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Introduction of Regional Energy Concepts

ENERGY TRANSFER POTENTIAL ASSESSMENT AND PLANNING REPORT

Province of Torino

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Introduction

The Province of Torino is located in the Piedmont Region. Its total area is equal to 6,821 km^2, with about 2,300,000 inhabitants.

The energy production from renewable sources is growing in last years, from 355 ktoe in 2001 to 446 ktoe in 2011 (renewables in final uses, see Table 1). The share of renewables in final energy uses has a share of 10.4% in 2011. About half of renewable energy is related to electricity production, while the remaining part consists of heat production for final uses, direct or from district heating systems. The electricity production is mainly from hydro source (85%), while smaller amounts are related to biomass powered systems and photovoltaic systems. More than 95% of the heat is produced from biomass, and the remaining part is from solar thermal or geothermal sources.

Table 1 – Renewable energy in final uses [1]

Energy carrier [ktoe]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Biomass (direct)	164.7	167.7	171	173.5	176.2	183.7	186.7	189.4	194	197.2	201.2
Biomass (district heating)	-	-	1.9	1.8	1.7	4.5	4.5	2.3	2.9	4.4	4.7
Solar thermal	0.5	0.7	0.8	1	1.1	1.4	2.1	3.0	3.9	5.1	6.0
Geothermal	0.1	0.2	0.3	0.4	0.6	1.0	1.4	2.0	2.4	3.2	3.7
Heat from renewables	165.3	168.6	174.1	176.7	179.5	190.6	194.8	196.7	203.2	210.0	215.6
Hydro	181.1	188.0	156.4	187.5	177.0	163.9	166	169.6	229.9	195.7	196.4
Biomass (power plants)	9.1	9.7	9.6	12.8	14.6	21.0	21.5	20.3	20.6	19.4	20.6
Photovoltaic	0	0	0	0	0.1	0.1	0.2	0.3	1.2	2.5	13.7
Wind	-	-	-	-	-	-	-	-	-	0	0
Electricity from renewables	190.2	197.8	166.1	200.3	191.6	185.0	187.7	190.1	251.8	217.6	230.8
Total Renewables	355.5	366.4	340.1	377.0	371.2	375.6	382.5	386.9	455.0	427.5	446.4

The renewable energy transfer potentials that will be considered in this report are related to electricity transfers and solid biomass transports.
However, the electricity production from renewables is currently significantly lower than the total production, and therefore the power lines appears to be abundant for any potential need of electricity export.
Considering wood biomass (wood logs, pellets and chipped wood), a significant part of energy consumption relies on biomass imports from neighbouring regions. A study performed last year [2] shows that in a future scenario in 2020 the energy consumption from biomass remains above the production potential of the region.

Electricity network of the concept region

The high voltage network of the region is composed by three different Voltage levels, as is shown in Figure 1: 132 kV, 220 kV and 380 kV. The total length in the region is about 0.2 km of lines per km^2. The region is well interconnected with neighbouring provinces (Biella, Vercelli, Asti and Cuneo), except for the province of Alessandria which is not connected through any high voltage power line. A 380 kV line is connecting the region directly with France, while two power lines are passing through Valle d'Aosta Region before reaching France (380 kV) and Switzerland (220 kV). These lines are part of the connection capacity with Europe, and therefore a consisted part of the imported electricity is not consumed in the province of Torino, but it is transferred to other Italian regions.

