin.

The settlements structure sees, in addition to the city of Turin, a single municipality with more than 100,000 inhabitants, represented by the city of Novara (300 thousand inhabitants). The other major districts are represented by provincial capitals and municipalities located on the outskirts of Turin. In the remaining area the typical settlements are small and medium-sized villages, with a high percentage of municipalities in the range 1000÷5000 inhabitants (39%) and lower than 1000 inhabitants (50%).

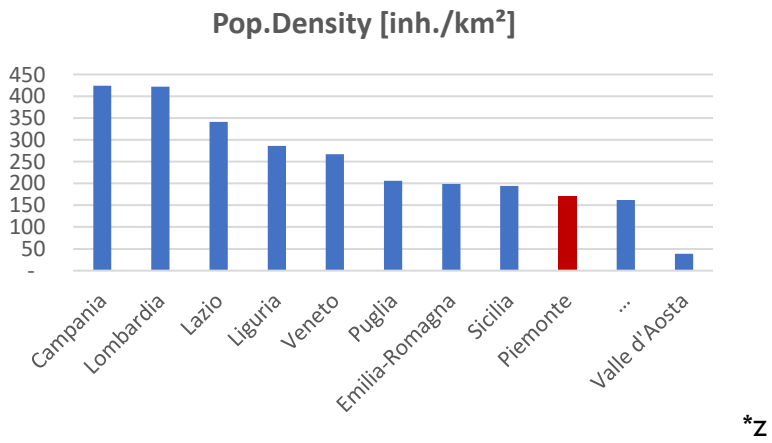


Figure 4 Population density | Comparing with national data

Table 1 Settlement structure of Italy and Piemonte Region

Settlement structure	National	Regional
Area (km²)	302,073.0	25,387.0
Population (thousands)	60,589.4	4,404.2
Number of municipalities (total)	7,960	1,197
Municipalities with inhabitants (number)		1,197
> 1.000.000		-
500.000 to<= 1.000.000		1
100.000 to < 500.000		1
50.000 to < 100.000		4
10.000 to < 50.000		60
5.000to < 10.000		69
1.000 to < 5.000		461
< 1.000		601

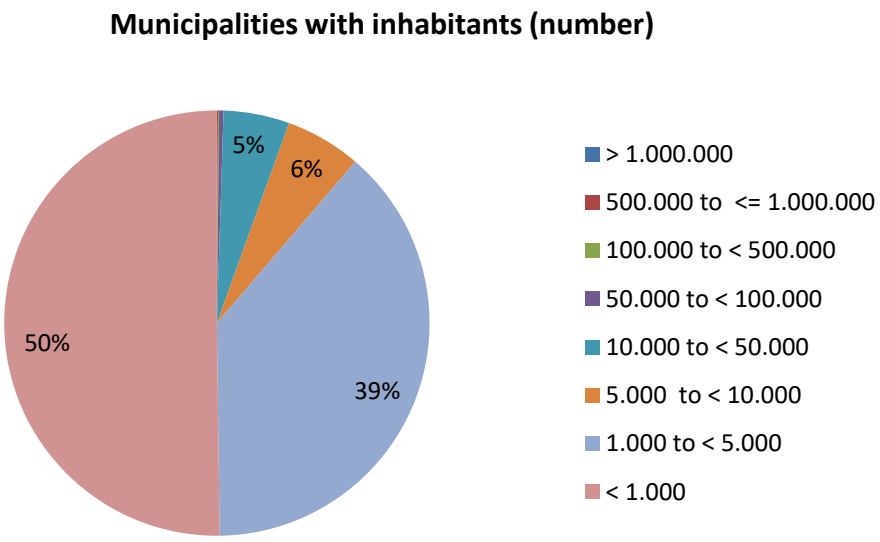


Figure 5 Municipalities with inhabitants

2.1.3 Demographic structure and development

2.1.3.1 Population

The population data at both national and regional level show a slightly increase in the long term (2003÷2018). However, the trend shows a little decreasing, focusing on the data available for the last three years (2015-2018).

Table 2 Population development | National and Regional data

Population development in thousands	National	Regional
2003	57,131	4,219
2005	57,875	4,272
2010	59,190	4,362
2015	60,796	4,424
2018	60,484	4,376

The regional trend, shown in the following figure, follows the national trend.

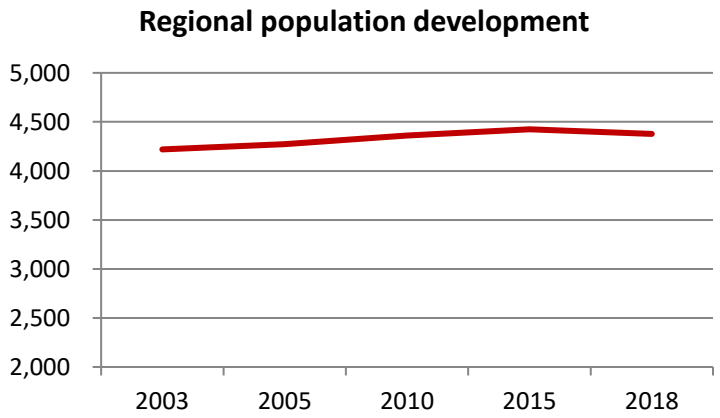


Figure 6 Regional population development

2.1.3.2 Households

Following graphs provide an overview of the development of households at national and regional level. At both national and regional level, the long term trend shows an increase in the number of households. However, a complete analysis must consider both the average size of the households. Considering the average dimension of the households the trend shows a decrease in the number of people in the family unit at national and regional level, as shown in Figure 8.

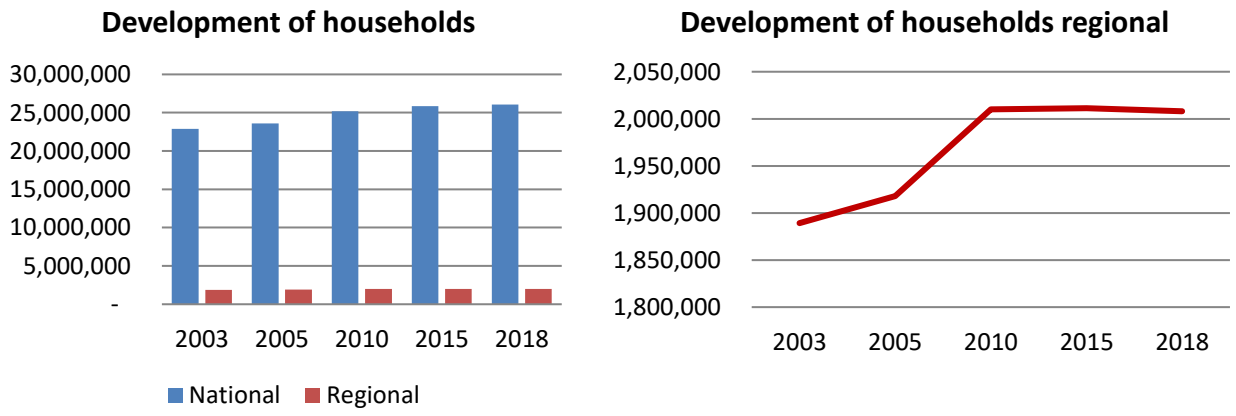


Figure 7 Development of households at regional and national level

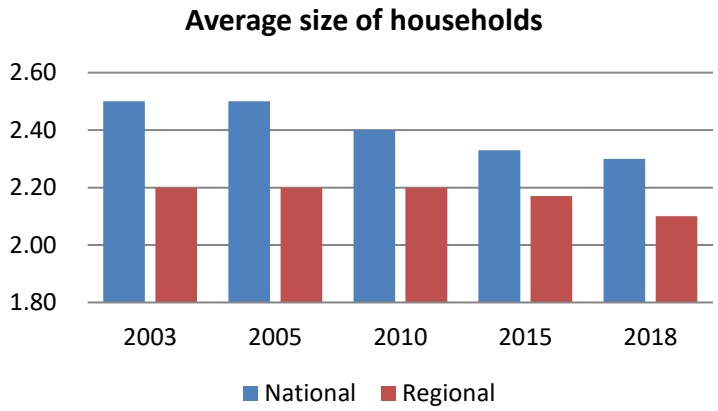


Figure 8 Average size of households

2.1.4 Regional economy

The regional economy analysis considers five different parameters:

- Income of households and Average Income of households
- Gross domestic product (GDP)
- Gross value added (GVA) and Number of employees

2.1.1.1. Income of households [M€] and Average income of households [€/HH]

The income of households shows an increase of 25% from 2000 to 2017, with a slightly lower trend than national data (+ 30%). The ratio between national and regional income of households has decrease from 8.5% to 8.2% from 2000 to 2017.

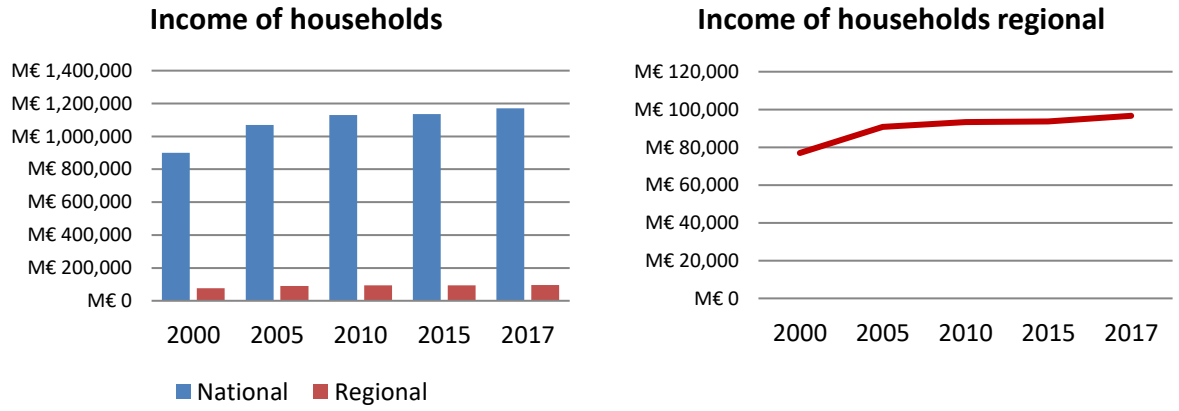


Figure 9 Income of households | National and regional data

Considering the average households' income, the regional data present values higher to the national average. For the years 2000 and 2017 the Piemonte average income of households was higher than the national data of 3% and 7%.

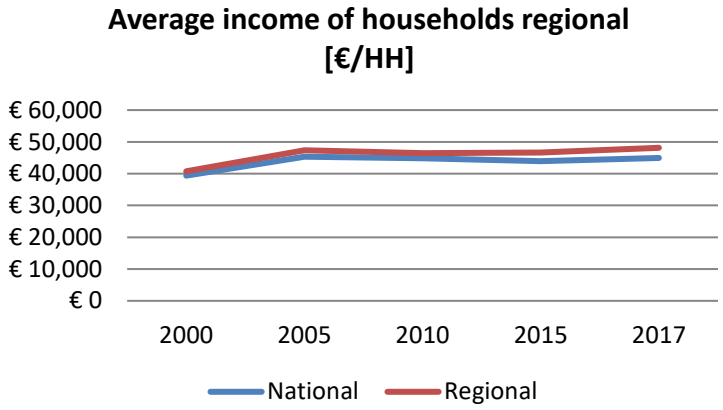


Figure 10 Average income of households

2.1.1.2. Gross Domestic Product (GDP)

GDP has seen continued growth within the region (+32%) and both at national level (+39%) from 2000 to 2017. The ratio between regional and national data shows a slightly reduction in the regional contribution to the national GDP, from 8,1% in 2000 to 7,7% in 2017, with absolute GDP values in 2017 of 132 700 M€ and 1,725,00 M€ at regional and national levels, respectively.

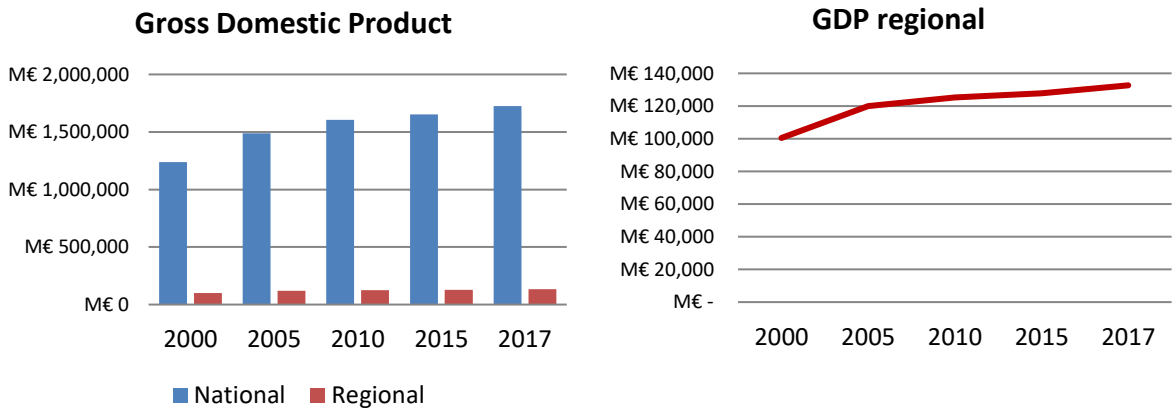


Figure 11 Gross Domestic Product | National and regional data

2.1.1.3. Gross Value Added and Number of employees

The comparison between GVA at national and regional level (Figure 12) shows how industry in Piemonte play a higher role respect to services. The industry represents respectively the 19% and 24% at national and regional level while services contribution is 69% at national level and 65% for Piemonte region.

Considering the employees, the industry presents a similar distribution to GVA, with the same increase between national and regional level. Comparing different sectors, the number of employees (%) in industry is quite lower (-2% and -3%) than the GVA share, to the advantage of services sector.

