Pilot Region "Valle d'Aosta"

Status Quo Report and Masterplan

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BER</td>
<td>Regional Energy Balance</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined heat and power</td>
</tr>
<tr>
<td>EV</td>
<td>Electric vehicle</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>MV</td>
<td>Medium Voltage</td>
</tr>
<tr>
<td>PEAR</td>
<td>Regional Energy and Environment Plan</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
</tr>
<tr>
<td>RES</td>
<td>RENEWABLE ENERGY SOURCES</td>
</tr>
<tr>
<td>ZEV</td>
<td>Zero Emission Vehicles</td>
</tr>
</tbody>
</table>
1 Summary

This document has two main goals: in the first part the status quo describes the current situation of existing energy resources and consumption in the Aosta Valley regional territory. A special emphasis is given to renewable energy sources, energy storage (electric and thermal), sustainable mobility and smart grids. The governance and the structure of the electricity system are described in terms of generation, transport, distribution and end-users profile. The R&D initiatives and demonstration projects already activated are also described.

The report update and summarizes the data available from other sources dealing with the energy and environment issues, with particular reference to the Regional Energy and Environmental Plan 2011-2020 (PEAR) that is currently in the approval process.

In the second part, the Master Plan, the document aims to provide to decision makers the guidelines to integrate the regional policies and plans in the energy sector. The guidelines account for the territorial characteristics and the social and economical context.

Particular attention is reserved to the penetration of the electric propulsion in the area of public and private mobility, for which the implementation of a real dedicated infrastructure is required. The latter involves the distribution grid, frequently assisted by RES generators, and the urban and logistic arrangement related to the flow of people and goods. In this section of the document, a methodological bottom-up approach used, based on the increasing diffusion of smart nodes equipped with up-to-date electro-technologies.

The diffusion of stationary and mobile storages has the goal to contain as much as possible the power back-flows to the primary medium voltage cabins. The proposed pilot plant configuration represents the concretization of a smart nodes typical structure and is aimed to experimental monitoring and the tuning of the numerical simulations. In this sense the projects aims to confirm how a correct and smart use of the stationary and mobile storages may carry energetic and environmental advantages sufficiently important to compensate, in view of an evolution of the local grid, the sum of the irreversibility losses connected to the storage energy chains.

In this version but also with the next updates, the Master Plan guidelines may support the choices of the Public Administration in the energy planning sector up to 2030 within a vision of increasing sustainability and reliability of the energy system.
2 The Pilot Region

2.1 General description

The energetic system of a region as Aosta Valley is tightly tied to numerous variables of different nature, some purely geographical (conformation of the territory, climate, presence of energetic sources, etc.), some others connected to the social-economic context (population, productive activities, mobility, building patrimony, etc.).

In this chapter we want therefore to focus the attention on the general picture within which the Alp-Store themes can be inserted. The knowledge of such aspects is fundamental to verify the reliability of the data of the following chapters and to understand the system in whole.

The Aosta Valley is characterized by small and very small municipalities, most of which situated at the feet of the mountains and near large water basins. These are a territorial assets for natural resources, landscape and historical importance but also represent a weak point for economic development because of mountain depopulation, and the difficulty in transport connections and in communications, which are more and more complicated for the settlements at high altitudes. The Alpine region, at the same time fragile and rich of human and natural resources, is the place where you can put into practice, in an exemplary way, the concept of territorial cohesion, showing how integrated development strategies, conscious and full of quality, can enhance the geographical features.

Renewable energy sources such as hydropower, solar, wind, and biomass, exist throughout the Aosta Valley though their use is to a certain degree limited due to inadequate or total lack of electric network, which, generally speaking, doesn’t permit a distribution at high levels of efficiency of the produced energy. This sometimes constitute a constrain to the diffusion of distributed renewable energy sources and, consequently, a waste of the production opportunities offered by the territory. The strengthening of the distribution network sometimes causes serious problems and expenses, linked, from one side, to the natural environment, in which the impact of these lines would be in contrast with the surrounding landscape and, on the other side, to the technical or economical impossibility to create appropriate distribution lines turned to support the users’ energy requirements.

2.1.1 Key data

The territory of Aosta Valley is 3263 km2 and is mainly mountainous. The average height is around 2106 meters above sea level, varying from 310 m to the border with Piemonte to 4810 m of Mont Blanc mountain. The particular territorial conformation determines a low use of the soil: less than 10% of the soil is exploited for human settlers and farming, the remaining part of it being covered by rocky and glacial surface or forests. The non-homogeneity of the territory is the cause of a particular
microclimatic conditions connected to the altitude, to the exposure of the slopes, to the different conditions depending on wind and air humidity.

According to the “enclosure A” of the DPR 412 of 1993, that divides the Italian communes on the “degree-days”, all the cities are included in two only climatic bands (E and F):

- Zone E: cities that have a number higher than 2100 degree-days and not superior to 3000;
- Zone F: cities that have a number higher than 3000 degree-days.

The province of Aosta counts 74 cities: 1 more than 5000 inhabitants; 14 from 2000 to 5000 inhabitants; 59 less than 2000 inhabitants.
The resident population in Aosta Valley has experienced a slow but continuous increase during the years. In the last decade the increase has been around 1% per year, rising from 119,546 inhabitants in 2001 to 128,230 as of the 31st December 2011, with a general increase of 8,234 individuals.

The territory is rich of water basins (which also has numerous surfaces perpetually snowed or covered by glaciers) and has seen, during the years, a progressive increase of the productivity of electric energy from plants and micro-plants of hydroelectric type. The productivity of this technology is attested alone more than 99% of the whole production effected in Aosta Valley that is about 3,000 GWh a year. The remaining 0.5% is composed by systems based on small combined heat and power plants (CHPs), photovoltaic (PVs), biomass and wind plants. Although the large amount of produced electric energy, the requirement of the region is only a third (about 992 GWh), the remaining is ex-
ported towards the Italian territory and Switzerland through high/medium voltage lines. The actual direction of the energy flow on the high voltage line is not known.

Beside hydroelectric power plants, there is still a good production potential from RES that is poorly exploited (especially solar and wind). Therefore, the necessity to give a great impulse to the distributed generation rises, increasing both the actual implementation and the relationship of single consumers with these matters.

2.1.2 Existing energy and climate activities
The Aosta Valley energy plan 2011-2020 (PEAR) has been acknowledged by the regional government and it is currently pending for the final approval. The PEAR is a document turned to the regional monitoring and planning in the energy sector, indicaing the existing development perspective. One of the main goals of the plan is to meet the regional Burden Sharing objective which sets the ratio between the energy produced by RES and the total energy consumed to a minimum of 52%. The attainment of this goal is planned for 2020.

In the following are listed the main projects presently active in the region, regarding existing energy and climate activities:

Alpine Space Program 2007/2013:

- ALPHOUSE - To improve energy efficiency in buildings;
- SHARE - Sustainable Hydropower in Alpine Rivers Ecosystems;
- iMONITRAF! - Monitoring of road traffic related effects in the Alpine Space and common measures and ALPCHECK2 - creating a road transport model covering the whole Alpine area;

Other Projects:

- Pilot project DEVAL Smart Grid – aimed at implementing a smart grid in the Valsavarenche and Val di Rheme context.
- Reve Grand Paradis – aimed at introducing an integrated electric mobility structure in the Gran Paradiso area, through the introduction of electric bicycles and vehicles supported by an opportune charging infrastructure.
- Green Road – implementation of an infrastructure for electric vehicles batteries charging in the Aosta Valley.
Chapter 3  Status quo of Energy System

In this chapter will be outlined the methods of production, consumption and storage of energy mostly in use in the Aosta Valley context. The energy sector includes electric energy, thermal energy and transports. The reference year is 2011. Most of the data are taken from the regional energy plan (PEAR) that is the official regional source where the information in theme of energy can be found. The data source is quoted in the text.

3.1  Energy Production

3.1.1  Conventional Power Plants
In the region there are no conventional plants for electric production (intended as plants fuelled by natural gas, coal and the by-products of oil) for two principal reasons: all the sources of production above mentioned should be imported being not present on the territory and, above all, because of the great availability of rivers and water basins.

3.1.2  Renewable Energies
Thanks to the satisfying availability of water and the mountainous structure of the territory, the Region can rely on an energy production mainly based on the hydroelectric source. Nowadays is beginning an exploitation of the wind resource, that may be significant in some areas, and of biomass for heating and CHP.

3.1.3  Water
Water is the most diffused method for power production from renewable sources in the Aosta Valley. The largest part of the hydroelectric plants exploits a small basin for water collection at high altitude, from which water is transported to the plant through penstocks. In some cases, in major production plants, dikes of containment have been realized to create basins able to feed plants of greater power. The following picture represents the main rivers in the Aosta Valley territory.
The hydro-electric resource has been, in the years, largely exploited and the residual potential is negligible with respect to what implemented so far. In the territory the hydroelectric plants power range from some dozens of kW to more than 100 MW. The park is composed by both basin and run-of-river installations. The classification by size sees:

- 133 plants with power lower than 100kW for 3MW average power;
- 46 plants with power between 100kW e 1MW for 18MW average power;
- 33 plants with power between 1MW e 10MW for 134MW average power;
- 16 plants with power higher than 10MW for 380MW average power.