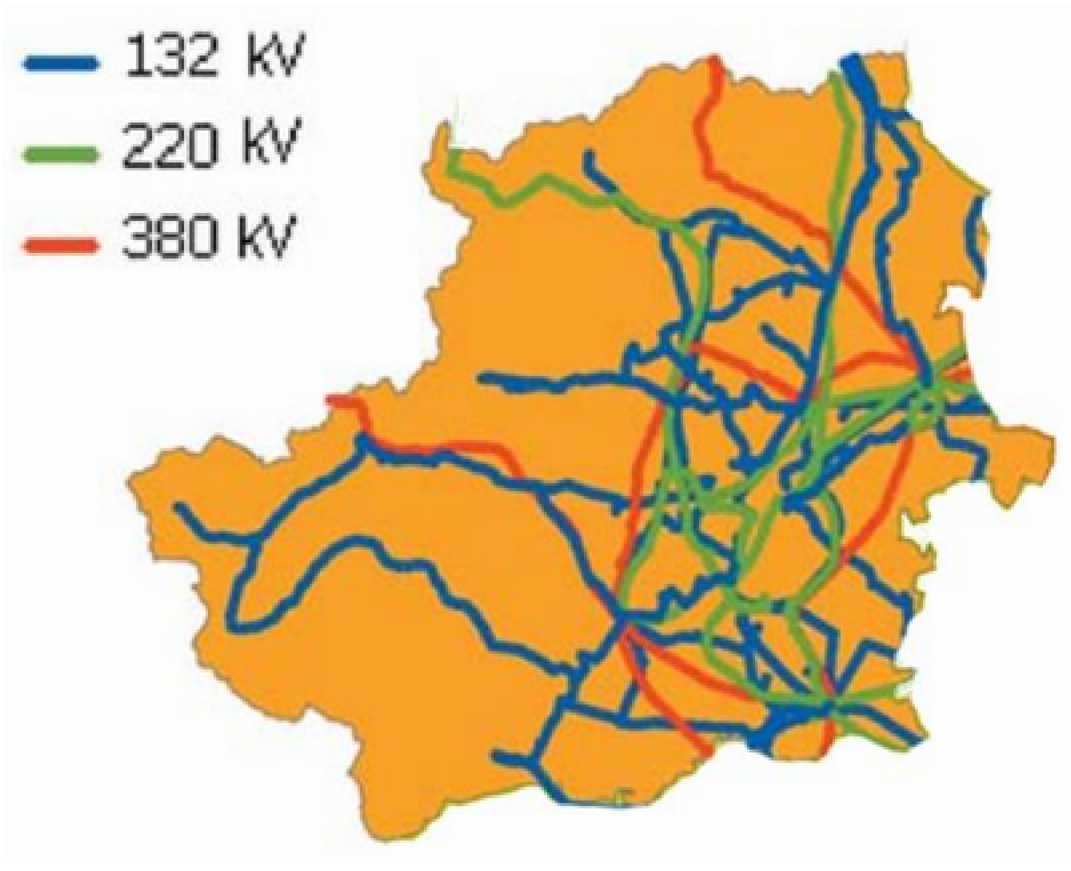

Figure 1 – High Voltage network in Province of Torino [3]

The high voltage network of the province of Torino is currently able to manage the electricity produced from renewable sources. The photovoltaic systems are providing a marginal part of the total electricity production, while the hydropower production is present from many years, and the power lines have been designed considering this amount of power production.

Available regional excess of renewable energy

The current energy production from renewable sources in the region is well below the total energy consumptions, with a share of about 10% with respect to final energy uses in the year 2011.

Table 2 shows the total electricity production for the years 2000-2011 [1]. The trend shows a significant increase of total electricity production, mainly related to CHP and fossil fuels power plants in the years 2000-2007. From 2008 the thermal power plants are decreasing, with a corresponding increase of CHP plants production. In the same years the photovoltaic production is drastically increasing, but it remains a marginal part in the total share (see Figure 2).

Table 2 – Total electricity production

Electricity production [GWh]	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Hydropower	2,153.4	2,105.6	2,186.7	1,819.2	2,180.7	2,058.3	1,905.6	1,930.4	1,972.4	2,674.3	2,275.7	2,284.6
Thermal power plants	254.4	167.4	79.1	45.1	1,795.7	5,631.6	5,633.8	5,548.4	4,928.6	3,095.7	2,482.2	2,638.4
CHP plants	2,791.6	2,812.5	2,782.9	2,891.6	2,952.8	4,481.1	4,963.3	5,080.0	6,392.3	6,679.2	7,058.3	7,258.4
Photovoltaic	0.0	0.0	0.0	0.0	0.5	0.7	1.4	2.1	3.2	14.1	29.3	159.4
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	5,199.4	5,085.5	5,048.8	4,756.0	6,929.6	12,171.7	12,504.1	12,560.9	13,296.5	12,463.3	11,845.5	12,341.0
By which by RES	2.252,78	2.212,03	2.300,06	1.931,19	2.329,61	2.228,41	2.151,02	2.182,81	2.211,31	2.928,50	2.530,20	2.684,13
Share	43%	43%	46%	41%	34%	18%	17%	17%	17%	23%	21%	22%