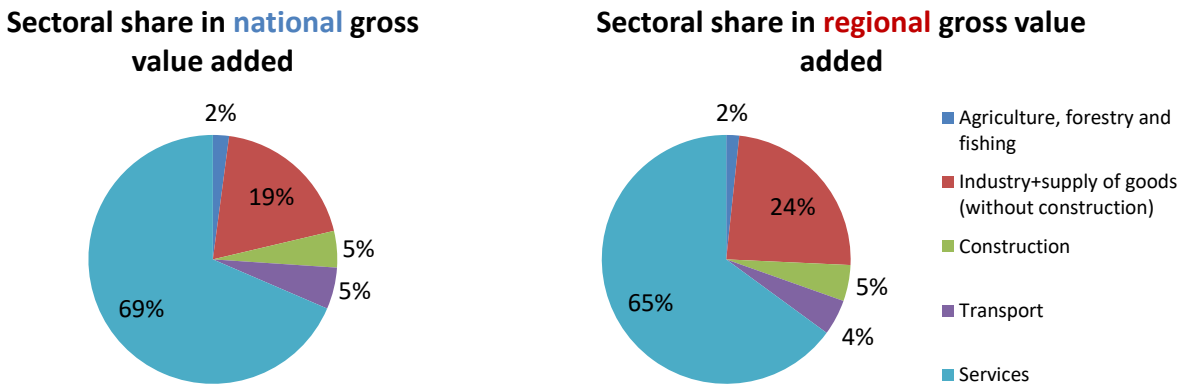
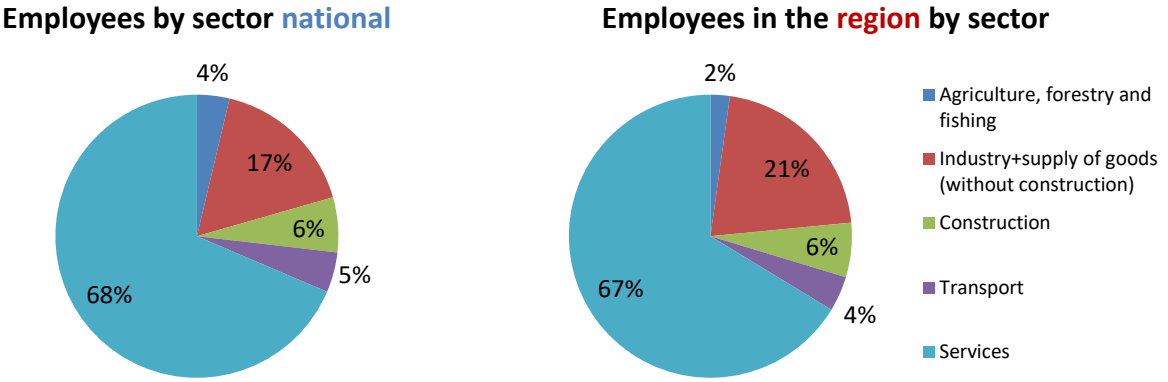


Figure 12 Sectoral share in GVA | National and Regional data



2.1.5 Particularities of the region

Piemonte, with all the Po valley, is historically the seat of the Italian productive poles. The region is closely linked to the industrial manufacturing sector and the automotive sector. Over the years, the industrial sector has been very concentrated in the territorial area of the city of Turin, which has led to a strongly centralized demographic structure in the capital and relative building development in the Turin metropolitan area.

The demographic dynamics started in the early 1900s and was completed in the 70s with a strong migratory flow from the rest of the country especially from the regions of southern Italy.

Due to the economic crisis that began in the 2000s, Piemonte region started a slow conversion process, trying to focus increasingly on activities disconnected from the industrial sector, such as tourism, services, excellent agriculture and knowledge production, with a growing role of research centres and universities, aiming to a leader in innovation.

Historically in the region there have been excellence in innovation. In the city of Ivrea, despite the reduced incidence from a demographic point of view, it has been established an international leadership with the development of the first personal computer “Programma 101”, developed in 1965 by Olivetti.

Focusing on demographic conditions, the extension of the region, and the orography lead in a strong heterogeneity in the territory, which characterizes the urbanistic typologies of the area. Unique in Italy is the large number of municipalities, about 1/8 of the municipality at national level are in Piemonte, due to the fragmentation linked to the regional orographic contest. The considerable urban fragmentation has led to a regional context characterized by a strong heterogeneity of the requests for services of each municipality.

The regional extension has also led over time to a strong influence from the neighbouring regions and nations. Four main influence quadrants are identifiable in Piemonte. The Turin and its metropolitan area can be considered as an independent area with a little influence from France. The area of the province of Cuneo, in the south-west of Piemonte is strongly influenced by Liguria and France. The northern provinces (Biella, Novara, Vercelli and Verbano-Cusio-Ossola) are economically linked to Lombardia region and the Asti and Alessandria areas are connected to Liguria and Emilia Romagna.

Due to orographic characteristics and specific meteorological conditions, the Po Valley and the metropolitan area of Turin are hotspots for air quality, characterized by accumulation of pollutants (particulate matter and NOx), especially in winter. The main sources identified are, for NOx, traffic and heating of buildings, while, for particulate matter, these are traffic and biomass combustion. The reduction of concentrations of pollutants below the limits set by the EU and the standards indicated by the WHO is therefore a priority of the territory.

3. Infrastructure

3.1. Energy related infrastructure

3.1.1 Electricity grid infrastructure

The national operator in the transmission grid infrastructure is TERNA.

The grid is connected with France with two main nodes (380 kV) on the west of Piemonte, and trough the Valle d'Aosta region. Connection with France and Switzerland (220 kV) are present at Passo Gries in the north of Piemonte and through Valle d'Aosta. National connection with Lombardia and Liguria are present in the eastern and southern Piemonte (380 and 220 kV), while the internal regional network consists in a second level network, in blue colour in the figure below (132 kV).

The electricity grid with sub-network reaches the entire inhabited area of the region.

Latest available data (TERNA 2018 annual data) are reported in figure below concerning the exchange at national and NUT2 level. In blue are reported data related to the energy needs and in black the data related to the amount of energy exchanged between regions or nations.

Regarding Piemonte region is possible to see how the quantity imported to the node connection with Switzerland and France is exported to Lombardia and Liguria/Emilia Romagna because the regional electricity demand in Piemonte is covered by indigenous production.

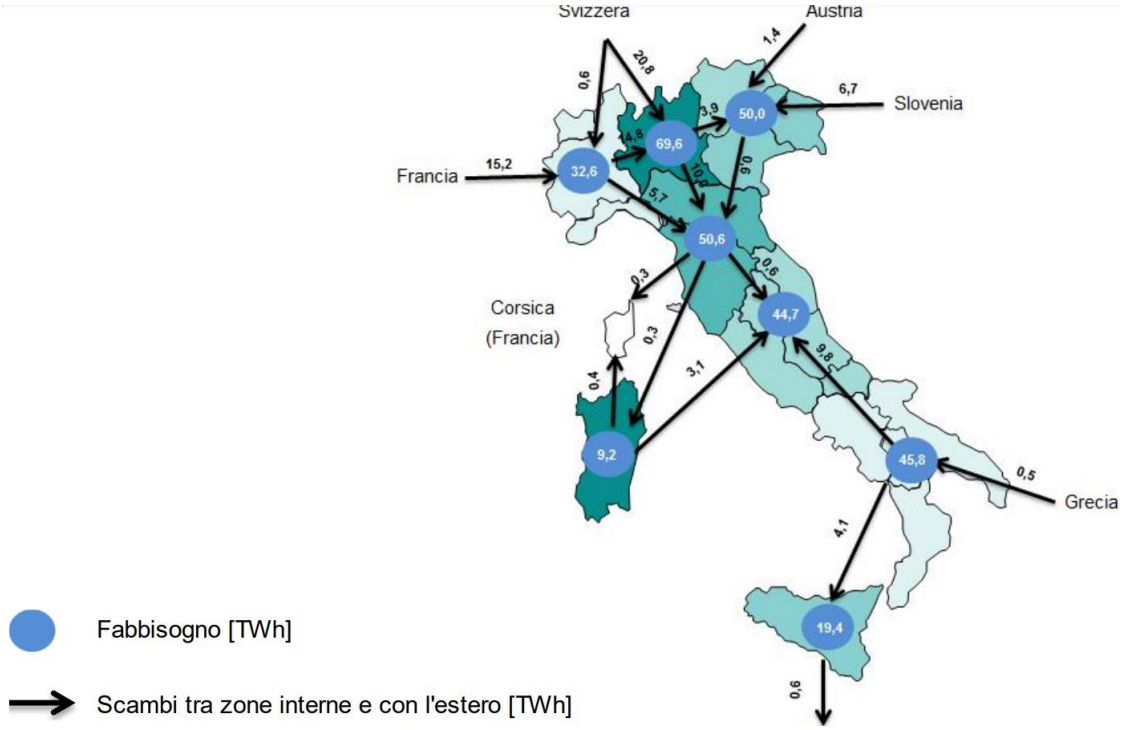


Figure 13 Electricity grid exchange| source: TERNA

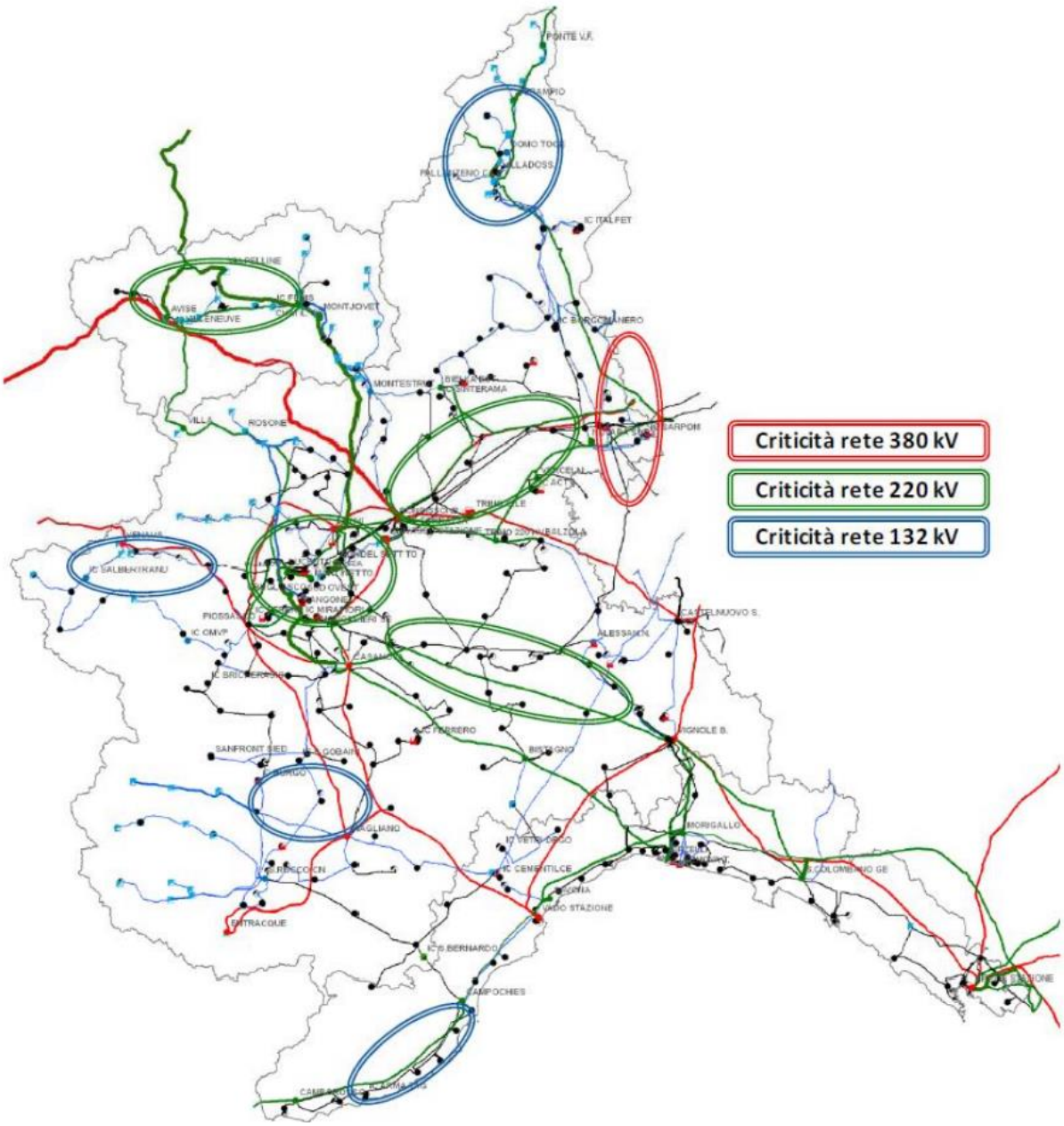


Figure 14 Electricity grid infrastructure and main critical node | source: TERNA

3.1.2 Gas grid infrastructure

The main operator in the grid infrastructure is SNAM, as reported in following figure. The Susa valley area is served by a distinct operator Metanodotto Alpino, as well as small area in the south of Piemonte, served by Energie S.r.l as 3rd level network.

In the north of the region at Passo Gries is located the access point from Switzerland import. While 6 access point are present on the first level of the network for trade with Lombardia. The connection to Liguria as well other connections with Lombardia and Valle d'Aosta is performed with 2nd level network (green colour in following map).

The grid served 90% of the municipalities and the main part of the population, excluding 174 municipalities located mainly in mountain and rural area. In the excluded area gasoline, LPG and wood biomass are the main fuels.