Source: “Servizio Gestione Demanio e risorse idriche dell’Assessorato opere pubbliche, difesa del suolo e edilizia residenziale pubblica”, updated to 21/10/2011

Over 74 municipalities of the Aosta Valley, 64 are involved in withdrawals for energetic purpose. Up to now, the plants present on the territory are 228 with a nominal gross annual power on design of
535 MW, corresponding to a gross effective power of 899.5 MW (source Terna, 2011). The larger regional energy producer is, by far the company CVA S.p.a. That owns more than 90% and produces about 95% of the total electric energy. Other minor producers, such as F.Ili Ronc Srl. C.E.G. Srl play a minor role in the regional hydroelectric sector. The following table reports the hydroelectric energy production for the year 2011 distinguished by power.

<table>
<thead>
<tr>
<th>Source</th>
<th>Power</th>
<th>Unit</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,561.864</td>
</tr>
<tr>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>392.521</td>
</tr>
<tr>
<td>Hydro-electric</td>
<td>up to 1 MW</td>
<td>MWh</td>
<td>95.711</td>
</tr>
</tbody>
</table>

*Table 2 Hydro-electric production (2011)*

**Water - CVA s.p.a. – Compagnia delle Acque Valdostane**

CVA represents the first producer of electric energy in the region and owns the greatest number of large power installed plants (>10 MW). The table below provides information on the energy production from 2006 to 2011.

<table>
<thead>
<tr>
<th>Year</th>
<th>Region</th>
<th>Source</th>
<th>Power</th>
<th>Unit</th>
<th>Energy produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,355,427</td>
</tr>
<tr>
<td>2005</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>504,235</td>
</tr>
<tr>
<td>2005</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>up to 1 MW</td>
<td>MWh</td>
<td>126,313</td>
</tr>
<tr>
<td>2006</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,348,460</td>
</tr>
<tr>
<td>2006</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>512,450</td>
</tr>
<tr>
<td>2006</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>up to 1 MW</td>
<td>MWh</td>
<td>122,660</td>
</tr>
<tr>
<td>2007</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,331,224</td>
</tr>
<tr>
<td>2007</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>515,324</td>
</tr>
<tr>
<td>2007</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>up to 1 MW</td>
<td>MWh</td>
<td>128,341</td>
</tr>
<tr>
<td>2008</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,349,515</td>
</tr>
<tr>
<td>2008</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>534,821</td>
</tr>
<tr>
<td>2008</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>up to 1 MW</td>
<td>MWh</td>
<td>128,080</td>
</tr>
<tr>
<td>2009</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 10 MW</td>
<td>MWh</td>
<td>2,351,616</td>
</tr>
<tr>
<td>2009</td>
<td>Valle D'Aosta</td>
<td>Hydro-electric</td>
<td>&gt; 1 MW a 10 MW</td>
<td>MWh</td>
<td>511,019</td>
</tr>
</tbody>
</table>
### 3.1.3.1 Wind

The exploitation of the wind natural source is possible thanks to wind machines generally called wind turbines. Two different typologies of wind turbines can be distinguished basing on the type of the module used: The vertical axis generator (from 0,1 to 1 MW) and the horizontal axis generator (from 0,1 to 3 MW).

In the Aosta Valley, the wind potential is complex to assess. The zones mostly swept by constant ventilation, adequate to the exploitation for wind electricity production, are essentially situated in mountainous territories hardly reachable, thus limiting the possibility of plants installation and forcing the engineers to carry out deep evaluations of feasibility.

Crossing the data related to the geo-morphographic situations with social-economic data, logistic data and with wind data, deduced by national coverage models, the portion of territory potentially suitable for the installation of wind machines can be extracted, obtaining the useful surface, equal to 12,8% of the regional territory (green zones in the underlying figure). Crossing the information on the useful surface with the maps of wind productivity, a maximum potential production of 117 GWh/year with an installed total power of 65 MW has been assessed.

However in 2011 no industrial wind power plants were installed in the Aosta Valley; the total installed power was less than 0,05 MW with a production of 18 MWh. A wind power installation of average size is in La Thuile, with a mini wind plant of 12 kW power, positioned in a zone characterized by a wind speed between 5 and 6 m/s, and Verrès with a mini wind plant rated 25 kW. In 2012, CVA installed also 3 turbines rated 850 kW in Saint Denis for a total of 2,55 MW.

### Table 3: Hydro-electric energy production from 2005 to 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Region</th>
<th>Type</th>
<th>Capacity</th>
<th>Power Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>up to 1 MW</td>
<td>118,973</td>
</tr>
<tr>
<td>2010</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>&gt; 1 MW a 10 MW</td>
<td>2,372,294</td>
</tr>
<tr>
<td>2010</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>up to 1 MW</td>
<td>513,644</td>
</tr>
<tr>
<td>2010</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>&gt; 10 MW</td>
<td>2,561,864</td>
</tr>
<tr>
<td>2011</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>&gt; 1 MW a 10 MW</td>
<td>392,521</td>
</tr>
<tr>
<td>2011</td>
<td>Valle D'Aosta</td>
<td>Hydro-elec</td>
<td>up to 1 MW</td>
<td>95,711</td>
</tr>
</tbody>
</table>

The above table reflects the hydro-electric energy production from 2005 to 2011 in the region of Valle d'Aosta, Italy.
In the following image are indicated in green the zones reputed suitable for the installation of wind plants. These areas satisfy the main requirements in terms of wind presence, urban installations, altitude and territory typography.
3.1.3.2 Solar photovoltaic

In the Aosta Valley the average medium solar irradiation varies locally according to the morphological and atmospheric characteristics of the zone. In Aosta it is 1.600 kWh/m² that is a remarkable irradiation, above all if compared to the values of regions as Campania or Sicily, mainly for the clearness of the atmosphere due to the absence of fogs and hazes that penalize most of the north of Italy. As regards the solar photovoltaic the following data can be given:

- The installed power has increased in the last years due to the National policies;
- The lowest Italian average plant size is in the Aosta Valley (12.5 kW); 82% of the installations are on buildings. This is mainly linked with the morphology of the territory;
- The services and domestic sectors cover 62% of the installed power, of which 28% is composed by residential sector.
- In 2011 in the Aosta valley were installed 1116 PV power plants with a total power of 13.9 MW. The production from PV plants in 2011 was 11.1 GWh.

3.1.3.3 Solar thermal

The solar thermal installations exploit the sun energy to heat water; the main installations regard domestic plants for sanitary warm water production. Up to 2011, the total surface of solar thermal panels installed is assessed equal to 15.200 m², for a production of 12.16 GWh/year. (Source: PEAR)

This value does not account for a part of the installation in the tertiary sector, agriculture sector and industrial sector. This part is the one that, since 01/01/2009, did not enjoy of easing at a regional level.

3.1.3.4 Combined heat and power generation (CHP)

With the term “combined heat and power” (CHP) is intended a plant able to produce contemporarily electric power and thermal power for heating. CHP plants are composed by a thermal engine whose waste heat is recovered thanks to a heat exchanger. For large installations (>10 MW), steam plants or gas turbines can be employed. For smaller powers, internal combustion engines are more indicated, although some installations may employ micro-gas turbines.

In 2011 6.4 GWh of thermal energy from biomass fuelled CHP plants were produced, for total primary energy consumption 13.1 GWh. The total installed power in 2011 is 4.5 MW. Source: PEAR.
3.1.3.5 Biomass (thermal)

As biomass is intended a plurality of organic materials (of animal or vegetable origin). The Aosta Valley has a good potential for biomass use from vegetable origin, having large areas covered by forest. Presently, biomass is exploited for the heating of buildings, both through small scale plants and large plants connected to a district heating network. In this chapter the amount exploited for CHP plants feeding is not considered.

According to the data from the RENERFOR project, about 40% of the small/medium firms uses biomass for heating, whereas in the civil field only 11.2% of the houses exploits biomass as heating fuel for the main boiler; instead, 36.3% of the auxiliary boilers are fuelled by biomass.

The main existing biomass fuelled industrial plants are those of Morgex, Pollein and Pre Saint Didier, with a total installed power of 18 MWt and an annual production of 35.1 GWh in 2010. In the following table is visible the data of the three plants. Moreover in 2011, in 2011, two biomass fired district heating CHP plants were started in the Municipality of La Thuile.

<table>
<thead>
<tr>
<th>Plants</th>
<th>Power [MW]</th>
<th>Production [MWh/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgex</td>
<td>10</td>
<td>17900</td>
</tr>
<tr>
<td>Pollein</td>
<td>4</td>
<td>4200</td>
</tr>
<tr>
<td>Pre Saint Didier</td>
<td>4</td>
<td>13000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18</td>
<td>35100</td>
</tr>
</tbody>
</table>

Table 4 biomass: district heating plants power and production
3.2 Energy consumption

3.2.1 Electric energy

Below it’s possible to have a vision of the electric consumption of the main activities in the Aosta Valley. The subdivision into high, medium and low voltage consumers is provided. All the same activities are merged into the main product category.

Among large scale consumers, with more than 100,000 kWh/year of energy consumption, it’s possible to notice that the steel industry has a great impact on the overall consumption.