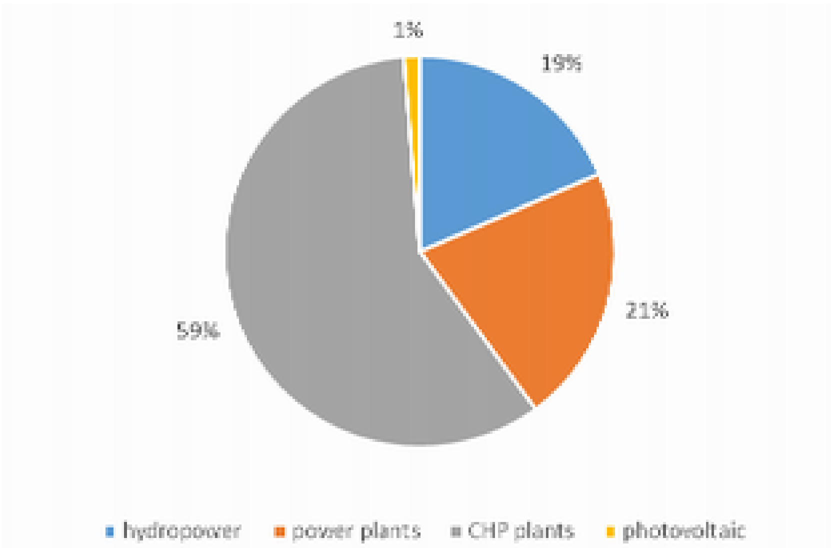

Figure 2 – Electricity production share in 2011

The energy production from biomass is included in the thermal power plants and CHP plants. The resulting share of electricity production is slightly above 20%.

Table 3 shows the electricity consumption in final uses [1]. Comparing the data with the electricity production in the region a significant variation can be observed. In the years 2000-2004 the region needed to import a significant part of electricity needing from neighbouring regions, while in the following years the production in always higher than the consumption of the final uses. This change is mainly related to the installation of some natural gas combined cycles in the city of Turin, which are also supplying heat to the local district heating network.

Table 3 – Electricity consumption and production in final uses

Electricity consumption [GWh]	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Residential	2,414.8	2,459.6	2,444.3	2,458.7	2,557.8	2,553.5	2,592.0	2,516.9	2,562.0	2,580.4	2,624.2	2,560.6
Commercial and public services	2,288.9	2,344.5	2,461.5	2,619.1	2,687.8	2,720.5	2,966.8	2,945.7	2,985.2	3,062.8	3,117.3	3,193.6
Industry	6,595.0	6,648.7	6,027.9	6,016.6	5,988.9	5,767.7	5,907.7	5,984.1	5,625.5	4,540.7	4,628.8	4,509.0
Agriculture	51.5	55.3	48.1	55.9	62.8	64.7	70.6	66.0	60.3	64.1	63.1	68.4
Transport	355.7	360.8	370.9	374.9	370.1	399.5	420.3	415.3	441.0	434.0	436.4	431.8
Total final uses	**11,705.8**	**11,869.0**	**11,352.7**	**11,525.2**	**11,667.4**	**11,505.9**	**11,957.4**	**11,928.0**	**11,674.0**	**10,682.0**	**10,869.8**	**10,763.4**
Total Production	5,199.4	5,085.5	5,048.8	4,756.0	6,929.6	12,171.7	12,504.1	12,560.9	13,296.5	12,463.3	11,845.5	12,341.0
Transfer	**- 6.506,40**	**- 6.783,50**	**- 6.303,90**	**- 6.769,20**	**- 4.737,80**	**665,80**	**546,70**	**632,90**	**1.622,50**	**1.781,30**	**975,70**	**1.577,60**

Taking into consideration dispatching priority of RES in comparison with fossil electricity generation and the fact that only about 22% of the total production comes from RES, also considering optimistic development scenarios of renewable sources, there is no possibility of having a regional excess of renewable energy with respect to the electricity consumption.

Energy production from photovoltaic systems

The photovoltaic systems are significantly growing in last years, as a consequence of the incentive tariffs promoted by the Italian regulations.

Table 4 shows the information about the photovoltaic systems installed in the province of Torino in the last years [4]. The increase of number of systems and installed power is remarkable, although the total energy production remains low when compared to the electricity consumption in the whole region.

Table 4 – Photovoltaic systems evolution over last years

		2009	2010	2011	2012
Number of systems	-	2,315	4,414	8,188	11,846
Peak power	*MW*	22.3	49.6	238.5	326.6
Energy produced	*GWh*	14.1	29.5	160.8	311.7

It has to be observed that the amount of energy reported in Table 4 is the real annual production of the photovoltaic systems in the region, while the installed power refers to the 31st of December of each year. Therefore, it is not correct to divide the energy on the power to obtain the average hours of operation, as many systems have been installing in the considered year, and their contribution to the energy production of this year is only partial.