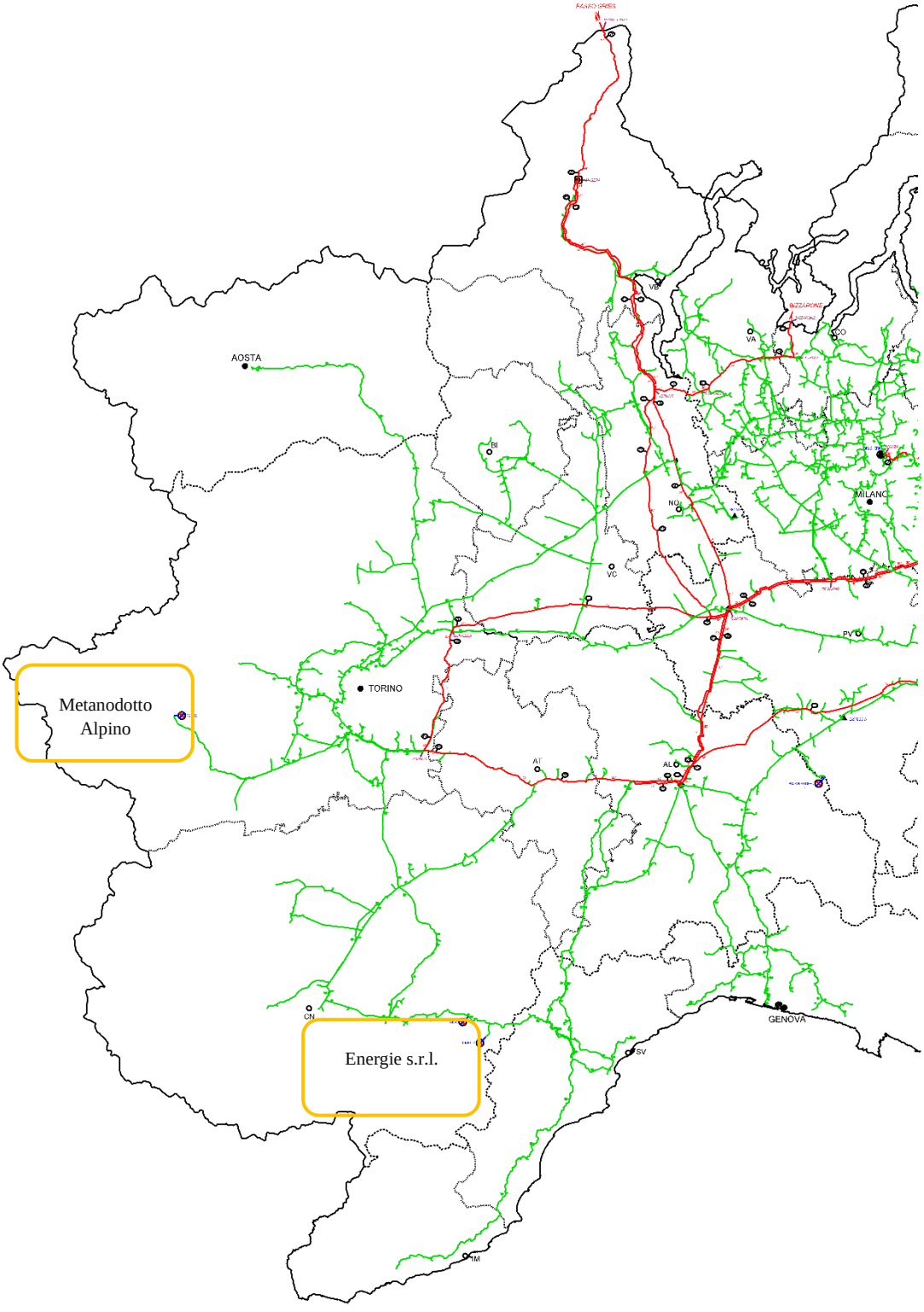


Figure 15 Gas grid infrastructure | source: SNAM

3.1.3 District heat infrastructure

The main DH network in Piemonte is operated by IREN and serves the city of Turin and other municipalities in the outskirts of the city.

The network serves about 62 million m^3 (75% residential, 25% services sector), with an annual generation of 1.9 TWh of thermal energy (2018 data).

The heat production is provided by multiple generation units, both CHP and integration boilers. The newest CHP units are combined cycles with natural gas turbines, while a gas turbine, a steam turbine and a natural gas engine are no longer in operation. The DH system is also equipped with heat storage units: 5,000 m^3 of tanks are installed in Torino Nord site, 5,000 m^3 in Martinetto site (near Torino Nord) and 2,500 m^3 in Politecnico site.

In 2019 has been connected also the CHP fired by waste located in the south-west of the city, with the connection to the network of the Beinasco municipality (not represented in following figure).

According to AIRU and GSE data, Piemonte region is the second region considering the final user volume served with about 85 million m^3, second only to Lombardia with 140 million m^3.

In following map are reported the main DH network (sources: GSE, AIRU) respect to the energy served to the final user. Turin DH is not reported.

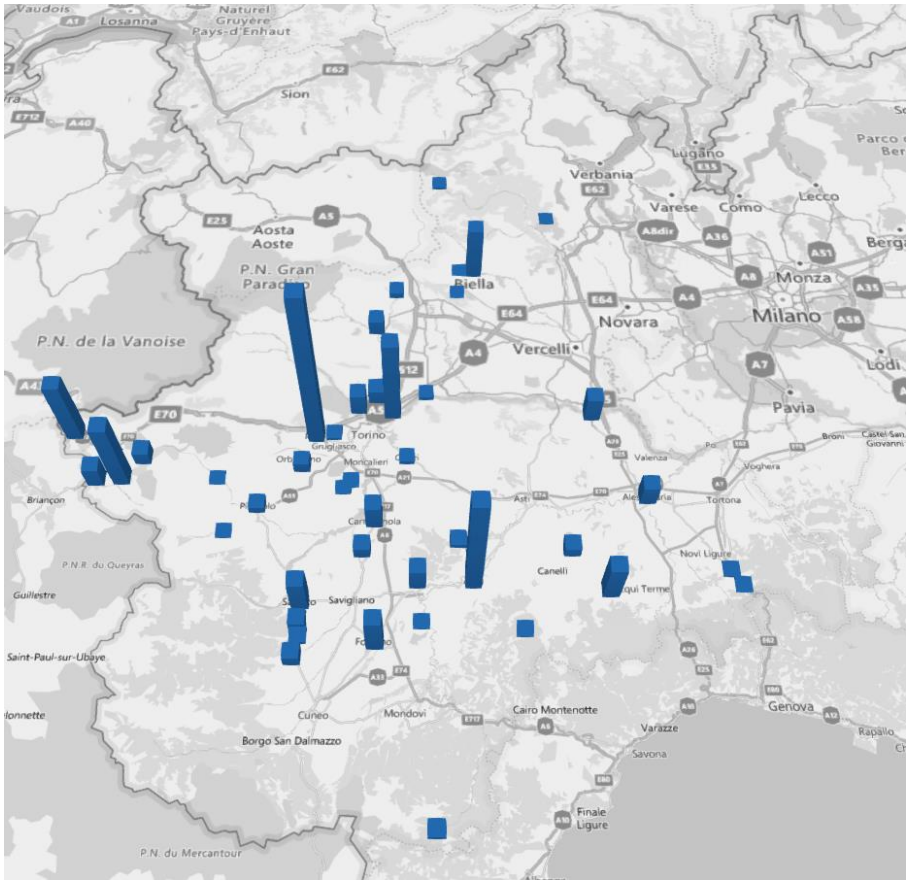


Figure 16 DH network in Piemonte and energy served to final users | excluding Turin DH

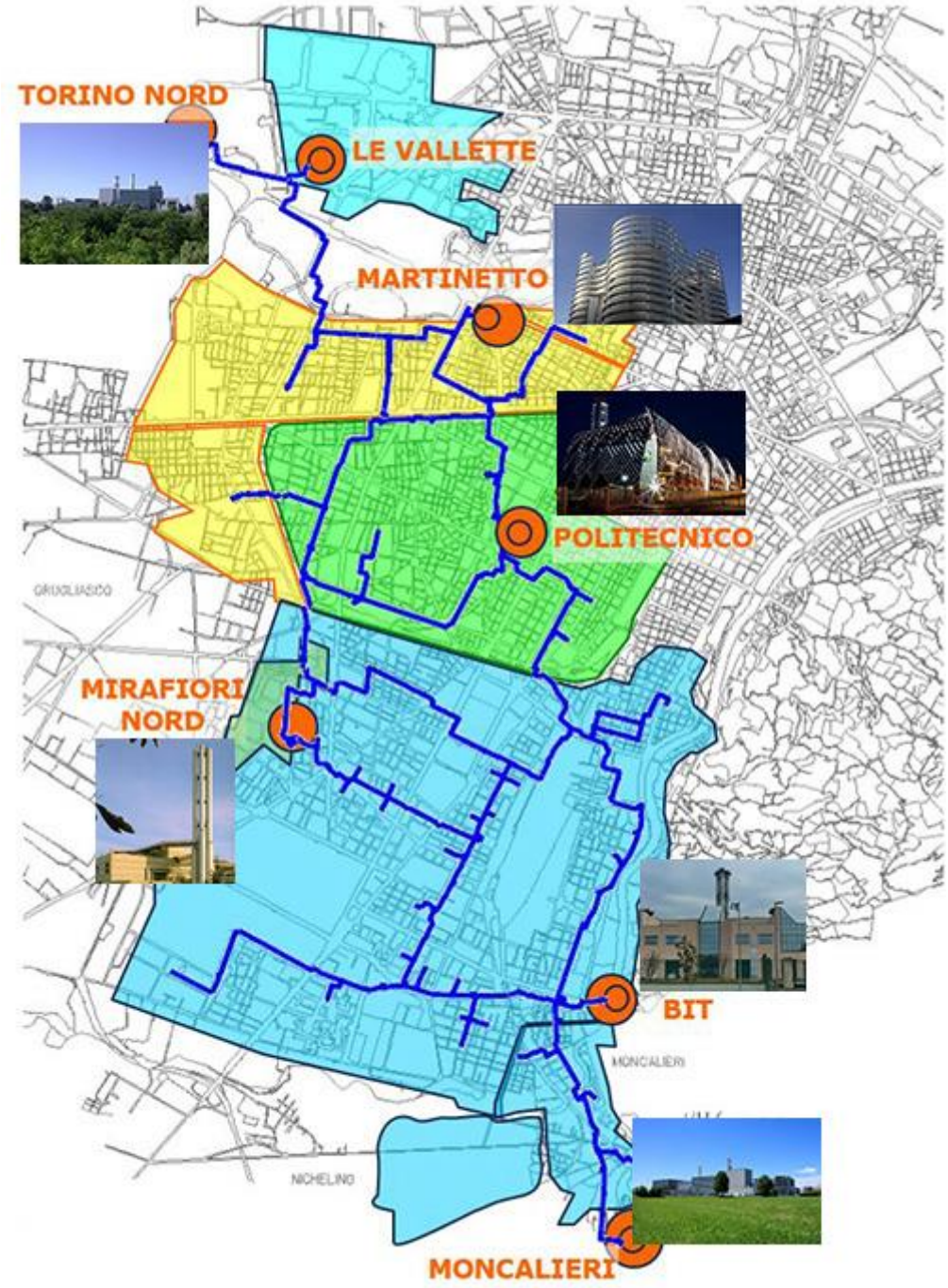


Figure 17 Turin DH network | source IREN

3.2. Mobility and transport related infrastructure

3.2.1 Rail network

Piemonte is the first Italian region for the extension of the railway network (2000 km), followed by Lombardia (1870 km of railway lines).

8 km of the network operate with 4 electrified tracks. About 600 km, 30% of the network, are double electrified tracks and the rest are single track, of which about 600 km are electrified.

The Region has acquired direct competences on some railway lines that interest the regional territory:

- Turin-Ceres
- Settimo-Pont
- Novara-Turbigo

The remaining Piemonte railway lines (approximately 1,888 km with 283 stations) owned to Rete Ferroviaria Italiana S.p.A.:

The main sections are following:

- Torino-Bussoleno-Bardonecchia (-Modane), with Frejus connection to France;
- AV Torino-Milano
- (Milano-) Trecate-Novara-Vercelli-Torino
- Torino-Asti-Alessandria
- Alessandria-Novi Ligure-Arquata (-Genova)
- Alessandria-Tortona-(Voghera-Piacenza-Bologna)
- [Berna (CH)-Iselle (CH)] -Domodossola-Novara-(Genova)
- Domodossola-Verbania-Arona-(Sesto Calende-Gallarate)

Following infographic report the structure of the regional rail network.

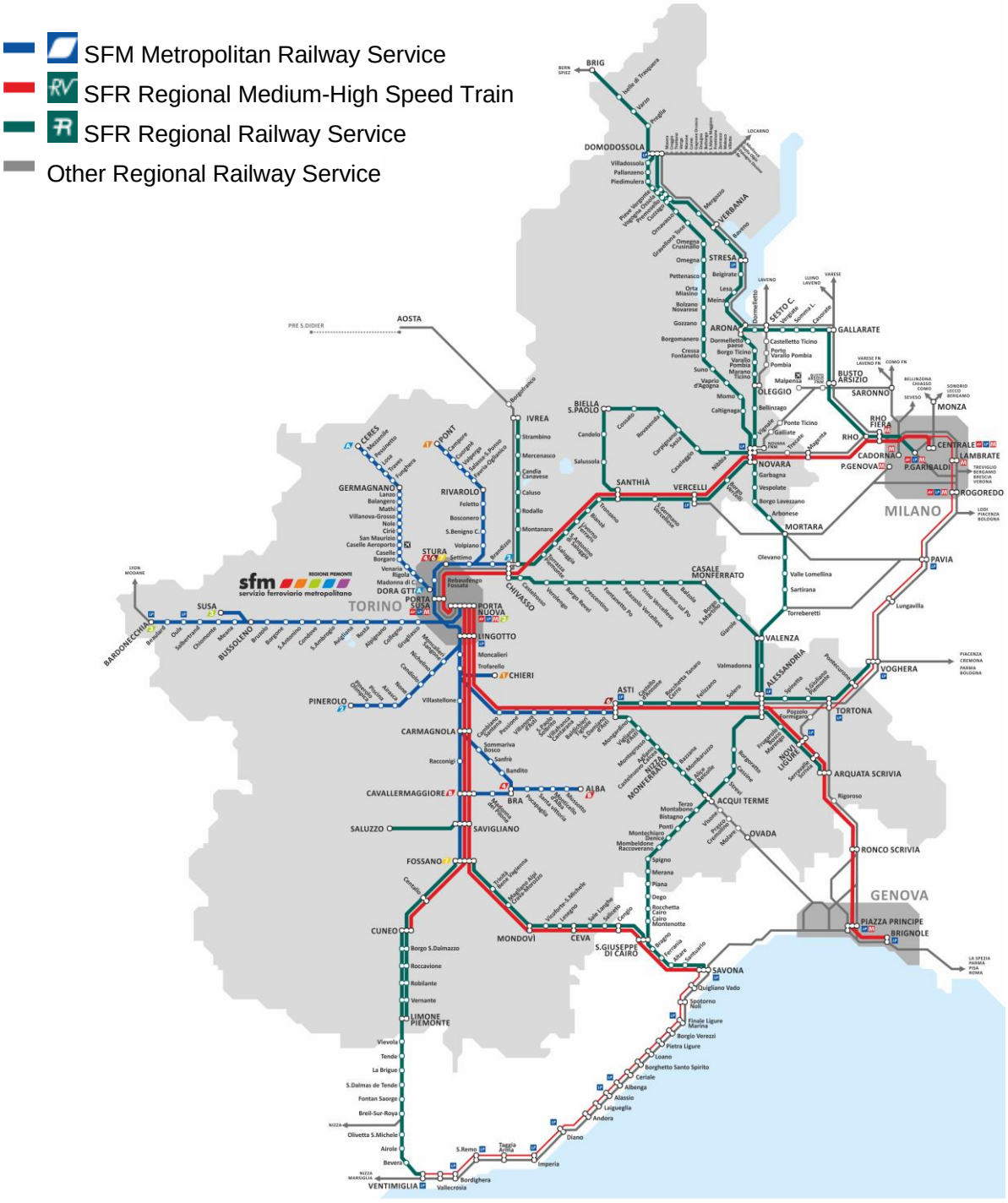


Figure 18 Rail network | source: Servizio Ferroviario Metropolitano (SFM)

3.2.2 Road network

The road network is reported in following figure.