For the consumers rated less than 100,000 kWh/year, it’s possible to observe that the terrestrial transport industry has a great impact with respect to the other sectors.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>n</th>
<th>Typology</th>
<th>kWh (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>240</td>
<td>Technical gases</td>
<td>54,688,195</td>
</tr>
<tr>
<td>High</td>
<td>271</td>
<td>Steel Industry</td>
<td>277,628,739</td>
</tr>
<tr>
<td>High</td>
<td>280</td>
<td>Metal elements</td>
<td>4,476,344</td>
</tr>
<tr>
<td>High</td>
<td>603</td>
<td>Transport media</td>
<td>6,417,020</td>
</tr>
</tbody>
</table>

Table 5 Users in high voltage

<table>
<thead>
<tr>
<th>Voltage</th>
<th>n</th>
<th>Typology</th>
<th>kWh (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>1</td>
<td>Private houses</td>
<td>236,703</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>General services</td>
<td>1,025,295</td>
</tr>
<tr>
<td>Medium</td>
<td>9</td>
<td>Other areas</td>
<td>776,578</td>
</tr>
<tr>
<td>Medium</td>
<td>11</td>
<td>Agriculture firms</td>
<td>383,169</td>
</tr>
<tr>
<td>Medium</td>
<td>110</td>
<td>Liq. Fuels extr</td>
<td>265,206</td>
</tr>
<tr>
<td>Medium</td>
<td>130</td>
<td>Metal extr.</td>
<td>475,903</td>
</tr>
<tr>
<td>Medium</td>
<td>141</td>
<td>Extraction from C</td>
<td>1,787,589</td>
</tr>
<tr>
<td>Medium</td>
<td>150</td>
<td>Cheese Ind.</td>
<td>263,084</td>
</tr>
<tr>
<td>Medium</td>
<td>151</td>
<td>Meat Industry</td>
<td>6,239,936</td>
</tr>
<tr>
<td>Medium</td>
<td>153</td>
<td>Pro Ind</td>
<td>5,372,051</td>
</tr>
<tr>
<td>Medium</td>
<td>159</td>
<td>Drinks</td>
<td>12,890,230</td>
</tr>
<tr>
<td>Medium</td>
<td>200</td>
<td>Industry of L</td>
<td>343,958</td>
</tr>
<tr>
<td>Medium</td>
<td>220</td>
<td>Editor</td>
<td>875,887</td>
</tr>
<tr>
<td>Medium</td>
<td>244</td>
<td>Production of O</td>
<td>195,983</td>
</tr>
<tr>
<td>Medium</td>
<td>248</td>
<td>Other Chemical Industries</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>252</td>
<td>Plastic products industry</td>
<td>14,835,237</td>
</tr>
<tr>
<td>Medium</td>
<td>266</td>
<td>Concrete manufact</td>
<td>259,980</td>
</tr>
<tr>
<td>Medium</td>
<td>267</td>
<td>Non metallic minerals</td>
<td>202,227</td>
</tr>
</tbody>
</table>
## Table 6 Users in Medium voltage

<table>
<thead>
<tr>
<th>Voltage</th>
<th>n</th>
<th>Typology</th>
<th>kWh (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1</td>
<td>Private homes</td>
<td>151,295,985</td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
<td>General services for houses</td>
<td>22,406,880</td>
</tr>
<tr>
<td>Low</td>
<td>3</td>
<td>Heat pumps</td>
<td>30,391</td>
</tr>
<tr>
<td>Sector ID</td>
<td>Sector Name</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Low 9</td>
<td>Other sectors</td>
<td>624,965</td>
<td></td>
</tr>
<tr>
<td>Low 11</td>
<td>Farms and related services</td>
<td>2,424,907</td>
<td></td>
</tr>
<tr>
<td>Low 12</td>
<td>Breeding and related services</td>
<td>1,101,513</td>
<td></td>
</tr>
<tr>
<td>Low 13</td>
<td>Territory drainage</td>
<td>5,750</td>
<td></td>
</tr>
<tr>
<td>Low 14</td>
<td>Irrigation for agriculture</td>
<td>114,105</td>
<td></td>
</tr>
<tr>
<td>Low 20</td>
<td>Forest management</td>
<td>60,853</td>
<td></td>
</tr>
<tr>
<td>Low 50</td>
<td>Fishing and fish breeding</td>
<td>6,524</td>
<td></td>
</tr>
<tr>
<td>Low 110</td>
<td>Liquid fuels extraction</td>
<td>163</td>
<td></td>
</tr>
<tr>
<td>Low 141</td>
<td>Mine extraction</td>
<td>405,972</td>
<td></td>
</tr>
<tr>
<td>Low 150</td>
<td>Food industry in associated form</td>
<td>566,027</td>
<td></td>
</tr>
<tr>
<td>Low 151</td>
<td>Meat, fish, milk industry</td>
<td>2,100,816</td>
<td></td>
</tr>
<tr>
<td>Low 153</td>
<td>Food industry of farm products</td>
<td>2,736,308</td>
<td></td>
</tr>
<tr>
<td>Low 159</td>
<td>Drinks</td>
<td>269,587</td>
<td></td>
</tr>
<tr>
<td>Low 170</td>
<td>Textile</td>
<td>32,875</td>
<td></td>
</tr>
<tr>
<td>Low 180</td>
<td>Clothing industry</td>
<td>304,278</td>
<td></td>
</tr>
<tr>
<td>Low 191</td>
<td>LEather industries</td>
<td>2,509</td>
<td></td>
</tr>
<tr>
<td>Low 193</td>
<td>Shoes industry</td>
<td>12,671</td>
<td></td>
</tr>
<tr>
<td>Low 200</td>
<td>Cork and wood industry</td>
<td>2,080,092</td>
<td></td>
</tr>
<tr>
<td>Low 212</td>
<td>Paper items</td>
<td>7,415</td>
<td></td>
</tr>
<tr>
<td>Low 220</td>
<td>Press and editorial industry</td>
<td>523,856</td>
<td></td>
</tr>
<tr>
<td>Low 232</td>
<td>Oil refineries</td>
<td>48,042</td>
<td></td>
</tr>
<tr>
<td>Low 247</td>
<td>Pharma industries</td>
<td>3,802</td>
<td></td>
</tr>
<tr>
<td>Low 248</td>
<td>Other chimica industries</td>
<td>1,837</td>
<td></td>
</tr>
<tr>
<td>Low 251</td>
<td>Rubber items industries</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Low 252</td>
<td>Plastic industries</td>
<td>67,097</td>
<td></td>
</tr>
<tr>
<td>Low 261</td>
<td>Glass industries</td>
<td>47,888</td>
<td></td>
</tr>
<tr>
<td>Low 262</td>
<td>Keramic product industries</td>
<td>102,047</td>
<td></td>
</tr>
<tr>
<td>Low 264</td>
<td>Brickwork industries</td>
<td>33,767</td>
<td></td>
</tr>
<tr>
<td>Low 266</td>
<td>Concrete manufacturers</td>
<td>129,192</td>
<td></td>
</tr>
<tr>
<td>Low 267</td>
<td>Non metallic mineral industries</td>
<td>373,344</td>
<td></td>
</tr>
<tr>
<td>Low 273</td>
<td>Other steel production industries</td>
<td>114,478</td>
<td></td>
</tr>
<tr>
<td>Low 274</td>
<td>Aluminium industriest</td>
<td>3,989</td>
<td></td>
</tr>
<tr>
<td>Low 280</td>
<td>Metallic elements</td>
<td>868,090</td>
<td></td>
</tr>
<tr>
<td>Low 290</td>
<td>Mechanical industries</td>
<td>776,669</td>
<td></td>
</tr>
<tr>
<td>Low 300</td>
<td>Machinery industries</td>
<td>8,058</td>
<td></td>
</tr>
<tr>
<td>Low 310</td>
<td>FABB.MACCH.APP.</td>
<td>27,056</td>
<td></td>
</tr>
<tr>
<td>Low 320</td>
<td>Radio facilities ind.</td>
<td>58,614</td>
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</tr>
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<td>Low 330</td>
<td>Medical facilities ind.</td>
<td>430,083</td>
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<tr>
<td>Low 340</td>
<td>Automotive industries</td>
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<tr>
<td>Low 353</td>
<td>Transport constr. and fixing</td>
<td>245,198</td>
<td></td>
</tr>
<tr>
<td>Low 361</td>
<td>Furnitures industries</td>
<td>543,580</td>
<td></td>
</tr>
<tr>
<td>Low 362</td>
<td>Manufacturer industries</td>
<td>125,753</td>
<td></td>
</tr>
<tr>
<td>Low 370</td>
<td>Recycling</td>
<td>6,624</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>401</td>
<td>Electric energy</td>
<td>1,052,828</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>--------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Low</td>
<td>402</td>
<td>Gas</td>
<td>131,628</td>
</tr>
<tr>
<td>Low</td>
<td>410</td>
<td>Water</td>
<td>1,919,305</td>
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<tr>
<td>Low</td>
<td>450</td>
<td>Other industrial works</td>
<td>907,326</td>
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<td>Low</td>
<td>452</td>
<td>Constr. sites civil</td>
<td>2,348,367</td>
</tr>
<tr>
<td>Low</td>
<td>453</td>
<td>Constr. sites civil</td>
<td>1,969,139</td>
</tr>
<tr>
<td>Low</td>
<td>501</td>
<td>Vehicles selling</td>
<td>677,729</td>
</tr>
<tr>
<td>Low</td>
<td>502</td>
<td>Vehicles Maintenance</td>
<td>1,553,367</td>
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<tr>
<td>Low</td>
<td>505</td>
<td>Fuel and oil retailing</td>
<td>924,297</td>
</tr>
<tr>
<td>Low</td>
<td>510</td>
<td>Wholesale</td>
<td>1,309,623</td>
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<tr>
<td>Low</td>
<td>521</td>
<td>Large scale trade</td>
<td>5,073,160</td>
</tr>
<tr>
<td>Low</td>
<td>522</td>
<td>Small scale trade</td>
<td>5,512,768</td>
</tr>
<tr>
<td>Low</td>
<td>524</td>
<td>Small scale trade</td>
<td>14,765,963</td>
</tr>
<tr>
<td>Low</td>
<td>527</td>
<td>RIPARAZIONE DI</td>
<td>116,682</td>
</tr>
<tr>
<td>Low</td>
<td>551</td>
<td>Hotels</td>
<td>28,727,106</td>
</tr>
<tr>
<td>Low</td>
<td>553</td>
<td>Pubs, restaurants</td>
<td>23,327,981</td>
</tr>
<tr>
<td>Low</td>
<td>555</td>
<td>Provisions of coke food</td>
<td>116,746</td>
</tr>
<tr>
<td>Low</td>
<td>602</td>
<td>Other transport</td>
<td>2,970,189</td>
</tr>
<tr>
<td>Low</td>
<td>603</td>
<td>Transport using oil and gas pipes</td>
<td>179,107</td>
</tr>
<tr>
<td>Low</td>
<td>604</td>
<td>F.S. other uses</td>
<td>945,227</td>
</tr>
<tr>
<td>Low</td>
<td>620</td>
<td>Aircraft transport</td>
<td>19,538</td>
</tr>
<tr>
<td>Low</td>
<td>630</td>
<td>Auxiliary activities</td>
<td>3,620,501</td>
</tr>
<tr>
<td>Low</td>
<td>640</td>
<td>Communications</td>
<td>7,201,185</td>
</tr>
<tr>
<td>Low</td>
<td>650</td>
<td>Credit</td>
<td>2,790,266</td>
</tr>
<tr>
<td>Low</td>
<td>660</td>
<td>Insurance companies</td>
<td>86,269</td>
</tr>
<tr>
<td>Low</td>
<td>670</td>
<td>Auxiliary activities</td>
<td>94,605</td>
</tr>
<tr>
<td>Low</td>
<td>700</td>
<td>Real estate activities</td>
<td>131,108</td>
</tr>
<tr>
<td>Low</td>
<td>710</td>
<td>Renting without operator</td>
<td>92,741</td>
</tr>
<tr>
<td>Low</td>
<td>720</td>
<td>informatics</td>
<td>716,984</td>
</tr>
<tr>
<td>Low</td>
<td>730</td>
<td>R&amp;D</td>
<td>53,328</td>
</tr>
<tr>
<td>Low</td>
<td>740</td>
<td>Other activities</td>
<td>7,351,351</td>
</tr>
<tr>
<td>Low</td>
<td>751</td>
<td>Public administration</td>
<td>14,173,318</td>
</tr>
<tr>
<td>Low</td>
<td>752</td>
<td>Road network services</td>
<td>23,552,913</td>
</tr>
<tr>
<td>Low</td>
<td>753</td>
<td>Road network services</td>
<td>350,052</td>
</tr>
<tr>
<td>Low</td>
<td>801</td>
<td>Public education</td>
<td>2,686,660</td>
</tr>
<tr>
<td>Low</td>
<td>802</td>
<td>Private education</td>
<td>1,784,121</td>
</tr>
<tr>
<td>Low</td>
<td>851</td>
<td>Public hospitals</td>
<td>858,860</td>
</tr>
<tr>
<td>Low</td>
<td>852</td>
<td>Private hospital</td>
<td>406,204</td>
</tr>
<tr>
<td>Low</td>
<td>853</td>
<td>Other health services</td>
<td>868,178</td>
</tr>
<tr>
<td>Low</td>
<td>854</td>
<td>Other health services</td>
<td>872,728</td>
</tr>
<tr>
<td>Low</td>
<td>900</td>
<td>Ecological services</td>
<td>521,831</td>
</tr>
<tr>
<td>Low</td>
<td>910</td>
<td>Recreational activities</td>
<td>1,314,334</td>
</tr>
<tr>
<td>Low</td>
<td>920</td>
<td>Other private sanitary services</td>
<td>5,204,501</td>
</tr>
</tbody>
</table>
3.2.2 Thermal energy
The total thermal energy consumption of the Aosta Valley in 2011 was calculated in 2389.3 GWh. Of the latter, 2297.1 GWh come from fossil fuels and 92.1 from RES. Source: PEAR