Due to this aspect, the potential energy production of existing systems needs to be estimated from the current installed power. The most recent available data about installed power can be obtained from Atlasole database [5], containing all the photovoltaic systems. As of January 2014, there are 13,638 PV systems in the region, for an installed peak power of 349,853 kW.

Assuming an average value of 1,200 equivalent hours, taking into account the multiple expositions of the systems, the possible shadows and other factors that limit the efficiency, the current electricity production from PV systems can be roughly estimated to be of about 420 GWh. This amount of energy is much larger than the measured production of 2012, but remains significantly lower than hydro power.

Another important aspect that needs to be taken into account is the generation profile of the photovoltaic systems. Even if the annual amount of energy is small, it is possible that in some particular situations (e.g. during summer holydays) the solar production reaches high levels of share w.r.t. electricity consumptions. This is not the case for the global network of the region under analysis, as the total PV installed capacity is about 350 MW, which is lower than one of the natural gas plants installed in Turin. However, an estimation of the solar generation profile will be provided.

The daily generation profile is strongly dependent on the azimuth and slope of the systems, as Figure 3 and Figure 4 show [6]. As there is no information about the characteristics of the systems installed in the region, an average value need to be taken into account.

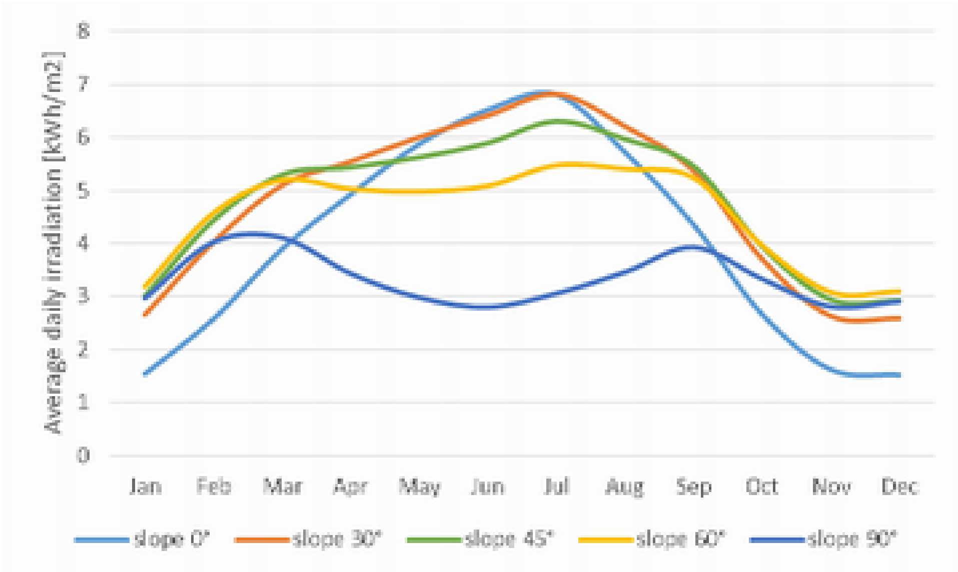

Figure 3 – Average daily irradiation in the city of Turin for different slopes (azimuth 0°)