The total length of the regional roads is 32,168 km, mainly municipal roads, while the highways total length is about 1,650 km.

Highways	Main roads	Secondary roads	Municipal roads	Local roads	Total
1,648 km	2,891 km	7,663 km	16,972 km	2,944 km	32,168 km

Highways network operates both on south-north and east-west direction. International connections are present in the north with Switzerland and in the west with France. Secondary connections with France and Switzerland are realised through the Valle d'Aosta highway connection and trough Liguria (to France).

The national highway connections are present in the regional network. One with Valle d'Aosta region, three connections with Liguria in the southern Piemonte and four different connections with Lombardia in the eastern Piemonte.

The main flow at regional level is registered on the highway network (which include also Turin ring road). Following figure reports a comparison of different measurements on the regional road network at different road network level.

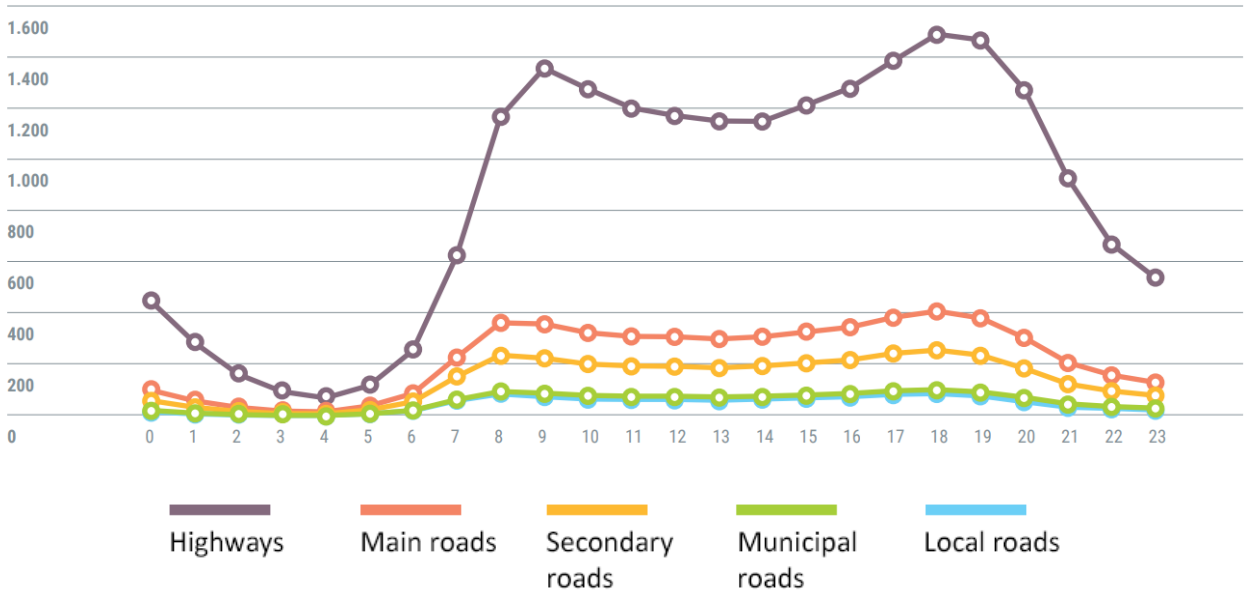


Figure 19 Average flow registered in a working day - November 2017 | source: Regione Piemonte

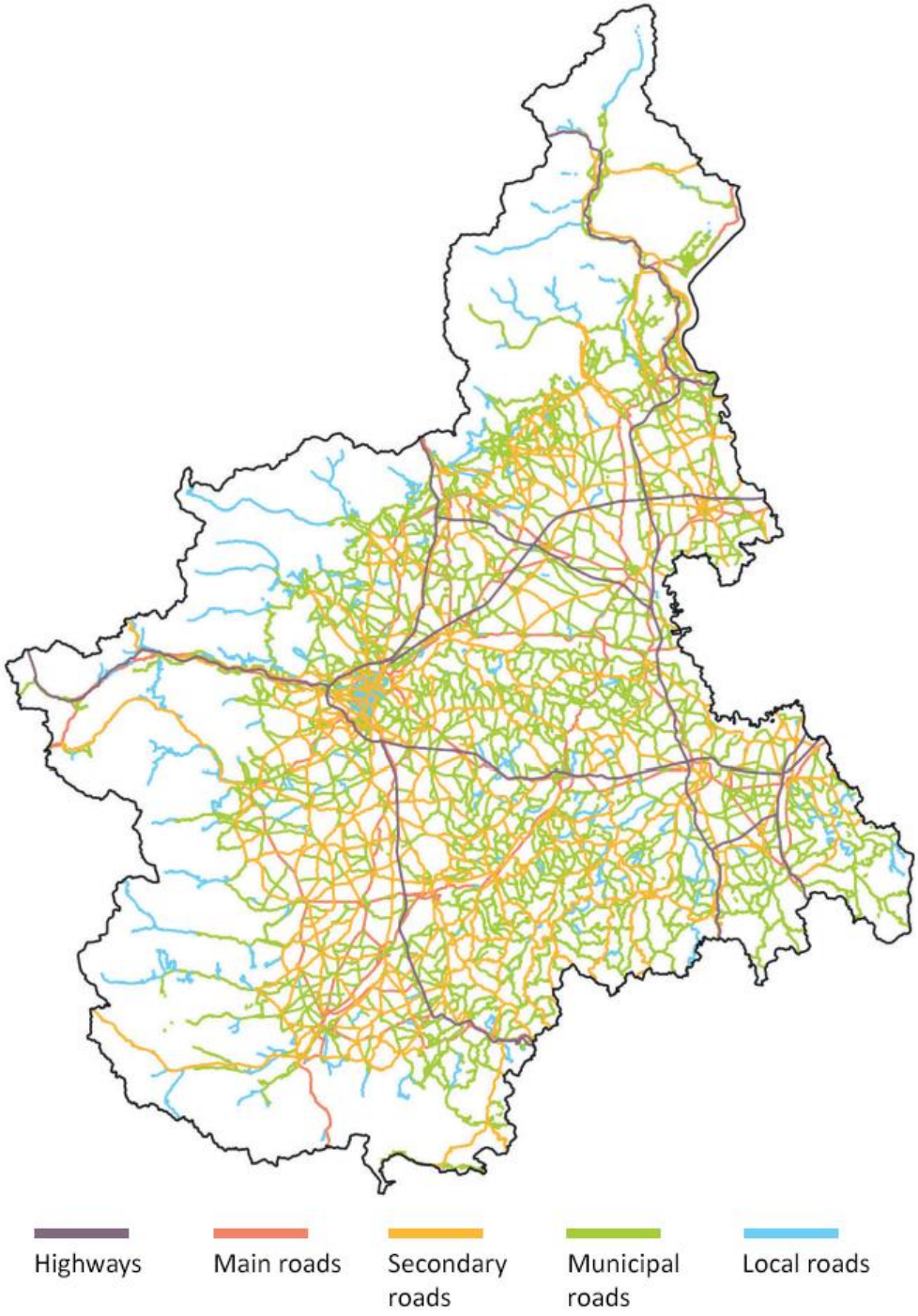


Figure 20 Regional road network | source: Regione Piemonte

3.2.3 Aviation and waterways infrastructure

No waterway infrastructure is present in the region.

Focusing on aviation the main airport is the International Sandro Pertini Airport, located in the municipality of Caselle, in the outskirts of Turin. Near the city of Cuneo, in the south-west of region is present a second airport, the "Aeroporto Alpi del Mare – Cuneo Levaldigi" located 15 km

from the city of Cuneo. The airport of Cuneo operates both on freight and passenger transport but presents lower flows respect the Caselle airport.

3.3. Particularities of regional infrastructure

The border position, in the north-west of Italy, makes Piemonte a terminal region from the point of view of national electricity and gas networks (with the development of the main networks to Turin). At the same time, the location of the region makes it a transit corridor for the main networks (both energy and transport) to western and central Europe.

The morphological characteristics and the high population and industrial density of the Po Valley area have allowed a much wider development of the infrastructures than in the rest of the country, with the construction of highly interconnected networks.

On the other hand, the presence of the large mountain regional area leaded in heterogeneous conditions. The different valleys are characterized by areas highly served by energetic and transportation networks, also thanks to the presence of interconnection points with neighbouring regions and nations, and areas that are not yet served by the network of gas distribution or transport infrastructures, especially railways.

4. Transport

4.1. Basic data and modal split

Following charts shows the data related to modal split freight and passenger transport. The data related to year 2016 are available from EUROSTAT and official statistics only at national level. No information is provided for “water” freight transport for Italy. No information is available also for NUTS2 level.

Concerning Piemonte region, there should be no substantial differences with respect to the Italian data, given the lack of data on “water” freight transport at national level.

The main mode of freight transport is “road transport” (85,3% of modal share), similarly for passenger transport related to cars uses (81,9% of modal share)

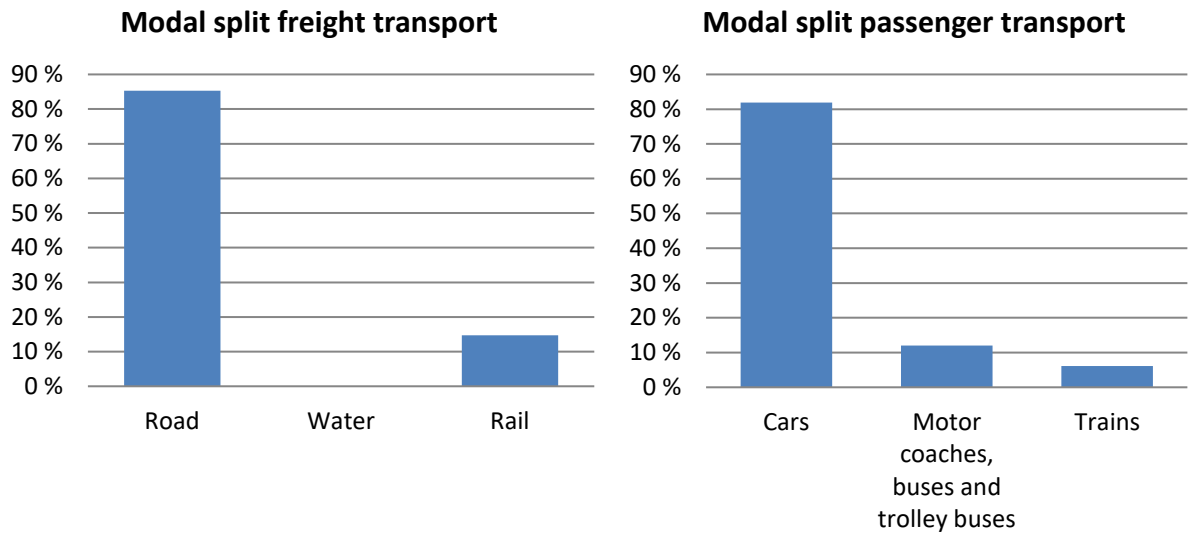


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Figure 21 Modal split of freight transport and passenger transport

4.2. Road transport

Data related to motor vehicles by type and fuel are available both at national and regional level. Considering Passenger and tons kilometre data the information is available only at national level.

4.2.1 Motor vehicles by type and fuel

The data shows an overall vehicle stock in the region of 3.66 million of vehicle (7.5% of national total).

Table 3 Motor vehicles by type

Motor vehicles by type	National	Regional
Passenger cars	37,859,458	2,883,412
Motorcycles	6,604,011	445,679
Lorries	4,016,380	318,633
Buses	97,753	5,993
Road tractors	161,956	11,099
Other motor vehicles	1,072,093	92,791
Total	**48,739,558**	**3,664,816**

The share in the stock considering vehicles by type is similar to the national one, with a higher contribution (almost 90%) related to passenger cars (77%) and motorcycles (12%).

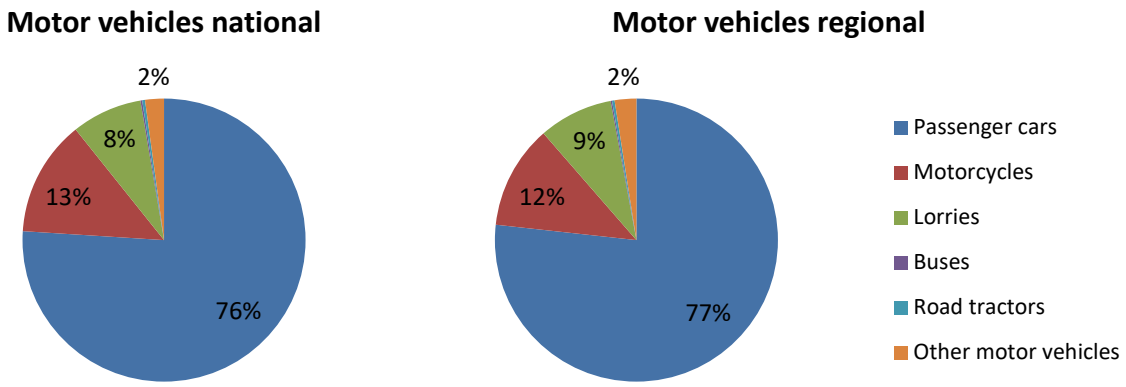


Figure 22 Motor vehicle by type | National and regional share

4.2.2 Passenger cars by fuel, kilometre and fuel performance

The passenger cars stock counts 2.88 million of vehicles (7,6% of national stock). no difference is appreciable considering the vehicles per capita with a regional and national value of 0.62 and 0.62 respectively.

Considering the cars by fuel Petrol and Diesel engine are more than 90% of the stock, the remaining quota is covered by bivalent fuel (Petrol/LPG and Petrol/Methane). Pure and hybrid electric vehicles currently constitute a marginal percentage of the regional stock.