![Figure 5 Thermal production in Aosta Valley in 2011](image)

3.2.3 Transports
The consumption in 2011, estimated basing on the information contained in the PEAR, is about 6000 GWh/year. This data is in phase of verification and revision, as it appears over-estimated. Below, is reported a table for the transport consumptions.
3.2.4 Conclusions

On the basis of the previous paragraphs, the main conclusions are given below:

- The production from RES (more than 99% from hydropower) exceeds the internal electric consumption. The electric production from non hydroelectric source is less than 1% of the total.

- The electric consumption is distributed between industry (44%) and residential and tertiary sector (40%).

- The thermal energy production for heating comes prevalently from fossil source; the most consuming sector is the civil sector (about 2/3 of the total).

- The transport sector weights by 45% on the total energetic consumption.

- The industrial sector covers a great part of the total electric consumption, while the remaining part is divided among the service and household sectors (with a slight increase over the previous year). The agricultural sector demand is irrelevant compared to that of the other sectors.
The total consumption per head of electric energy has increased from 5.654 kWh in 1998 to 6.678 kWh in 2011; as the domestic circle has passed, for the same years, from 1442 kWh to 1490 kWh (+0.4%).

The transport and the civil sector (the latter intended as heating of the buildings) require a large amount of fossil fuels; only a small part of the energy required for the civil heating (69.6 GWh in 2011) is produced by renewable sources. In 2011, the total consumption was attested to 2408.59 GWh for thermal heating uses and 2714.7 GWh for transport.
3.2.5  Trends

3.2.5.1 Electric energy
The graph below illustrates the electric energy consumption classified for the different categories of users in the Aosta Region; as visible almost all the sectors have grown since 2000, while just lately the consumptions are decreasing and so in some sectors they present a variable trend.

In the following figure the comparison between electric energy production, consumption and export (which is the difference between production and consumption) is provided. As visible, the Aosta Valley region is seen from the external system point of view, as a producer.

![Figure 7 Electric consumptions by sector (GWh) (log scale) Source: PEAR](image)
3.2.5.2 Thermal energy
In the figure below the values of the thermal consumption in the last decade are reported. In this case, the values of production and consumption are equal. In fact there is no storage or export of the energy outside of the region.
3.2.5.3 Transport

The figure below shows the consumed energy in the transport sector for the Aosta Valley region. The values have been elaborated according to the official information of the Regional Energy Balance and of the PEAR. However, there is a discontinuity between 2004 and 2005 due to the difference between some data acquisition sources.

So far in course the research for a standardization of the acquisition methodologies, as the estimation of this kind of consumption is very complex. This complexity is caused by the large number of energy suppliers (fuel stations), by the different vehicles typologies (cars, trucks, trains, cable transports...) and by the difference of the traffic types (local or crossing).

Figure 9 Transport consumption 2000-2011 (source: PEAR)
3.3 Energy transmission and distribution

The electric transmission within the Region is mainly supported by three types of lines at Very High Voltage:

In the following figure is reported the map of the electric cabins for the medium-high voltage conversion. It deals with 13 power cabins designed to be bi-directional. Due to the production of the medium and large scale RES plants (hydro and PV), some cabins often operate with a power flow in the opposite direction (i.e. medium to high voltage).

![Figure 10 Map of the electric cabins](image)

3.3.1 Power Grid

In general the distribution lines of the power grid are composed by:

- High Voltage lines from 60 to 150 kV;
- Medium Voltage lines from 5 to 25 kV;
- Low Voltage lines less than 1000 V, normally 400 V;
- HV/MV step down transformer (primary cabins), transformers on poles or medium voltage (MV/LV) cabins (secondary cabins), circuit breakers and switches, tools for measure.
In the following figure, the main high voltage lines and their position on the territory are indicated.

![Power Lines](image)

**Figure 11 Main high voltage power lines in the territory**

Two companies manage the power distribution in the Region with the first running by far the larger share of the network:

- **Deval**
  
  Inside the Region the distribution of the energy is managed by Deval society. The plants are composed by about 4205 km of power lines:
  
  - 57 km of High Voltage lines;
  - 1382 km of Medium Voltage lines;
  - 2766 km of Low Voltage lines;

  The society also controls 13 primary cabins and substations where the transformation of the electric energy HV/MV happens, and at last 1519 secondary cabins where the MV/LV passage takes place.