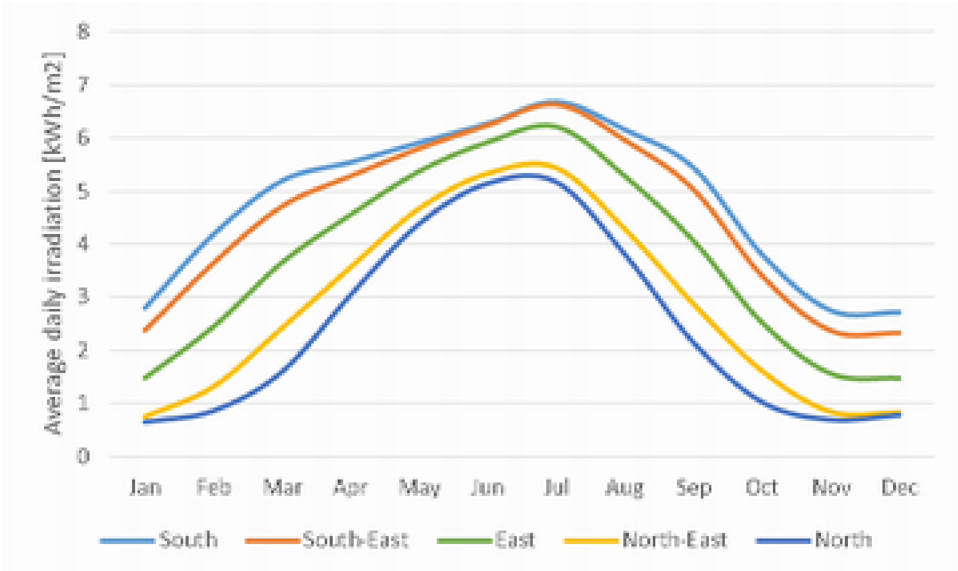

Figure 4 – Average daily irradiation in the city of Turin for different azimuths (slope 35°)

Considering a photovoltaic system with optimal slope (35°), the orientation of the system has important consequences on the energy produced over the day. Figure 5 shows the variation of daily irradiance in the city of Turin in July. Depending on the azimuth, the maximum production of the system happens at a different hour of the day. The resulting average irradiance for a mix of systems with different orientation is given in Figure 6. The result is a decrease of the daily peak power. Therefore the maximum power of a mix of systems with different orientations would provide a decrease of the annual peak power. The effect of different slopes has a similar effect.

As a result, the daily peak power of the installed photovoltaic systems in the region will be lower than their nominal peak power.

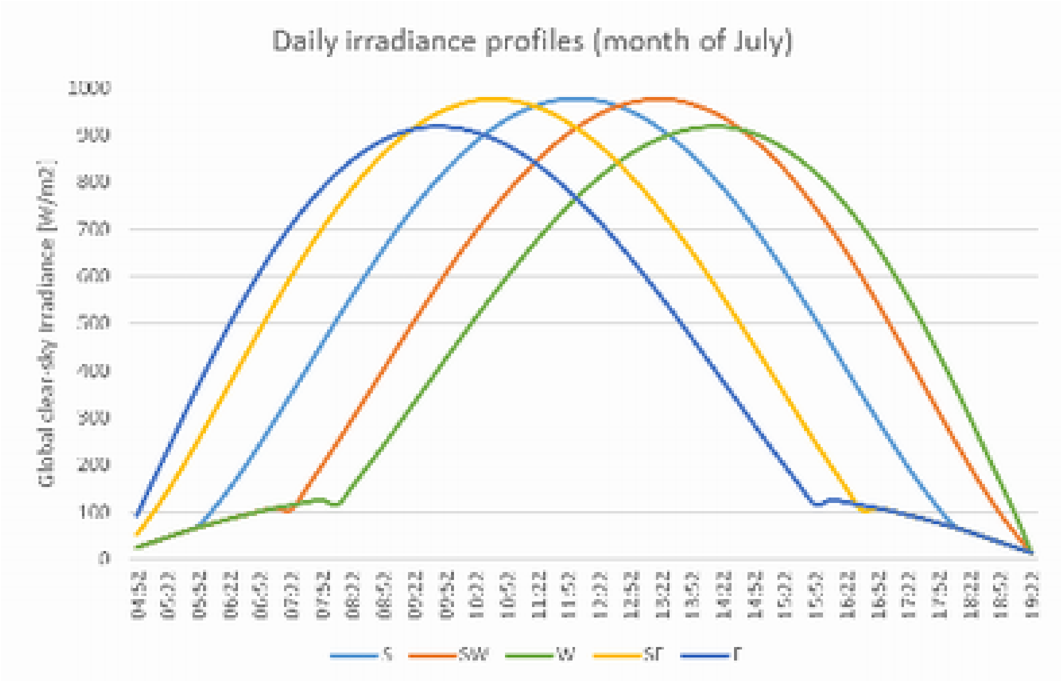

Figure 5 – Daily irradiance profiles in the city of Turin for different azimuths (slope 35°, month of July)