Table 4 Passenger cars by fuel | National and regional data

Passenger cars by fuel (number)	National	Regional
Petrol	18,360,105	1,427,376
Petrol-flex fuel		
Diesel	16,260,625	1,187,084
Electric	5,743	350
Liquefied petroleum gas		
Natural gas		
Petrol / Liquefied petroleum gas (bivalent)	2,211,368	226,890
Petrol / natural gas (bivalent)	911,246	34,350
Petrol / electric (hybrid)	117,433	7,159
Diesel / electric (hybrid)	3,332	203
Hydrogen / fuel cell		
Total	37,869,852	2,883,412

Following figures show data related to the regional stock of passenger cars by fuel, both in number and share.

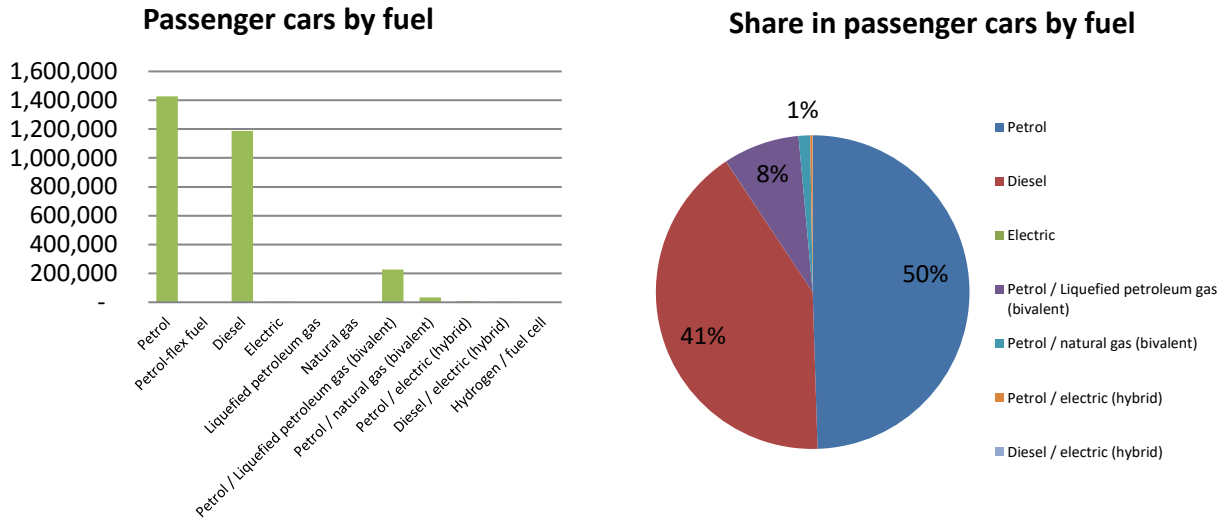
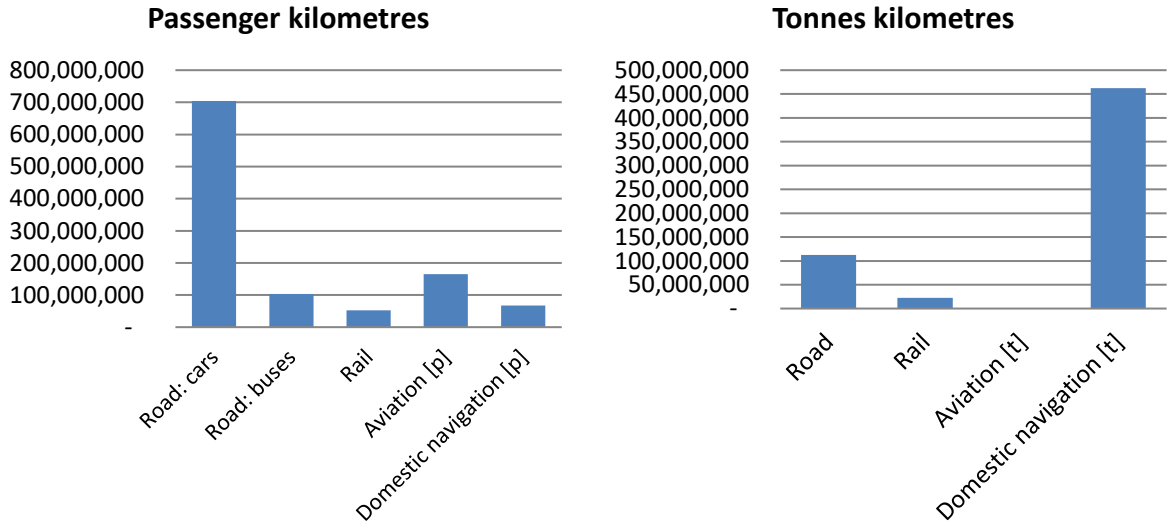


Figure 23 Passenger cars by fuel | Regional data

4.2.3 Passenger- and tonnes kilometres

Considering passenger and tonnes kilometres (pkm and tkm) no data are available at NUTS2 level. Following charts show the national analysis of passenger and tonnes kilometres. Data related to aviation and domestic navigation are reported in passengers (p) and tonnes (t) instead of passenger-kilometre (pkm) and tonnes-kilometre (tkm).



4.2.4 Particularities

The importance of the automotive sector in the region lead to a significant presence of passenger cars per capita (0,64 cars/inhabitant), respect to national data (0,62 cars/inhabitant) and other EU28 nations.

The importance of road and passenger transport is a critical factor for the region and related air quality, also due to the high traffic flows “to and from” the metropolitan area.

4.3. Rail transport

4.3.1 Passenger and tonnes kilometres

Information related with passenger and tonnes kilometres is already discussed in the section 4.2.3.

4.3.2 Development of passenger and goods transports

No data are available at NUTS2 level. Following charts show the national development for rail freight and passengers transport share.

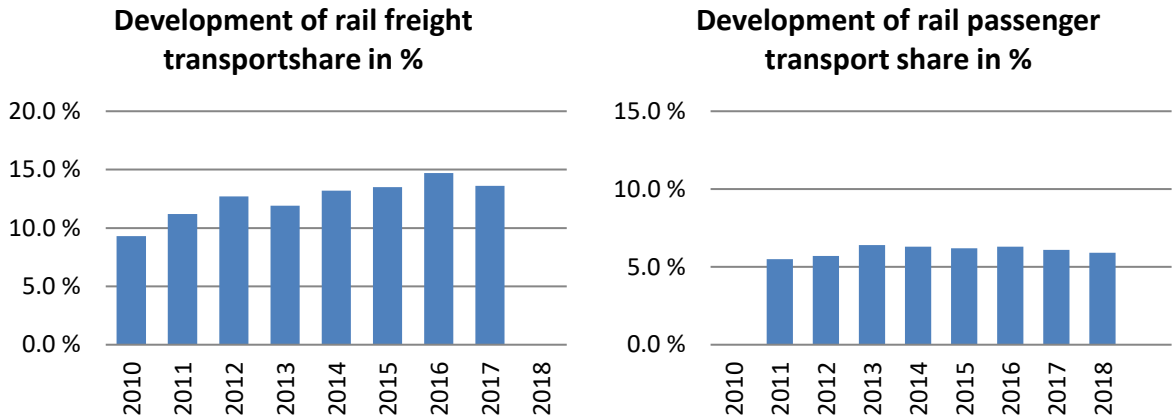


Figure 24 Development of rail and passenger transport share | National data

4.3.3 Particularities

Information related with passenger and tonnes kilometres is already discussed in the section 4.2.4.

4.4. Air and waterway transport

No waterway transports are present within Piemonte region.

Focusing on air transports, data are available both at national level as well as at regional level reporting absolute values expressed in passengers/year and t/year. 0.2% respect national data (with 1.5 kt/year) and 2.5% considering passenger transport (with 4 million passenger/year). Considering the value of passenger (about 1 passenger/inhabitants) as well as the reduced contribution on freight transportation, the air sector could be neglected with respect to the others transportation mode reported in previous paragraphs.

5. Energy status

The following nomenclature is used in the chapter:

- PP Primary production
- GIC Gross inland consumption
- TI Transformation input
- TO Transformation output
- FEC Final energy consumption

5.1. Energy in the European and national context

The comparison at European, national and NUTS2 level shows how solid fossil fuel and petroleum product are less present in Piemonte region, thanks to a higher contribution of Natural Gas. Considering electricity, the share in the region presents similar value than EU28 and National data. Slightly higher value of renewables could be observed as well as a greater value in the derived heat contribution to final energy consumption (almost double if compared to EU28 and National share).

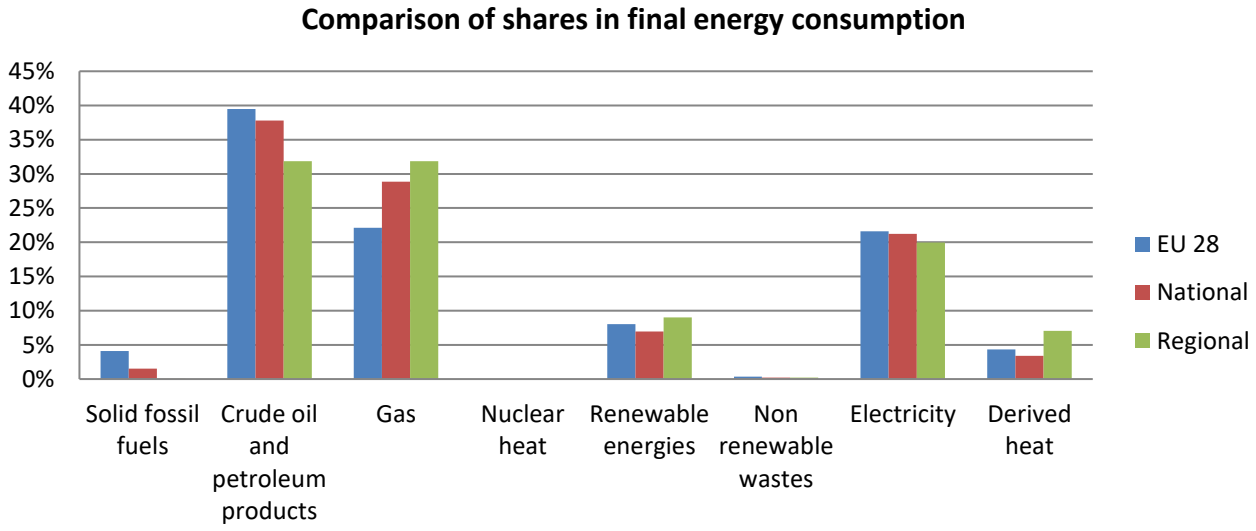


Figure 25 Comparison of shares in final energy consumption

5.1.1. Simplified energy balance of EU 28

The simplified energy balance, as reported in figure below, shows a strong dependence for the EU28 on fossil fuel import. Renewable energies as well as nuclear derived energy are a significant contribution in Gross Inland Consumption and, considering Nuclear Heat, in Transformation Input for electricity production.

The electricity has a comparable value to natural gas in Final Energy Consumption, lower only than petroleum products.

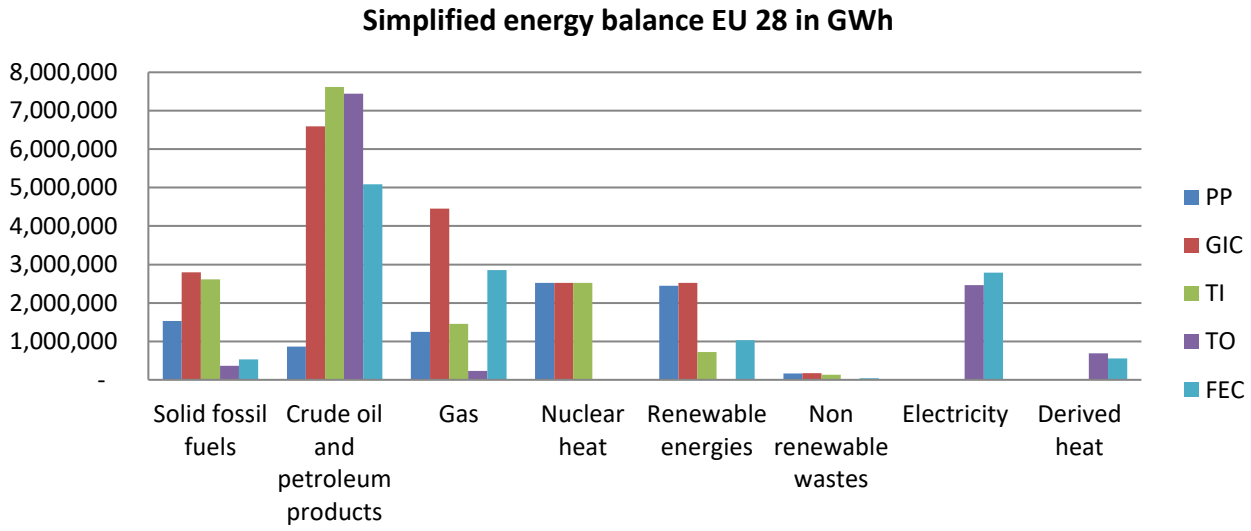


Figure 26 Simplified energy balance EU 28

5.1.2. Simplified national energy balance

For the simplified national energy balance, reported in Figure 27, similar consideration can be done with respect to the high fossil fuel import and dependence both on final energy consumption as well as transformation input.

The electricity has a lower value if compared to natural gas in Final Energy Consumption. Respect to EU28 the contribution of petroleum product and solid fossil fuel is lower and compensated by higher natural gas relative values.