- **C.E.G**
  
  For the municipalities of Saint Christophe, Allein, Gignod, Doues, Valpelline and for the zones of Arpuilles, Entrebin, Excenex, Porossan, the C.E.G (Electric Gignod Cooperative) is in charge for the production, distribution, trading and metering of electric energy.
3.3.2 Metering

In the last years, in the Aosta Valley as in the rest of Italy, a substitution campaign of the traditional electric energy-meters with the electronic ones has been effected by Vallenergie company. With the new energy-meters it is possible the remote operation for every client (without the intervention of an employee) for the following services:

- Activations, disactivations and all the contractual changes of the system;
- The control of the effected consumption, also in different moments of the day, allowing an invoicing in which the cost of the kWh depends on the schedule of absorption

3.3.3 (Smart) grid issues and development status

The satisfaction of energy demand and the need to reduce pollutant emissions is creating a deep change in the electric systems configurations: the concept of generation, traditionally carried out in large centralized sites, is progressively displaced by small size plants connected to the distribution grid in proximity of the end user. Currently, the issues related to this new type of electrical architecture leads distributors to verify and eliminate the penetration limits of distributed generation. The distributors action must involve architecture and coordination of the protection systems, regulation and automation of the primary cabins, in order to allow a safe operation of the electric system.

The transmission system is also involved in these deep structural changes of the distribution grid; the latter is evolving from its historical "passive" function towards an active management of distributed energy resources (intended as generators with production not tethered to a program, controllable loads and storage devices) and / or rapid reconfiguration of the grid topology.

With Resolution ARG / elt No. 39 of 2010 "Procedure and criteria for investments selection with the incentive treatment referred to in paragraph 11.4 d) of Appendix A to resolution for Electric Energy and Gas Authority December 29 2007, n° 348/07 " pilot projects of distribution efficiency of electric energy are facilitated. The distribution grid, with the increase of distributed generation (DG), the transition of passive users to active type, must handle new situations and problems such as:

- Transit limits;
- Power flow reversal;
- Voltage quality;
- Undesired standalone phenomena;
Owing to these issues, the development status of the smart grid is limited to the implementation of pilot projects. Within the Aosta Valley Region the following pilot projects are being carried out in order to meet the new needs of the electric grid:

- "AlpEnergy - Virtual power systems as an instrument to promote transnational cooperation and sustainable energy supply in the Alpine space" under the operational program of transnational European Territorial Cooperation Objective 3 - 2007/2013, "ALPINE SPACE", approved by DGR n° 1000 10/04/2009; - Pilot project "Deval Smart Grid" developed at the town of Villeneuve and valleys of Valsavarenche and Rhèmes, that provides for the development of energy management systems in a flexible and efficient way with the use of remote monitoring systems of the equipment and the management of data communications by means of Wi-Fi network;

- The project "RêVE Grand Paradis - Electric Vehicles Grand Paradis Grid ". The aim of these projects is to contribute to the creation and dissemination in the Aosta Valley of a new concept of virtuous electric energy distribution grid focused on distributed production from renewable sources, its local consumption and flows management, in order to develop a model of the regulatory framework to encourage the emergence of smart grid of electric energy distribution;

- The project “Smart Grid DEVAL” has main objective the automation, protection and control of the Villeneuve substation HV/MV through load and generation measurement, partial regulation of some RES power plants and data exchange with Terna Spa;
3.4 Energy storage

- **Mobile Batteries (Electric Vehicles)**
  Electric vehicles are today circulating in the Aosta Valley territory to a very limited extent. There are a very limited number of units, less than 25 units, bought by privates and laying out of any planned initiative. Moreover seven vehicles have been bought within some demonstrative projects funded by European funds and are currently used mainly by public companies or entities.

  Assuming an average capacity of 12,5 kWh per Vehicles the total energy stored can be assessed in about 100 kWh.

- **Stationary Batteries**
  Presently not installed with, the exception of some units currently used as backup power for hydroelectric plants and small UPS.

- **Pump Storage and water basin power plants**
  No hydraulic pumping storage systems are today installed; however the existing plants, with their basins, can store a remarkable amount of energy.

  Each basin can be described by a water volume, a drop in meters and a frequency of intervention, the latter being connected to the installed power and to the natural water supplies. The storage time constants of the regional plants vary from some hours to some months. The characteristics of the storages can be resumed according to the maps indicating the position of the plants. The operational logics of the hydraulic plants can be set in order to optimize the energetic variables of interest (for example profit, grid equilibrium, support to the other renewable sources).

  The maximum value of the Energy theoretically storable, calculated basing on the volume of the basins and the related drops, is about 80 GWh. Of the latter, about a half is stored in the Cignana basin.
4 Future Energy System

4.1 Regional Energy Production

The regional energy production has been estimated up to 2020 and up to 2030. The scenarios at 2020 are derived from the PEAR. The scenarios have been extended from 2020 to 2030 according to different assumptions that currently represent the best possible guess on the future development.

4.1.1 Conventional Power Plants

In the regional context, no conventional power plants for electricity production fed by fossil fuels are planned to be installed. The conventional plants are limited to the thermal energy production (boilers).

In the future the thermal energy quota produced by fossil fuels is expected to decrease because of the combined effect of the regulatory framework that, on one hand, supports the installation of RES such as solar thermal energy and PV and, on the other hand, encourages the implementation of energy efficiency measures.

4.1.2 Renewable Energies

The energy produced by renewable sources is effected by the exploitation of hydro, wind, solar and biomass. The water source covers more than 99% of the total production with a value almost equal to 3000 GWh/year. The other sources offer a lower, but non negligible, contribution. Biomass is used both for thermal energy production and for combined heat and power. This scenario is not expected to considerably vary in the future.

4.1.3 Hydro-electric

Scenario to 2020

In order to assess assumptions for the hydro-electric production re-powering, new investments and Minimum Vital Flow (DMV) have been considered. The DMV current regulations require that, downstream of each water intake, an opportune water flow is provided in order to assure the natural ecological integrity of the river, in particular preserving the water life. Thanks to this regulation, many
hydroelectric plants have been adapted to the Minimum Vital Flow release. The Minimum Vital Flow release is cause of a lack of production quantifiable in 120/130 GWh/year.

The PEAR scenario for the definition of hydro-electric potential, considers the concession requests that should be released in the next years in the hypothesis of a percentage of success near that obtained the former year.

In the Scenario delineated by the plan, the production increase assumed from 2011 to 2020 is about 190 GWh. In the following table are reported the values of potential production for each year, derived accounting for the new installations and the norms of minimum vital flow.

![Hydro-electric production 2011 - 2020](Image)
Region "Valle d'Aosta", Italy
Status Quo and Masterplan

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Minimum vital flow</th>
<th>New plants and repowering</th>
<th>Planned production</th>
<th>CO₂ saved [t/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2709</td>
<td>-130</td>
<td>0</td>
<td>2709</td>
<td>1,581,998</td>
</tr>
<tr>
<td>2012</td>
<td>2931</td>
<td>-130</td>
<td>12</td>
<td>2813</td>
<td>1,642,500</td>
</tr>
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<td>2013</td>
<td>2931</td>
<td>-130</td>
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<td>2825</td>
<td>1,649,508</td>
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<td>2014</td>
<td>2931</td>
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<td>116</td>
<td>2917</td>
<td>1,703,236</td>
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<td>2015</td>
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<td>-130</td>
<td>128</td>
<td>2929</td>
<td>1,710,244</td>
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<td>2016</td>
<td>2931</td>
<td>-130</td>
<td>140</td>
<td>2941</td>
<td>1,717,252</td>
</tr>
<tr>
<td>2017</td>
<td>2931</td>
<td>-130</td>
<td>152</td>
<td>2953</td>
<td>1,724,260</td>
</tr>
<tr>
<td>2018</td>
<td>2931</td>
<td>-130</td>
<td>164</td>
<td>2965</td>
<td>1,731,268</td>
</tr>
<tr>
<td>2019</td>
<td>2931</td>
<td>-130</td>
<td>176</td>
<td>2977</td>
<td>1,738,276</td>
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<tr>
<td>2020</td>
<td>2931</td>
<td>-130</td>
<td>190</td>
<td>2991</td>
<td>1,746,452</td>
</tr>
</tbody>
</table>

Table 11 increase of hydro-electric production and estimates to 2020. Source: PEAR

Scenario from 2021 to 2030
Because of the very high degree of exploitation of the water resource and the recent political and environmental trends, new installations are not forecasted between 2020 and 2030. The production is thus considered constant and equal to 2990 GWh el/year (net of losses due to minimum vital flows)

Figure 13 increase of hydro-electric production and estimates to 2020. Source: PEAR
4.1.3.1 Wind Energy

Scenario 2011-2020

In 2008 a study has been conducted in order to characterize the Valley territory in correlation with the possibility of the wind source use; from this study resulted the possibility of installing wind turbines for a power of 65 MWe, which would provide a productivity of 117 Gwhe/year.