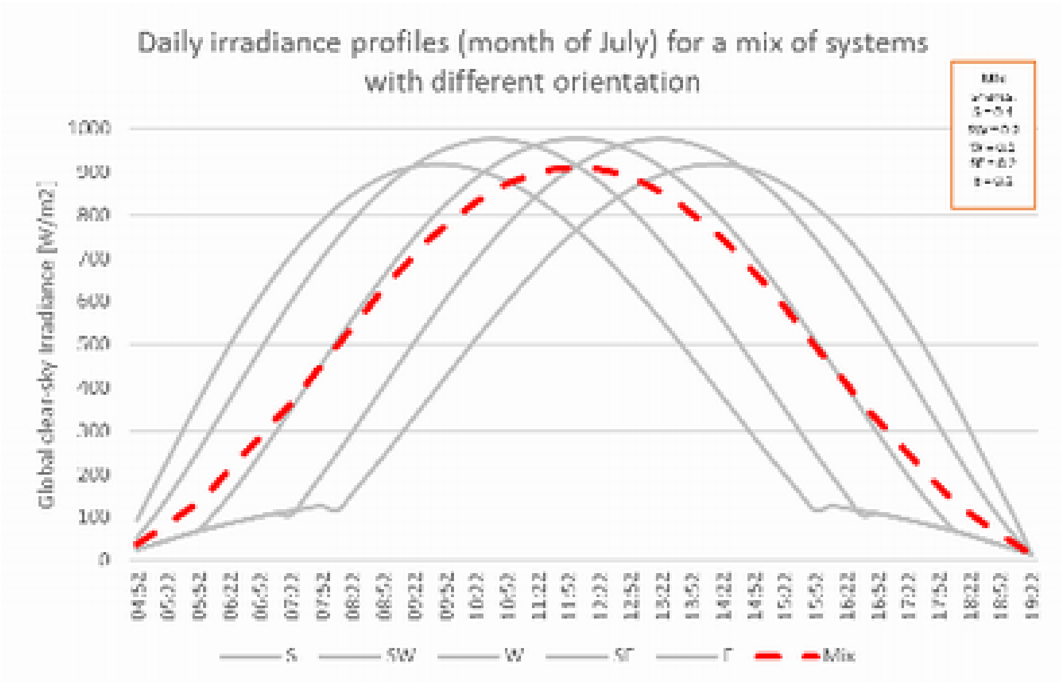

Figure 6 – Daily irradiance profiles in the city of Turin for a mix of PV systems (slope 35°, month of July)

RES demand of neighbouring regions

A detailed analysis of the neighbouring regions would require many data that are not currently available.

The neighbouring regions are Valle d'Aosta region and Biella, Vercelli, Asti and Cuneo provinces in Italy, and the Rhone-Alpes region in France.

Some annual data about electricity are available on macro regions, therefore is known that there is a net annual import of electricity from France and from Valle d'Aosta. At the same time there is an export of electricity towards the others Italian provinces, but there are no data about the amounts of energy involved. Moreover, Valle d'Aosta has an excess production of about 2,9 TWh, all from hydro power plants, which are currently exported through the province of Turin to the others Italian regions.

It is not possible to calculate the renewable share of the electricity, as some data are available for the regions but not for the provinces.

In any case, the electricity production from renewables remains near 20% of the total production, and there are currently no possibilities of measuring the destination of that energy.

Considering the other renewables, the only source that can be imported or exported is the wood biomass. However the province of Turin is already consuming a larger amount of biomass than the local availability, mainly imported from Eastern Europe and other Italian regions.

Present energy transfer possibilities

The current energy transfer possibilities of the electricity networks are much higher than the production from renewable sources.

Moreover, some power lines passing in the region are used to supply to other Italian regions an amount of electricity which is imported from abroad (France, France and Switzerland through Valle d'Aosta). Therefore the current power lines have been designed considering larger amounts of energy than the local consumption and production.

As a consequence, an increase of energy production from renewables could use the existing grids without the need of changing the global capacity. However, in some cases it would be necessary to modify the local grids (low and medium voltage) in order to match the increase of power production.

List of figures

List of references

[1] Provincia di Torino, Ottavo Rapporto sull’Energia, http://www.provincia.torino.gov.it/ambiente/energia/programm/8_rapporto
[2] Renerfor Alcotra Project, PSEBL, www.renerfor.eu
[3] Arpa Piemonte, Rapporto sull’Elettromagnetismo 2012, http://www.regione.piemonte.it/ambiente/elettromagnetismo/dwd/2013/Rapportoelettromagnetismo2012.pdf
[4] GSE, Rapporto Statistico sul Fotovoltaico, http://www.gse.it/it/Statistiche/RapportiStatistici/Pagine/default.aspx
[5] Atlasole database, http://atlasole.gse.it/atlasole/
[6] PVGis website, http://re.jrc.ec.europa.eu/pvgis/