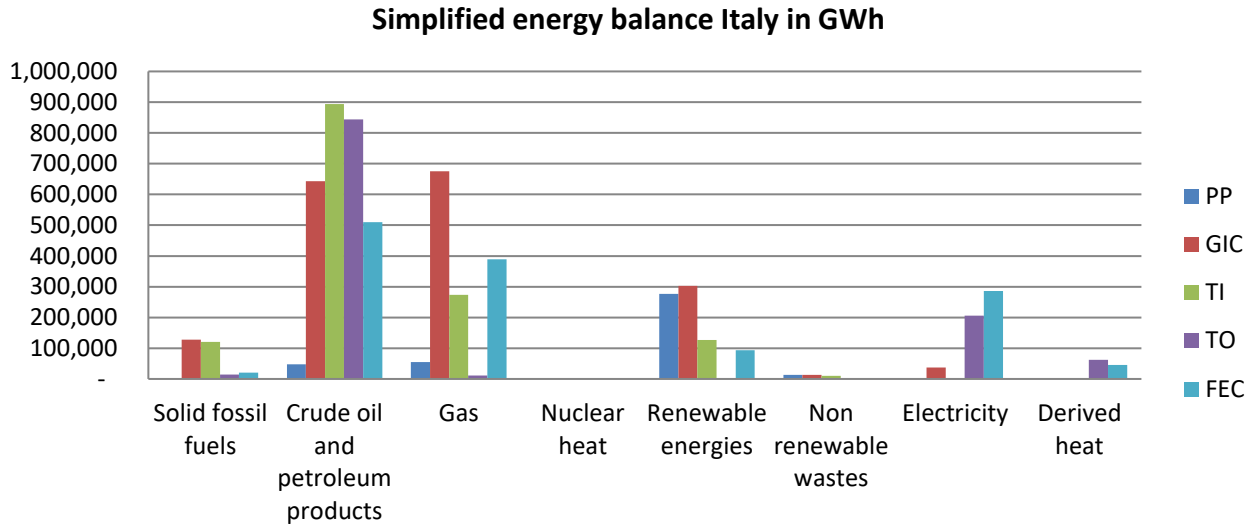


Figure 27 Simplified energy balance Italy

5.1.3. National electricity fuel mix disclosure

The national electricity fuel mix disclosure, reported in following table, combine both indigenous production and import from the other EU28 nations (mainly Switzerland, Austria and France). Imports (11,8% on the national mix) involve nuclear electricity within the national mix, otherwise not present considering the national electricity generation mix; imports increase also solid fossil fuel and renewable energies in national mix.

The main role (almost 38%) in the generation mix is from natural gas generation; renewables, evaluated as a whole, present comparable share in the final mix (almost 39%).

The third contribution, following natural gas and RES, is from solid fossil generation (15,5%). Nuclear and waste (non-RES) account for 3,8% and 3% respectively.

Focusing on renewables, the higher contribution in RES electricity generation is from Hydro power (15% of final mix), historically very exploited throughout the Alps. Solar and Wind farms (respectively around 8% and 6%) have grown in the last decade thanks to the incentive program started in 2010. Geothermal electricity production is located mainly in Toscana region, whereas Biogases are present in a similar percentage overall national territory.

Electricity fuel mix disclosure (national average)	%
Hydro	15.26
Tide, wave, ocean	-
Wind	6.36
Solar	7.95
Geothermal	2.26
Solid biofuels	1.47
Biogases (incl. sewage-gas)	2.97
Waste (renewable)	0.88
Liquid biofuels	1.69

Solid fossil	15.47
Liquid fossil	0.79
Gaseous fossil	37.97
Nuclear	3.78
Waste (not renewable)	3.14
Total	**100**
Renewable	**38.85**
Non renewable	**61.15**

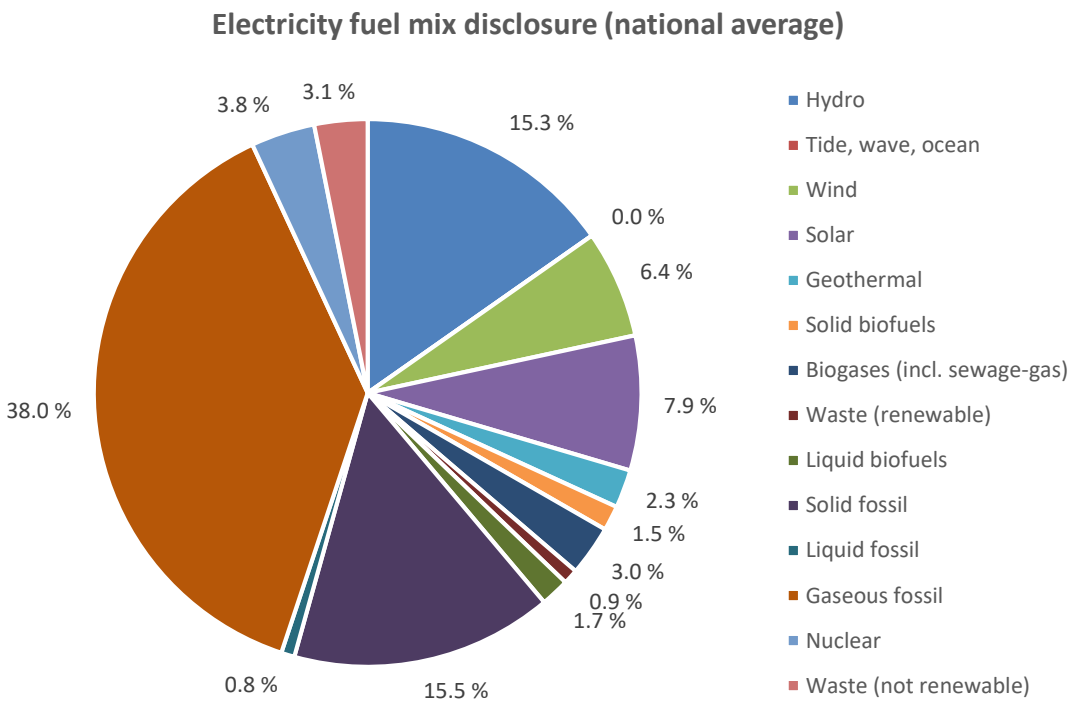


Figure 28 Electricity fuel mix disclosure (national average)

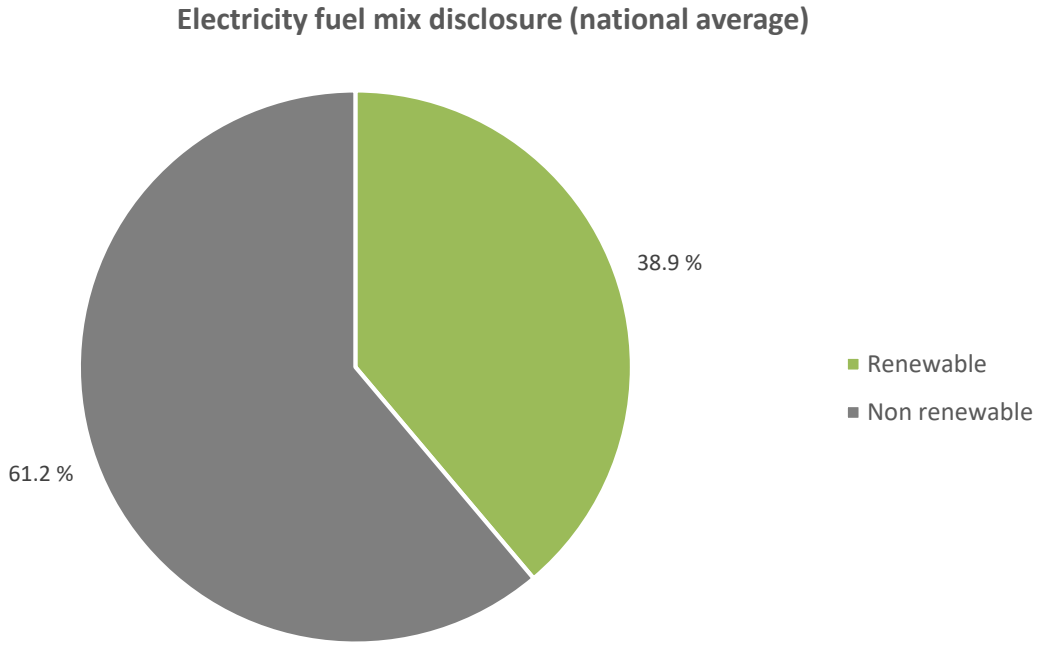


Figure 29 Electricity fuel mix disclosure (national average) | RES and non RES contribution

5.1.4. Time series of national final energy consumption

Figures in present chapter (Figure 30 and Figure 31) show a general reduction in the development of FEC and non-renewable energy available for FEC.

A long-term analysis highlights how after an initial increase in the FEC, from 90's to 2005 the effect of the economic crisis let in a drastic reduction in the energy available for FEC. The data also show how following the crisis we are currently in a stationary state with respect to FEC and non-renewable share in the FEC.

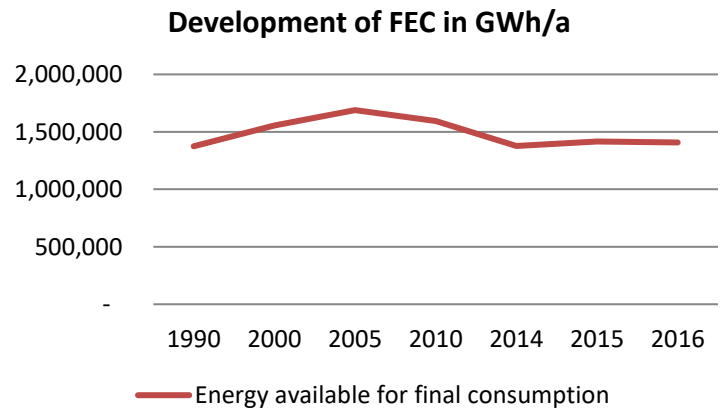


Figure 30 Development of FEC

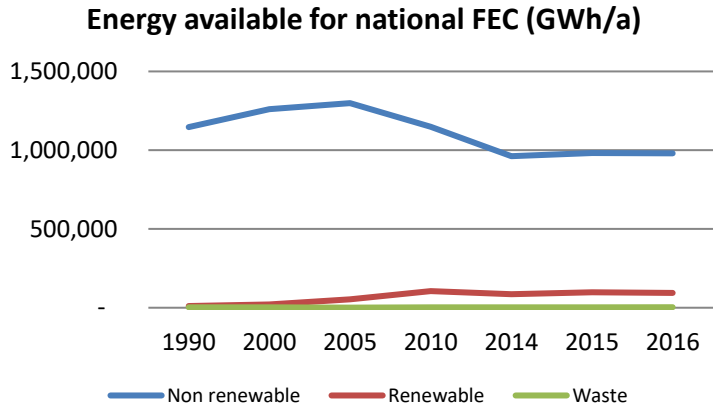


Figure 31 Energy available for national final consumption | Data by sources

Concerning renewables, a strong increase can be noted starting from the years 2000 up to 2005 Figure 32). However, this value cannot be justified by a development of the sector, but by a difference between the surveys carried out in the years prior to 2000 and the subsequent surveys, mainly related to the inclusion in the statistics of the thermal uses of biomasses in the residential sector (firewood).

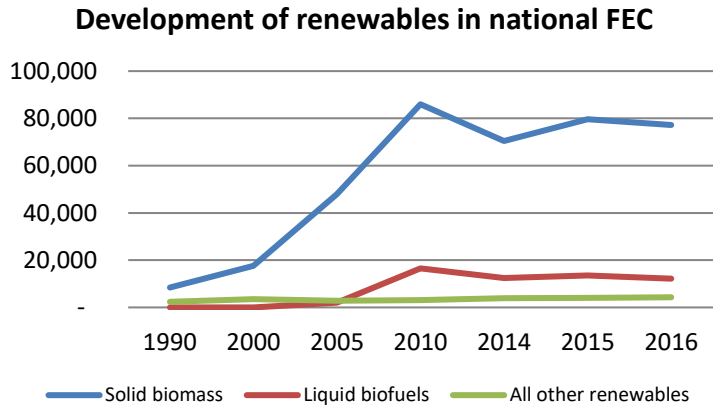
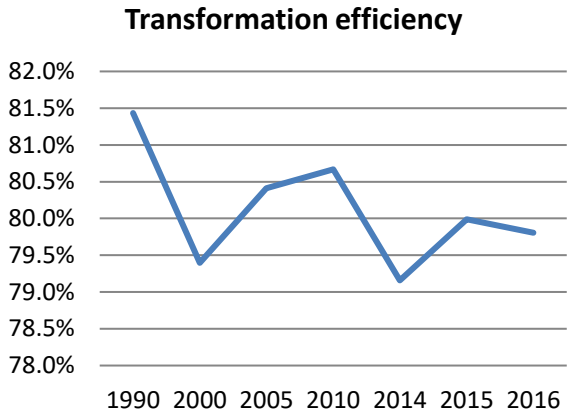
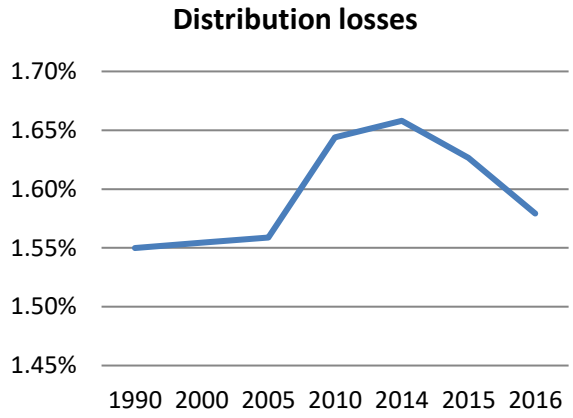


Figure 32 Development of renewables in national final consumption

Regarding transformation efficiency data show a slightly decrease in the last 30 years with a value of about 80%. Distribution losses can be considered stable with a value of about 1,60%.





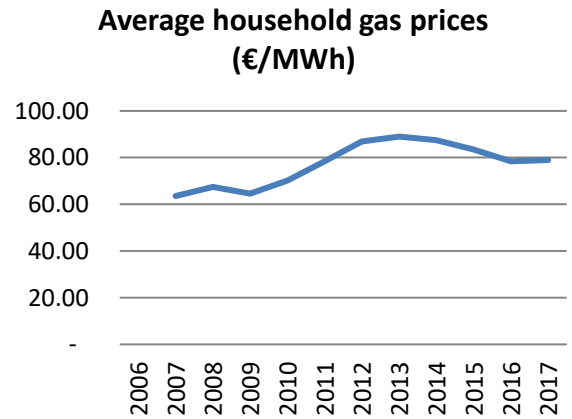
5.1.5. Energy prices – status quo and development 2005 to 2017

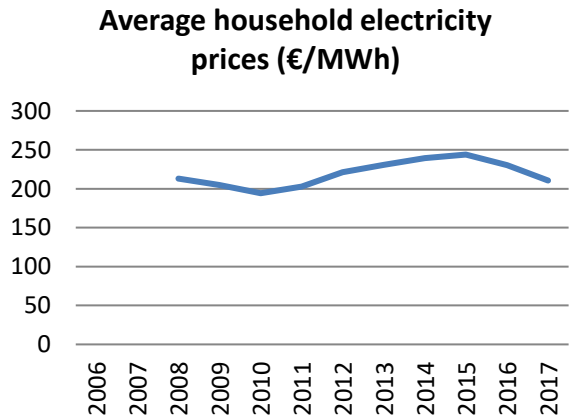
5.1.5.1. Electricity, Natural Gas and District Heating prices

Electricity and gas prices show similar pattern in the period 2007-2017. The trend is related mainly to the national electricity mix, depending on gas and fossil fuel for more than 40%.