In 2012 a wind plant of 2.4 MWe (3X850 kWe) was installed in the Municipality of St. Denis. In the plan scenario is assumed, by 2020, the installation of new wind turbines of size around 1 MW, other than a series of small size wind generators spread over the territory. The total power is estimated in about 8 MWe, corresponding to a production of 14.4 GWh/year.

![Wind production 2011 to 2020](image)

**Figure 14 Estimation of the wind generation 2011-2020**

Scenario 2021-2030

Although the wind energy potential is still far from being completely exploited, because of technical, environmental and political constraints, it should be assumed that the total installed power will not probably exceed the 2020 quota. Hence, no new installations are predicted for the decade 2021-
2030. The power installed in 2030 is thus supposed equal to 8 MW, for a production of about 14.4 GWh el/year.

4.1.3.2 Solar Photovoltaic

Scenario 2011-2020

In the scenario the installation trend already registered in the last years is assumed to keep growing, although in a less marked way with respect to the last years. The national incentive (feed-in scheme) will end before the end of 2013; meanwhile, the costs related to the technology are expected to decrease, making PV investment more attractive. Moreover, the norms about buildings energetic efficiency impose that in residential buildings of new construction and in restored buildings shall be installed RES power plants (decreto legislativo 28/2011).

Therefore, it is assumed that up to 2020 a total power of 40 MW will be installed, corresponding to an electric energy production of approximately 48 GWhe/year.

![Solar - Photovoltaic production 2011 - 2020](image)

*Figure 15 Estimation of PV production 2011 - 2020*

Scenario 2021-2030
In the period 2021 – 2030 the increase of the installed photovoltaic power is assessed to rise to 53.5 MW, corresponding to a total estimated production at 2030 of approximately 64.2 GWh/year. The increasing trend was supposed linear; the installed power increase rate was set to a half with respect to the 2010-2020 decade. This was chosen because of the saturation of the PV market, and of the expected lack of incentives in the medium term.

4.1.3.3 Solar Thermal

Scenario 2011-2020

The following table shows the trend of thermal Energy production from solar source provided in the decade 2010-2020 (source: PEAR). At 2020, a production of 28 GWh_th/year is assessed.

The development hypotheses in the planning period provide, starting from 2011, a constant trend for the installations of about 2.200 m² per year (about 280 plants, 8 square meters each), both for the presence of incentives and because the legislation about energy efficiency in civil buildings provides that in the new constructions and relevant restructurations the energy plants must be built in order to cover 50% of the consumptions for hot water, heating and refreshing by RES. From 31/5 2012 the
required percentage was 20%. In the planned 2020 scenario is expected a thermal energy production of about 0.28 GWh/year.

**Scenario 2021-2030**

The increasing trend in the 2020-2030 decade is assumed equal to the former decade. The estimated energy production is reported in the following table and diagram.
4.1.3.4 Combined heat and power

Scenario 2011-2020

To estimate the diffusion of CHP plants in the plan scenario up to 2020, have been taken in consideration the existing thermal plants rated more than 800 kW fuelled by diesel-oil and natural gas; then, a statistic analysis has been conducted to estimate the heating plants potentially suitable for substitution with CHP plants. This estimation has carried to take into consideration about 15% CHP of large district-heating projects.

In the scenario described in the PEAR is foreseen an installation up to 2020 of CHP plants for a total power of 4 MWt fuelled by diesel, and other 4 MWt for other CHP plants fuelled by biomass.

The installation of a CHP plant for the district heating of the Aosta city includes a subsystem fed by biomass (design power 1 MW el and 4 MW th) and another subsystem composed by an internal combustion engine (design power 18 MW el and 18 MW th).

The overall energetic production is estimated equal to 50 GWh el and 90 GWh th.
**Scenario 2021-2030**

Between 2020 and 2030 is the distributed generation and micro CHP are expected to increase their diffusion. Additional large industrial plants such as district heating plants are not expected to be installed, since the only user base having an adequate potential is the city of Aosta, already involved in the previously described project.

It is possible to estimate the power which is planned to be installed on the basis of some considerations: an average life of the plants equal to 30 years, the substitution of 20% of the existing end-of-life plants with CHP plants and a consumption of thermal energy in the civil sector equal to 2.400 GWh/year. Following the previous assumptions the total installed power would result equal to 6 MWth, for a production of 16 GWh th/year in 2030.

**4.1.3.5 Heat Pumps**

**Scenario 2011-2020**

Heat pumps operate by a reverse thermodynamic cycle, transferring the heat from low temperature to high temperature sources. The COP (Coefficient of Performance) is defined as the ratio between useful heat pumped to the high temperature source and the energy provided to the machine to effect the pumping (in general, the electric energy absorbed by a compressor motor). The convenience of using heat pumps resides in the values of the COP: high values provide economical advantages.

In the decade 2011 - 2020, within the District Heating project of the Aosta city, is foreseen the installation of a heat pump plant rated 19 MW th, with a COP equal to 2.85. The annual energetic production is estimated in 48 GWh th with a consumption of about 22 GWh el (source: PEAR).

Excluding the Aosta city, involved in the district heating project, is here hypothesized that up to 2020 1 MWth of heat pumping will substitute 1 MWth of diesel fuelled heating plants and 1 MWth of natural gas fed plants. The operation is expected to be of 2000 h/year with an average COP of 3.5.

**Scenario 2021-2030**

The same trend is expected for 2021 – 2030 period, with the additional installation of 2 MWth produced by heat pumps. The operation is expected to be of 2000 h/year with an average COP of 3.5.
4.1.3.6 Biomass (thermal energy)

**Scenario 2011-2020**

The increase hypothesis of the biomass plants installations, comes from the analysis of the buildings in the non-methanized areas, excluding also the areas in which are installed the biomass district heating plants. An increase of the installed power of 12 MWth is estimated within 2020 for the small-medium size plants; other 4 MWth are related to Combined Heat and Power plants. The produced energy results equal to 127 GWh/year; 32.7 GWh/year for the city of Aosta.

**Scenario 2021-2030**

Presently, it is difficult to make long term hypotheses for economic reasons, exhaustion of the resource. At 2030, is foreseen a scenario substantially unchanged with respect to 2020.
4.2 Regional Energy Consumption

The trend of electric and thermal consumptions has been elaborated following the estimations effected within the PEAR elaboration. The considered factors are: the annual increase of population (about 1%), the trend of the previous ten years and the increase of the average pro-capite consumptions. A series of interventions has been then assumed, aimed at reaching the regional goals imposed by the “Burden Sharing” ordinance; the latter have defined the plan scenario.

With this aim, the large projects in definition or in progress over the regional territory have been taken in consideration, together with the possible development of the different technologies about final users consumption savings, the rationalization of energy conversion chains, the development of the renewable energy sources.

For the goals achievement are predicted:

- interventions turned to the increase of the renewable energy sources;
- interventions related to energy efficiency, turned to the consumptions reduction; these may be, at their turn, subdivided into i) reduction of the energetic requirement; ii) efficiency improvements of energy conversion.

4.2.1 Electric energy

Scenario 2011-2020

In the following, are reported the values that contribute to the determination of the gross final consumption of electric energy. Starting from the values hypothesized in the free scenario, the different interventions described in the plan scenario are introduced. In the table below, the first row represents the free scenario consumption, from which:

- are subtracted the savings coming from energy efficiency interventions in civil and industrial sectors of the plan scenario.
- are added the consumptions deriving from the introduction of heat pumps expected in the civil and industrial sectors in the plan scenario.
### Energy Consumption

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP Aosta City</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>51</td>
<td>59</td>
<td>59</td>
<td>89</td>
<td>146</td>
<td>146</td>
<td>146</td>
</tr>
<tr>
<td>CHP diffused</td>
<td>16</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>54</td>
<td>55</td>
</tr>
<tr>
<td>Heat pumps</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Solar</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>19</td>
<td>21</td>
<td>23</td>
<td>25</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Biomass</td>
<td>40</td>
<td>46</td>
<td>48</td>
<td>50</td>
<td>51</td>
<td>52</td>
<td>53</td>
<td>54</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Boiler</td>
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<td>2183</td>
<td>2197</td>
<td>2251</td>
<td>2287</td>
<td>2267</td>
<td>2292</td>
<td>2190</td>
<td>2208</td>
<td>2226</td>
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<tr>
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<td>2262</td>
<td>2282</td>
<td>2393</td>
<td>2442</td>
<td>2426</td>
<td>2486</td>
<td>2445</td>
<td>2495</td>
<td>2516</td>
</tr>
</tbody>
</table>

### Table 12 Electric energy consumption

### Scenario 2021-2030

From the analysis of the last years trend and from the trends up to 2020, is remarkable a poorly significant (0.4% per year) increase of the electric consumption. This value is the result of two contrary effects: on the one hand the increase of the different typologies of electric uses and on the other hand the interventions turned to the increase of the energy efficiency. For the 2020 - 2030 period, we considered correct to use the same trend employed for the 2011 - 2020 period.

#### 4.2.2 Thermal energy

### Scenario 2011-2020

The thermal energy consumption in the decade 2011 - 2020 is estimated to slightly increase (about 10%). In the following table are reported the consumption values declined by technology (source: PEAR).

### Table 13 Thermal energy consumption
Scenario 2021-2030

From the analysis of the last years trend and from the trends up to 2020, is remarkable a poorly significant (1% per year) increase of the thermal consumption.