Data reported considers final energy prices (including VAT and levies). Gas prices in the last 10 years has reached a value of about 80 €/MWh with a peak in 2013 of about 90 €/MWh. Electricity currently has a value of about 210 €/MWh, after a peak in 2015 of about 250 €/MWh.

Starting 2014, a profound reform of electricity charging for end users and the residential sector took place in Italy, which led to a different structure of costs among the tariff components (fixed, energy, power).





Focusing on natural gas sector, the wholesale price in 2016 was about 19 €/MWh. For the residential sector the working price was 50 €/kWh and a final price of 78,5 €/MWh. In the industrial sector, due to reduced taxes on the natural gas uses, the working price was 27 €/MWh with a related final price of 32,5 €/MWh.

Concerning electricity sector, the wholesale price in 2016 was about 42,8 €/MWh. For the residential sector the working price was 13,6 €/kWh and a final price of 23 €/MWh. In the industrial

sector, due to reduced taxes, the working price was 8,6 €/MWh with a related final price of about 18 €/MWh.

Focusing on district heating (DH), the sector shows reduced regulation at national level, currently under review and definition. Because of this there is no systematic relief of prices, which vary considerably according to local operators. Therefore, the data concerning the metropolitan district heating network of the city of Turin (currently one of the largest in Europe) is reported.

The only data available are related to the final energy prices, for the residential and service sector in 2016 the prices was 77 €/MWh and 74 €/MWh for high DH energy demand.

The industry sector, due to the lower prices on natural gas, hardly realizes connections to the existing district heating networks. More often in industrial sector are present internal CHP technology based on natural gas for the combined production of electricity and heat/steam.

5.1.5.2. Oil and petroleum products

Oil and petroleum products, according to ministerial annual communication, present net prices that vary between 35 €/MWh for LPG and 55,3 €/MWh for heating oil, with petrol and diesel respectively at 50,8 €/MWh and 48,4 €/MWh.

The taxes and levies level play an important role in the definition of customer end price with a share variable from 44% LPG for to more than 60% for Diesel and Petrol

Oil and petroleum products					
Final consumption (€ cent/kWh)	Net price	Customer end price (incl. taxes and levies)	Share of taxes and levies	Energy content	
Petrol	5.08	16.11	68%	8.1	kWh/l
Diesel	4.84	14.31	66%	9.8	kWh/l
Heating oil	5.53	12.23	55%	9.8	kWh/l
LPG	3.51	6.29	44%	12.8	kWh/kg

5.1.5.3. Electricity grid injection tariffs renewables

In 2016 the main incentive program for renewable energies in Italy was related to the Ministerial Decree 23/06/2016 with the introduction of a scheme of differentiated injection tariffs according to the RES uses in electricity generation.

In following table are reported the lower and upper limit of the tariffs. The level of the tariff was related mainly to the power level of the plant and, in case of biomass, to the different sources of the biomass used in the power plant.

Electricity grid injection tariffs renewables	**€/MWh**
Hydro	90÷210
Tide, wave, ocean	300
Wind	110÷250
Solar photovoltaic	0

Solar thermal	291÷324
Geothermal	84÷200
Solid biofuels	115÷246
Liquid biofuels	60
Biogases	85÷233
Renewable municipal waste	94÷99

No incentive programs were present by 2016 for the biogas and biomethane injection in the gas network.

In 2018 and 2019 new injective programs has been introduced both for RES as well as a dedicated incentive program for Biogas-Biomethane network injection.

5.2. Regional energy demand

The regional energy demand and data reported in the table below are derived by national authority GSE and the statistics related to the Burden Sharing program, the national program that gives the different regions binding targets according to the 20-20-20 national objectives.

5.2.1. Regional energy demand by fuel and sector

The regional energy demand, considering fuels, shows how the final energy consumption is covered mainly by fossil fuels both Natural Gas and Petroleum product. Concerning petroleum products, the sector mainly responsible for this demand is the transport sector. The official regional statistic operated by GSE show a data in crude oil products significantly higher than the Ministerial data on the sale of petroleum products on the regional territory. The amount of about 40 TWh was higher of about 5 TWh with respect to the Ministerial data due to regional allocation of national consumption.

Second to fossil fuels, the electricity plays an important role in the regional energy demand followed by renewable energies (thermal). Considering RES (thermal) the main contribution is related to biomass utilization in residential sector for heating purposes. The contribution of RES in the electricity generation (38% as shown in previous chapters) is not explicit in the table below but is included in the data reported as “electricity”.

Table 5 Regional energy demand

Regional energy demand (GWh) - official statistics	Total	Solid fossil fuels	Crude oil and petroleum products	Gas	Renewable energies	Non renewable wastes	Electricity	Derived heat
2016								
Final energy consumption	**126,258**	**45**	**40,243**	**40,213**	**11,364**	**269**	**25,214**	**8,912**

Agriculture, forestry and fishing	1,585		1,239				346	
Industry (without construction), energy, water sewage etc	35,992	45	3,368	13,728	153	269	12,271	6,158
Construction	330		18	194			118	
Transport	36,356		33,977*	388	1,083**		908	
Services	14,793		410	6,476	351		6,882	675
Residential	37,202		1,230	19,427	9,777*		4,688	2,079

* data are not representative of regional real energy demand because including the regional breakdown of national consumption quotas according to allocation estimates defined by the GSE.
** data reported does not consider the double counting of energy related to sustainable biofuels.

Considering sector share the services and residential sectors are responsible of about 40% of the total regional energy demand while transport and industry shows a quota of 30% each. Agriculture is limited to 1% of the whole demand.

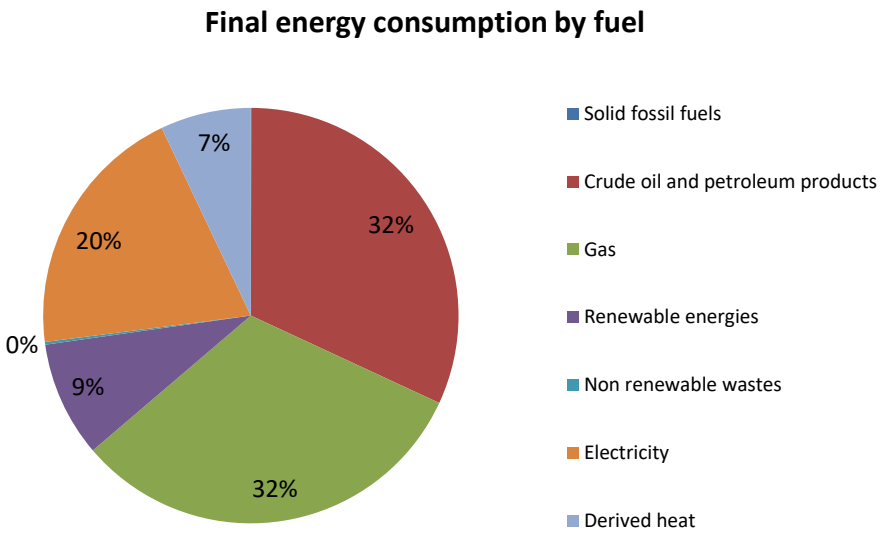


Figure 33 Final energy consumption by fuel

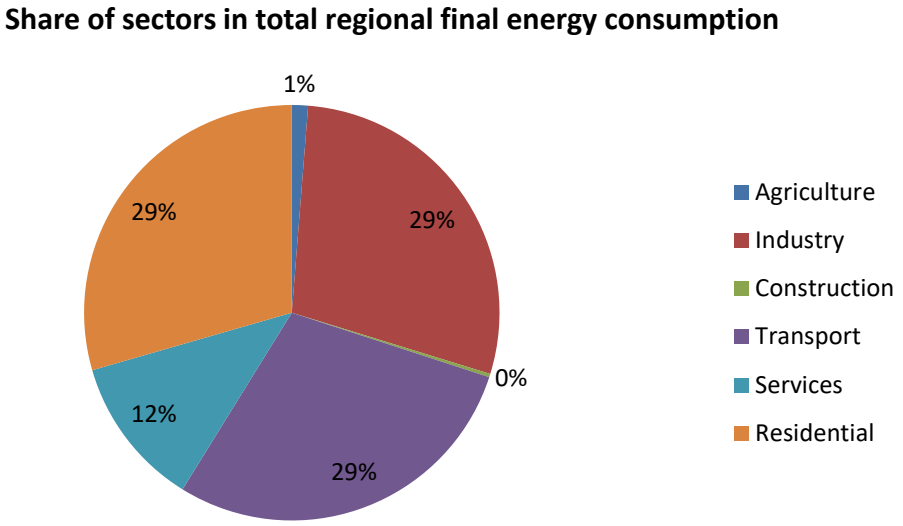


Figure 34 Share of sectors in total regional final energy consumption

Considering renewable (both thermal and electrical) the share in the final regional energy demand is 24%.

The share in sector shows an important contribution for residential sector (about 37%) driven by biomass utilization and electricity RES share. For industry the data is 31% followed by services with 25%. Agriculture is limited to 8% as well as transportation with a value of 4%.

Considering the reduced impact of agricultural sector in the whole regional energy demand (1%), the main field for RES implementation is the transport sector.

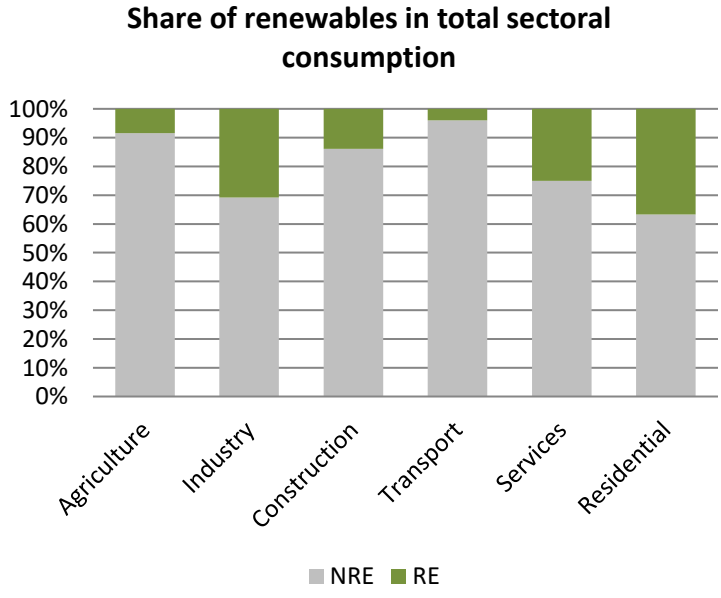


Figure 35 Share of renewables in total sectoral consumption

5.2.2. Regional particularities of energy demand

The regional electricity generation sector has changed dramatically over the past 20 years. Until the 2000s, regional electricity production took place mainly outside the borders of Piemonte (mainly covered by imports from the Liguria region). Following the liberalization of the electricity sector, there was an increase in indigenous electricity production, which led to greater fuel needs (mainly natural gas) and a consequent reduction in the efficiency of regional productions, linked to plants operating even in “only electricity” mode.

At the same time, the territory suffered a drop in fuel consumption, linked to the industrial crisis and a simultaneous shift in the consumption of petroleum products to natural gas.

Since the middle of 90’s, there has also been a continuous development of district heating networks in most metropolitan areas.

5.3. Regional energy supply

Following chapters report the regional generation of electricity, considering both industrial power plant as well as generation in final uses.

Concerning thermal generation, the data are reported only for district heating networks, no information are reported for CHP plants at the user (typical in industrial and services sectors).

5.3.1. Regional generation by source, capacity and output

Focusing on data is clear how natural gas was the first sources concerning electricity production in the region. In the region were present 2 “Electricity only” facilities while the other facilities were CHP. The global capacity in the region is up to 70% covered by few plants, the 2 electricity only power plant, the CHP serving the Turin DH network and the DH located in the outskirts of Turin.

Hydro power is the second installed capacity sources for electricity generation in the region, with a total amount of 820 facilities (considering from micro-hydro to traditional power plant). The source is also exploited as energy storage thanks to a pumping hydro plant with an additional power, with respect to the data in following table, of 1065 MW.

Follow solar photovoltaics and biogases, thanks to the incentive program started in 2010 and finished by 2016. Considering the solar source, the number of facilities, related to small residential and industrial power plant in 2016 was of about 51,400 units. Biogas are present mainly in rural area of the Po valley and operated for electricity only generation, with exception of a biogas plant near the city of Pinerolo which recover biodegradable wastes and is connected to the DH network of the city of Pinerolo.

Table 6 Electricity generation in the region

Electricity generation	Installed capacity (MW_{el})		Energy generated (MWh/year)	Number of facilities
Source:	Electricity only	CHP	Electricity	
Solid biomass (residues)				
Hydro	2,720		6,524,100	820
Tide, wave, ocean				
Wind	19		30,200	16
Solar photovoltaic	1,556		1,688,100	51,362
Solar thermal				
Geothermal (deep)				
Primary solid biofuels	62	1	555,200	47
Biogases (incl. sewage-gas)	147	3	1,029,900	218
Waste (renewable)	70		170,400	3
Biogasoline				
Biodiesel				
Liquid biomass (e.g. black liquor etc.)	53		120,000	32
Solid fossil				
Liquid fossil		63	368,500	1
Gaseous fossil	2,005	2,457	14,934,900	202
Nuclear				
Waste (notren.)			224,000	
Total	**6,630**	**2,524**	**25,645,300**	**52,701**
thereof non renewable	*2,005*	*2,520*	*15,527,400*	*203*
thereof renewable	*4,625*	*4*	*10,117,900*	*52,498*

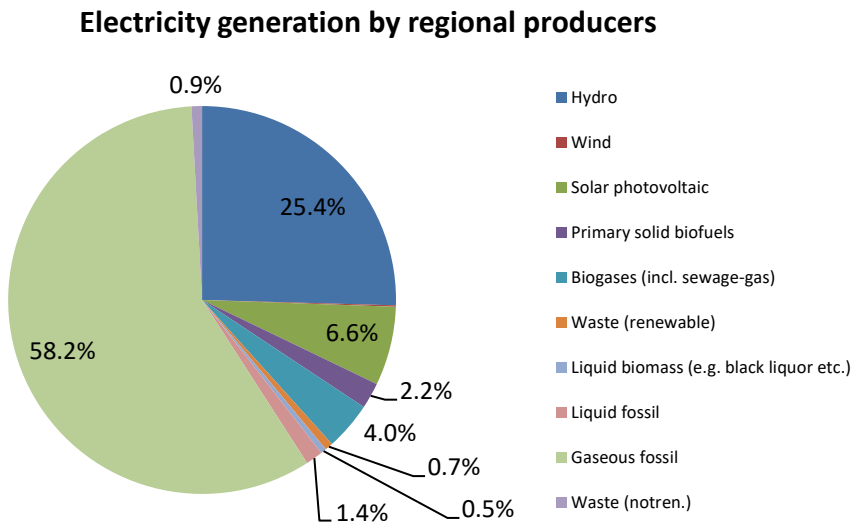


Figure 36 Electricity generation by regional producers

Focusing on heat generation, data related to the DH connected power plant are available not from official statistics but thanks to surveys operated by the AIRU association (Main association of DH operators in Italy).

The main share is related to the DH of Turin city which cover about 67% of the total of the energy generated with 1.8 TWh served to the city users. In the outskirts of Turin and in the main provincial capitals are present DH networks served by natural gas fired CHP plants while in the rural area and mountain area are present both biomasses fired as well as natural gas fired DH networks.

After 2016 an extension of the existing DH networks and realization of new DH network has been performed but related mainly to small and medium sized DH. In 2019 started also the recovering of the heat by the waste fired power plant of Turin, operating only in "electricity only" configuration by 2019.

Table 7 Heat generation in the region

Heat generation	Installed capacity (MW_{th})		Energy generated (MWh/year)	Number of facilities
Source:	Heat only	CHP	District heat	
Solid biomass (residues)				
Hydro				
Tide, wave, ocean				
Wind				
Solar photovoltaic				
Solar thermal				
Geothermal (deep)				
Primary solid biofuels	15	4	24,479	4
Biogases (incl. sewage-gas)		4	1,142	1
Waste (renewable)				
Biogasoline				
Biodiesel				
Liquid biomass (e.g. black liquor etc.)				
Ambient heat (heat pumps)				
Solid fossil				
Liquid fossil	4		56	1
Gaseous fossil	1,509	867	2,528,254	26
Waste (notren.)				
Total	**1,528**	**876**	**2,553,931**	**32**
thereof non renewable	*1,513*	*867*	*2,528,310*	*27*
thereof renewable	*15*	*8*	*25,621*	*5*

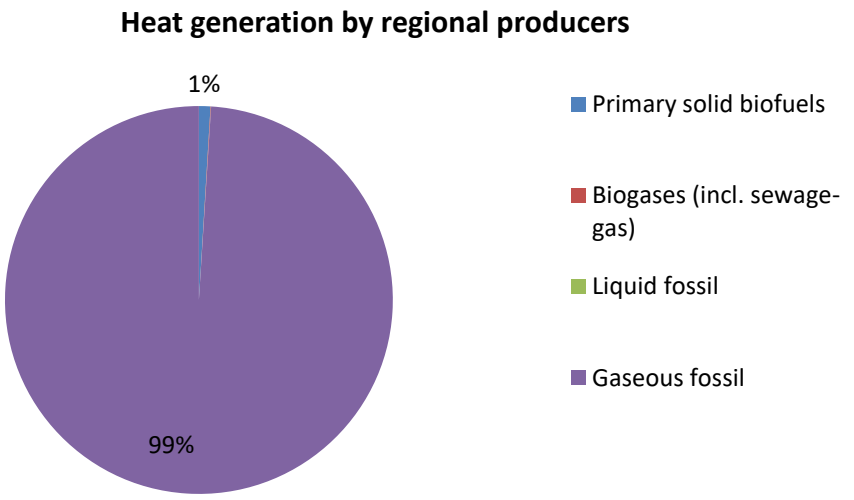


Figure 37 Heat generation by regional producers

5.3.1.1. Fuel Generation

Concerning heat production related to the biomasses uses in residential sectors regional data evaluate an indigenous production of 1,6 TWh. No official data are available due to the difficulties to evaluate the production by the user and the trade of forest biomass for heating purposes.

A production of pellet is also present in the region, related to the recovering of residues in an industrial process, with a production of about 100 MWh/year.

A small production of fuel from waste is also present and serves a cement production plant located inside the region.

5.3.2. Supply mix

Concerning electricity, the amount of electricity generated within the region is slightly higher than the regional energy demand.

Heat production is covered only by 29% with indigenous production related to DH systems.

Regarding transport sector, the dependence is all from import.

5.3.3. Energy storage

As reported in previous paragraph, in Piemonte region are present 1065 MW of Pumped hydro storage related to 1 facility. In 2016 the related production of electricity has been of about 556,5 GWh (about 8% of the RES Hydro power production).

	National		Regional	
Energy storage	**Number**	**Installed capacity (MW)**	**Number**	**Installed capacity (MW)**
Battery storage				
Pumped hydro storage	4	4017	1	1065
Power-to-gas				
Compressed air storage				
Other				
Total	4	4017	1	1065

5.3.4. Regional key technologies for supply

Focusing the attention on an increase in energy efficiency in thermal and electricity generation, a key technology for metropolitan areas is the development of the district heating networks, in combination with cogeneration plants, also given the potential disposal of plants operating exclusively in electricity only mode.

In the electric sector, the photovoltaic technology represents a solution with good possibilities of development, although with the end of the incentive programs the installations are reduced. The construction of medium and large-sized photovoltaic parks is difficult to implement, although the south-western area of Piemonte has a production potential, thanks to favourable weather conditions, with specific production values typical of the central-southern Italian area.

In the thermal sector, the use of biomass has possible development margins, albeit limited, mainly in the development of small district heating networks fuelled by wood chips in the mountain areas with higher building density and at the service of public administration buildings. In the residential sector, the role of biomass is central in covering thermal needs, although a renewal of the plant park is necessary, also in favour of appliances and boilers with greater production efficiency and lower pollutant emissions (PM10).

The role of the solar thermal source and the use of heat pumps is currently little exploited, although studies are evaluating the possibility to integrate the solar source in metropolitan district heating networks. The use of heat pumps in the production of heat is increasing, especially in hybrid systems combined with condensing boilers, due to climatic conditions and high operating temperatures of domestic thermal distribution systems.

5.4. Regional demand-supply balance and development potentials

5.4.1. Regional-self supply rate

In following tables, the regional balance is reported concerning indigenous production and final energy needs.

As analysed in previous chapters, concerning electricity, the amount of electricity generated within the region is slightly higher than the regional energy demand.

Heat production is covered only by 29% with indigenous production related to DH systems. The heat production from CHP at the user is not considered as indigenous production. No data are also present for heat pump and solar thermal production at the user.

Regarding transport sector, the dependence is all from import.

Table 8 Regional balance

Regional balance (MWh) regarding:	NREC	REC	Electricity	Heat
Non-residential sectors (without transport)	- 25,139,884	1,244,498	-6,028,141	4,278,345
Residential sector	- 20,050,355	-8,028,682	- 20,957,032	- 474,487
Transport sector	- 34,365,544	-1,082,515	- 24,737,004	-2,553,931
Total	**- 80,162,543**	**-9,615,009**	**431,576**	**-6,357,789**

Table 9 Regional coverage rate

Regional coverage rate regarding:	NREC	REC	Electricity	Heat
Non-residential	2%	347%	131%	37%
Residential	3%	18%	547%	123%
Transport	0%	0%	102%	-100%
Total	**1%**	**15%**	**102%**	**29%**

5.4.2. Energy efficiency potentials

In Piemonte, significant energy efficiency potentials can be found in the reduction of the heat demand of buildings. Some detailed scenarios are available for residential buildings, which account for 29% of total energy consumption. A basic and economic level of residential building renovation would lead to a reduction of the energy requirements by 20%. Where, on the other

hand, more incisive retrofit scenarios would lead to a reduction of more than 35%, although excluding uneconomic interventions.

The residential use of wood energy for heating purposes can be rationalized through the renewal of the heat generators stock. This would reduce the specific demand (tons/dwelling*year) of wood fuels, making them available to other end users, in a context of constant production.

The service and industry sectors require specific analyses and no overall data are available.

Efficiency in transport implies the spreading of electric mobility, which is an ongoing process. However, this objective will also require a general strengthening of the minor electricity grid, which in Italy has reduced capacity.

5.4.3. Resource potentials

Consumption of wood fuels cannot be increased in households, as it is already significant compared to sustainable production; however, it could be rationalized and thus replace more fossil fuels. The production of wood chips for small/medium DH networks, on the other hand, still has ample growth potential.

A conservative approach could also be followed for hydropower, by increasing plant efficiency and stabilizing the use of water resources.

Further territorial resources are solar and geothermal energy as well as urban and agricultural waste.

5.4.4. Technology potentials

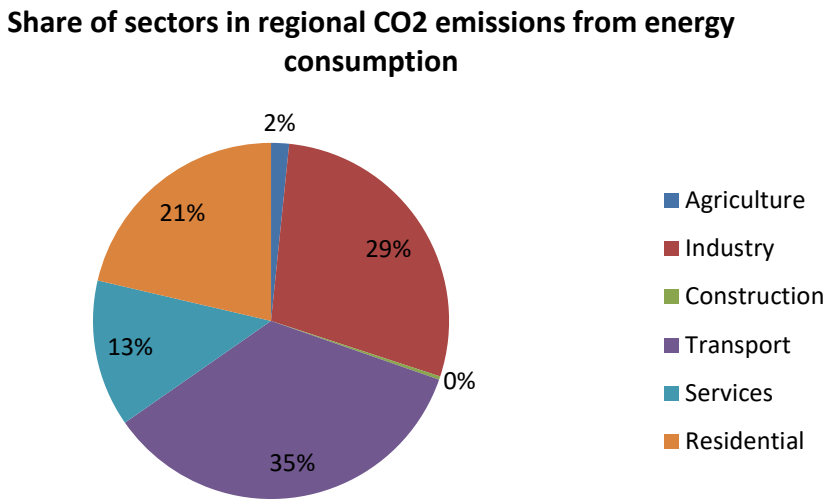
Concerning the exploitation of low enthalpy geothermal energy source in residential sector, due to the severe climatic conditions, it could be carried out only through hybrid thermal heat pump-condensing boilers. The use of this technology would allow an integration of renewable energy sources in buildings equipped with small autonomous boilers, currently installed in all non-metropolitan areas of the region.

The production of biomethane from urban and agricultural waste is a technological perspective of great interest for Piemonte, with some pilot plants of European interest.

A significant challenge will be the modernization of the electricity grid, with extensive integration of energy communities, prosumers, storage facilities and hydroelectric pumping plants.

6. CO2 Emissions

The national CO_2 emissions contribution of Piemonte is 8,6% with 26.8 Mt/y of CO_2. The main sector related to CO_2 emissions is transport (35%), followed by industry (29%), residential sector (21%), and services (13%). Agricultural sector contribution is neglectable, considering the emissions related to the energy needs as well as construction sector.



7. Key figures and bottom line of the situation

Piemonte region present a strongly fragmented territorial structure, with 8 provinces and 1,197 municipalities (the higher number of municipalities in Italy), due to the peculiar conditions of the area, with territorial development extended to mountain valley contexts. The high fragmentation involves into a settlements structure with a high share of small towns and villages with less than 5,000 inhabitants, especially in rural area. Most inhabited settlements are distributed in the region and are located, as territorial aggregation centres, at the mouth of the valleys and the share with the highest population density located in few municipalities in metropolitan areas, concentrated in the provincial capital municipalities and in the Turin metropolitan area.

Globally, the region is experiencing stability in terms of resident population, with an increase in the number of families and a relative reduction in the number of members per household. While territorially the most marginal areas are recording a continuous migratory flow towards the more urbanized areas.

Considering economic indicators, the region contribution to national GDP is 7,71% and 7,75% with respect to GVA. Piemonte shows a sectoral breakdown slightly oriented towards the industry sector compared to the national average.

The development of transport infrastructure is widely developed regarding road transport, while some territorial areas, especially in more marginal areas, suffer from reduced access to rail transport services. The data available at regional level therefore show a high dependence of freight and passenger transport on the use of cars and road transport.

The energy infrastructures are highly developed considering electricity, while the infrastructure for transporting natural gas, which is also widely developed in the area, does not yet reach the totality of the municipalities, mainly excluding few areas with low population density.

The analysis of the regional energy demand highlights a high dependence from fossil fuels import with high share of natural gas in all the sectors and petrol products in transport sectors. RES

presents a share in FEC of 24% thanks to high RES exploitation in electricity sector and thermal contribution of wood biomasses and derived heat.

The FEC is distributed between industry, transport and residential sectors (30% each) followed by services sector (12%).

Concerning electricity production, the region has a highly developed electricity generation park, and cover all its electricity demands. The greatest contribution is given by natural gas thermoelectric plants operating in cogeneration, while the other sources used, in order of importance, are hydroelectric (also as a storage facility), solar, biogas and solid biofuels.

Regarding thermal energy production, the region has an important presence of district heating networks in the metropolitan areas, while the remaining areas of the region see a strong contribution from biomasses for thermal use, second only to the use of natural gas. Biomass uses is linked to the territorial context that allows a coverage of part of the regional needs with local production of biomass fuels (wood-log, wood-chip).

The regional emission of CO_2 is estimated in 26.8 Mt/year with a value per capita of 6.1 t/year in total and 1.3 t/year per capita considering residential sector.

8. CONCLUSIONS

The region energy demand shows highly dependence from fossil fuels, also related to the high generation capacity of the region based on natural gas. Thanks to the generation facilities Piemonte in the last year covered the entire electricity requirement.

The electricity generation from RES is developed thanks to the hydroelectric sector and the development over the years 2010÷2016 of the generation from photovoltaic, biogas and biomass.

The development of district heating networks in combination with cogeneration plants has allowed a good coverage of the thermal energy needs of the metropolitan areas, although the difficulties to integrate the existing district heating networks with renewable energy sources. The thermal energy demand also sees good coverage given using biomasses in the heating sector.

Globally, the residential sector however requires energy retrofit actions due to the reduced energy performance of the regional building stock.

In the transport sector there is a high dependence on fossil fuels. The sector still finds difficulties to perform a transition to less impacting sources and electrification, except for rail transport, however, it is not so exploited for passenger transport even for daily journeys to metropolitan areas.

In addition to the growing demand for reduction of CO_2 global emissions, the regional territory currently needs urgent measures to reduce energy consumption due to the high impact generated by local pollutants (NO_x, PM10).