4.2.3  Transport
Scenario 2011-2020

The consumptions in the transport sector in the period 2011 - 2020 are expected to keep fairly constant. The values experiment a slight increase up to 2.770 GWh/year, in 2020 (source: PEAR).

![Figure 19 Estimation of transport consumption 2011 – 2020](image)

Scenario 2021-2030

Presently, the consumption trend between 2020 and 2030 is considered constant. The realization of new transport infrastructures in the Aosta Valley is not foreseen at medium term and no traffic plans are currently available.
4.2.4  Trends
From the considerations made in the previous paragraphs, is evident a slightly increasing trend in all the sectors analyzed. In this context, in which consumptions increase is moderate, are present remarkable margins of energy saving, possible through an adequate planning. The trends of the consumptions might moreover be improved through the rationalization of the energy chains and the application of intelligent systems with energy storage management.
4.3 Transmission and Distribution Grids

4.3.1 Stressors for the Regional Power Grid

➢ High-voltage

In the document containing the environmental evaluation of the development plan by TERNA (2012) some important actions are expected on the regional territory, regarding National grid adjustment and improvement; several criticalities are in fact present, in particular related to the 220 kV grid.

The interventions can be synthesized as follows:

1) re-construction of the 220 kV grid (in class 380kV, transiently exerted at 220 kV), and powering of the Avise-Villeneuve-Chatillon grid, to improve the transmission capacity from Switzerland in the links (220 kV) Riddes-Avise and Riddes-Valpelline (this intervention is prevented for 2014).

2) Rationalization of the 132 kV grid allowing a significant reduction of the environmental impact and the solution of the rigid T present on the grid, improving safety.

3) Rationalization of the 132 kV grid between Piemonte and Aosta Valley to assure the transmission in safety conditions of the hydro – power towards the areas of North Turin with a consequent reduction of the power lines in the territories.

➢ Medium- and low voltage

The development of the grid mainly depends on the legislation, and only in part on the local distributor (DEVAL Spa).

The penetration of smart grids combined with storage systems is assumed to limit the development and the re-powering of the grid.

4.3.2 (Smart) Grid Solutions

Among all smart grid solutions in the next ten years a diffusion of the smart nodes, composed by user, RES energy production plant (e.g. PV panel) and energy storage may take place. The smart grids will be constituted by the integration of the smart nodes through a central intelligent unit, allowing the remote control in function of the energy request by each user, of the load on the electricity grid and of the availability of energetic production. The management of the smart grid will reduce the disturbances on the electric grid with a reduction of the transported power in the lines. With equal infrastructure, a higher penetration of the renewable energy sources will be possible, thanks to the filtering effect produced by the smart nodes and the storage systems.
5 Future Energy Storage

In the future electric network the energy storage will be an essential component. The storage, in terms of energy on one hand and in term of power on the other hand, represents a good opportunity for the evolutionary electric system model. The Figure below shows how an electric system, equipped with an opportune energy storage, could be more flexible and intelligent with a bidirectional flow of energy and information.

This chapter begins with the description of storage requirements in the Aosta Valley as a basis to define the regional storage technical potential and the benefits that the entire systems may exploit in the future.

Figure 20 Electric system with energy storage

5.1 Storage Requirements

5.1.1 Short Term Storage
The presence of short term Energy storage systems allows to filter the grid disturbances. Each user equipped with storage will be seen as an almost constant load. The diffused application of the storage systems allows to eliminate the perturbations today present on the low voltage grid and allows to introduce new energy from RES.
In fact, renewable energy is featured by a stochastic production and can be absorbed by the grid in a limited quantity. The filtering of the consumption diagrams and of the production of the mini RES plants will assure the de-congesting of the electric grid.

This is of particular importance in a region of the alpine space characterized by technical difficulties for the power increase of the electric lines, often also very expensive.

5.1.2 Long Term Storage

The production of energy from hydro-electric source in a region of the Alpine Space is characterized by significant seasonal variations. The energy produced depends in fact on the available water flow rates which are influenced by the ice melting at high altitude. During spring and at the beginning of the summer, the water flow is at its maximum, while in winter they can almost drop to zero. For the filtering of the seasonal dynamics, very large storages are required, these storages can be technically implemented by the construction of large basins at high altitudes. So far, no other technology allows to store such energy amounts, with acceptable costs and efficiency.

The interventions on the hydraulic storage will be turned to re-equilibrate the high voltage grid. The result will be the reduction of the transmission losses and the possibility to increase the frequency of intervention. In this manner it will be possible to produce a higher power from RES (stochastic) and a reduction of the idling fossil power plants in stand-by, with their energy losses.
5.2 Potentials for Regional Storage

In this paragraph the feasible technical potential for regional storage is described. The technical feasible potential is defined as “the part of the theoretical potential which can be un-locked by available technologies and by complying with the regulatory framework” (deENet, 2010).

5.2.1 Hydrogen Storage Technologies

Hydrogen energy storage is still in the developmental stage but it is believed to become an integral component of any post-fossil energy market. The hydrogen can be stored in a gas, liquid, metal hydride or carbon-based form; in the two last cases, the gas is released through a chemical reaction to power a fuel cell. For stationary applications, pressurized series of cylinders with a total volume between 0.1 and 10,000 m³ are the simplest solution up to date. Currently available commercial cylinders can stand pressures up to 350 bars.

Up to 2020, no storage potential related to hydrogen can be expected, mainly because of technological difficulties connected to transport, storage and use of this vector. Up to 2030, an hypothesis of exploitation is likely for this kind of storage. The installation of a storage turned to satisfy the needs of medium size users (100 kW-1 MW) would be technically plausible, however it is difficult to assess the potential energy stored. Making assumptions on the number of users in the Aosta Valley, that may exploit this kind of storage in 2030, a potential stored energy value with hydrogen might be around 100 MWh.

5.2.2 Pump Storage

Pumped storage hydroelectricity is a method of storing and producing electricity to supply high peak demands by moving water between reservoirs at different elevations. At times of low electricity demand, excess generation capacity is used to pump water into the higher reservoir (Fig. 6). When there is higher demand, water is released back into the lower reservoir through a turbine, generating electricity. Reversible turbine/generator assemblies act as pump and turbine. Taking into account evaporation losses from the exposed water surface and conversion losses, approximately 70–85% of the electric energy used to pump the water into the elevated reservoir can be regained.

The relatively low energy density of pumped storage systems requires either a very large body of water or a large variation in height. The only way to store a significant amount of energy is having a large body of water located on a hill relatively near; in this sense the territory morphology of VdA region facilitates this form of energy storage and so this is the best short term storage that could be applied.
Pumped storage system may be economical because it flattens out load variations on the power grid, permitting thermal power stations such as coal-fired plants and nuclear plants that provide base-load electricity to continue operating at peak efficiency, while reducing the need for peaking power plants that use costly fuels. Capital costs to build hydro storage plants are high, however. Along with energy management, pumped storage systems help control electrical network frequency and provide reserve generation.

Nowadays the only plant suitable for transformation into a pumping plant is the one in Cignaia whose technical features are reported in the following:

- Volume: 15,975,000 m³
- Drop: 812 m
- Power: 37 MW

Assuming to exploit 80% of the pumping basin, the stored energy would be 28.3 GWh. No other plants are considered for modification into a pumping plant, since in the region there are not the conditions for new installations.

Similarly, the construction of new water basins or the enlargement of the existing ones is not considered as a viable options for the future due to mainly environmental resistance and policies.
5.2.3 Thermal Energy Storage Systems – Low Temperature

By means of micro CHP units installation in the single house, it’s possible (managing the plant with a logic of type heat follows) to contribute to the smoothing of the electric load peak inside the medium/low voltage network. In this way the living environment can be conceived as a low temperature energy storage system.

In the Aosta Valley most of the residential building are not connected to an heat grid. Under the theoretical assumptions that 15,000 residential smart nodes will be equipped by a solar thermal plant (with a hot water tank of 500 l) by 2030, a temperature drop of 40°C will correspond to a thermal energy storage of 340 MWh.

5.2.4 Mobile Batteries (Electric Vehicles)

The diffusion up to 2030 of the multiple ZEV mobility in the urban centres, and the consequent limitation of the traditional traffic, suggests an accelerated development of the electric traction concept. In this sense it can be interesting to consider the Electric Vehicles as mobile batteries that can interact with the smart grid. For example, the hypothetical presence of 5000 EVs on the Valley territory, each equipped with a 20 kWh capacity battery, would allow, by means an appropriate management of the charges, a further smoothing of the electric load peak inside the medium/low tension network, with a global energy storage of 100 MWh. Assuming that 75% of the 60,000 families in the Aosta
Valle d'Aosta, Italy
Status Quo and Masterplan

Valley owns two cars and all the second cars are electric, a total of 40,000 EVs would be present in the Valley. If each vehicle is equipped with a 10 kWh battery, the total storage with this technology would be 400 MWh in the year 2030.

5.2.5 Stationary Batteries
Several battery technologies exist for the use as utility-scale energy storage facilities. In the past, these installations exploited lead-acid batteries, but other battery technologies like Sodium Sulfur (NaS) and Lithium ion are quickly becoming commercially available. All the batteries are electrochemical cells.

Static energy storage up to 2020
Assuming that 30% of the 60,000 families in the Aosta Valley will own houses suitable for smart nodes installation. If each node can rely on a stationary battery of 10 kWh, the total regional storage assured by this technology is 20 MWh.

Static energy storage up to 2030
Assuming that, following the development of the legislation on energy efficiency, the houses suitable for installing smart nodes may increase up to 40%, the total storage capacity of the batteries installed may reach the value of 24 MWh.
5.3 Benefits of Regional Energy Storage

Generally speaking, technology progresses able to dramatically reduce the costs of electricity storage systems could drive revolutionary changes in the design and operation of the electric power system. Peak load problems could be reduced, electrical stability could be improved, and power quality disturbances could be eliminated. Storage can be applied to the power plants, in support of the transmission system, in various points in the distribution grid and for particular applications and equipments on the customer’s side of the meter. Energy storage systems in combination with advanced power electronics (power electronics is often the interface between energy storage systems and the electric grid) have a great technical role and lead to many financial and environmental benefits. Some of these are summarized in the following:

➢ Technical Role and Functions of Electricity Storage Systems:
  • Grid Voltage Support
  • Grid Frequency Support
  • Grid Angular (Transient) Stability
  • Load Levelling / Peak Shaving
  • Spinning Reserve
  • Power Quality Improvement
  • Power Reliability
  • Ride Through Support
  • Unbalanced Load Compensation

➢ Financial Benefits of Energy Storage Systems:
  • Cost Reduction or Revenue Increase of Bulk Energy Arbitrage
  • Cost Avoid or Revenue Increase of Central Generation Capacity
  • Cost Avoid or Revenue Increase of Ancillary Services
  • Cost Avoid or Revenue Increase for Transmission Access/Congestion
  • Reduced Demand Charges
  • Reduced Reliability-related Financial Losses
• Reduced Power Quality-related Financial Losses
• Increased Revenue from Renewable Energy Sources

➢ *Environmental Benefits of Energy Storage Systems:*

• Renewable Energy Source Sustainability
• Elimination of Hot Reservoir
6 Framework for future Storage Systems

In this chapter, the current situation of the Aosta Valley is described in terms of improvement that may be introduced in the existing energy system, taking in consideration the possibility of adding innovative techniques for the energy management; the regional energy system framework will be outlined from the point of view of the possible introduction of new technologies envisaging the energy storage. To attain said goal, an analysis of the regional energy system has to be carried out with regards to:

- the governance, intended as the authorities deciding the energy policy and guidelines, and operating and managing the main services connected to electric energy;

- the technology trends, which need to be very clear in order to understand what way is going to be chosen in the future as regards to the energy production and use;

- the actual state of the research and development activities presently in vogue, both within the scientific community and in the industrial world;

- the stakeholders, intended as the companies and the main users that will receive a direct feedback from the introduction of a new technology such as the exploitation of the electric energy storage.

In order to face completely and thoroughly the mentioned argument, a brief introduction of the Italian and European energy frameworks is given, in order to properly introduce the Aosta Valley regional situation in the global context.
6.1 Governance

The Aosta Valley regional energy system must be observed in the context of the national (Italian) and European frameworks, whose main governance authorities delineate the guidelines to be followed in terms of energy regulation and planning.

1) The European Commission

As first, the European Commission dictates the guidelines that European Countries need to follow for their future development in the energy field. In particular, the EU Commission energy policy in the medium-long term is trying to be delineated by the questions asked in the Green Paper “A 2030 framework for climate and energy policies”, where the EU Countries are asked to expose their vision of the future energy framework.

So far, in the short term, the energy guidelines followed by the European Countries are contained in the 20-20-20 program, delineating the main objectives to be reached by the single Countries within the deadline of 2020:

- 20% reduction of the carbon dioxide production with respect to the situation existing in 1990;
- 20% increase of the energy produced by the renewable sources with respect to the situation existing in 1990;
- 20% saving of the energy consumption with respect to the situation existing in 1990.

2) The Italian Framework

The guidelines provided by the European Commission need to be transposed by the Italian Authorities and implemented in the national energy system through the proper interventions. The main authorities at national level are listed below and briefly described:

- GSE (Gestore del Servizio Elettrico): performing the main functions of: incentivating the energy production from renewable sources; managing the energy flow from renewable sources within the Italian energy market; promoting the energy efficiency.
- TERNA: operating the transmission of the electric energy in the 63500 km of the high-voltage national electric network.
• AEGER: Italian Authority for electric energy and gas. The Regulatory Authority for Electricity and Gas (Aeeg) is the independent body which regulates, controls and monitors the electricity and gas markets in Italy

• ENEL: is the main DSO in Italy. The ENEL group is active in all areas of electric power, ranging from Smart Grid projects to Smart Cities studies up to Storage pilot plants.

Recently the National Energy Strategy has been presented. Among the priorities of action there is the developing of the electricity market and infrastructure. The strategy being pursued has three main objectives: to align electricity prices and costs to European standards; to ensure Italy’s full integration with the European market; and to maintain and develop a free market fully integrated with energy produced from renewable sources, gradually removing all distortions and absorbing current surplus production capacity. In order to eliminate the cost differential the Government will:

• Develop the electricity grid, to reduce congestions and bottlenecks between market zones and constraints on the full exploitation of the most efficient production capacity.

• Limit market inefficiencies and distortions. More specifically, the “other system charges” in electricity bills, which account for about 4% of the cost of electricity, will be carefully reviewed.

• Review the special conditions granted to specific categories of users.

• In addition to the Ministry of Economic Development the two main public institutions in charge of regulation in the areas of energy production, distribution, consumption, storage and electromobility are the Italian Regulatory Authority for Electricity and Gas and the Italian Electrical Committee.

Source: “Italian National Framework, AlpStore Project”

3) The Regional Framework

In the Energy field the Aosta Valley Region exercises its own competences in the respect of subsidiarity, differentiation and adequacy principles. Hence the local government has to comply with the European and Italian guidelines and objectives. The respect of those principles involves the fact that the Region has to undertake essentially a position of definition and planning of the policies, above all in the development of energy renewable sources and energy efficiency, while the implementation of them belongs to the local authorities (municipalities and mountain communities). Within the principles laid down by national law, the functions carried out by the Regions are:

• formulation of the objectives of regional energy policy;
- location and construction of district heating plants;
- development and exploitation of local resources and renewable energy sources;
- release of the hydroelectric concessions;
- energy certification of buildings;
- guarantee of safety, environmental and territorial conditions;
- safety, reliability and continuity of regional energy supply;
- achievement of the limitation of emissions of greenhouse gases set by the Kyoto Protocol.

The main regional planning document is the previously described Regional Energy and Environmental Plan. In the PEAR document is described the energetic scenario of the Aosta valley and are listed the possible initiatives turned to reducing the use of fossil fuel, to increasing the RES exploitation, and to containing the CO2 emissions. Moreover, the energetic objectives up to 2030, indicated in the Burden Sharing, have been defined. The initiatives effectively applicable within 2020 are evaluated, in order to achieve the pre-determined energetic goals.

The PEAR does not constitute an actuation instrument, but contains guidelines and useful indications in order to provide operative addresses through the legislative instruments.

It describes, moreover, the target that the region should reach to be coherent with what required in energetic and environmental terms.

Possible initiatives out of the PEAR may be considered by the Region if providing a contribution to improve the global energetic performance. In this case, these initiatives may be included in the future planning documents.
6.2 Technology Trends

Another important topic to be enlightened is the trend of the energy technologies in prevision for the next decades. In fact, in order to estimate the impact of a new technology such as the distributed energy storage, it is important to know which will be the future energetic panorama where said system is going to operate.

The main energy innovations that are foreseen for the future years according to the present trend, are essentially concentrated in the fields of transport and of distributed energy production and energy saving (operated mainly at a household level).

In particular, the potential innovations in the energy system may be connected to:

- **e-mobility**: the mobility through electric vehicles is nowadays no more limited to the purchase of electric vehicles by the private citizens, which do not currently appreciate this technology due to the high investment costs, but a sort of integrated system of public mobility, with innovative elements such as car sharing. Many experiments have been carried out in the years and, although not always positive results, many people believe that today the times are mature for this concept of mobility; this is basically possible to be affirmed because the electric vehicle technology is being today thought within the context of the territory in which it has to operate, and not considered as a general purpose mean of transport for urban, extra-urban and highway missions.

- **plus-energy house**: a plus-energy house is a house or a building in general able to produce more energy, during one year, of that required for its internal consumption. Its energy balance is thus positive. This is achieved using a combination of micro-generation technology and low-energy building techniques, such as: passive solar building design, insulation and careful site selection and placement. The power generation may be possible through solar panels so as through small size cogenerators, depending on the design chosen for the system. A reduction of modern conveniences can also contribute to energy savings, however many energy-plus houses are almost indistinguishable from a traditional home, preferring instead to use highly energy-efficient appliances, fixtures, etc., throughout the house.

- **distributed generation**: the concept of plus-energy house is strictly connected to the issue of distributed generation, which is the generation of electric power through a large number of small plants, both cogenerative and renewable.
6.3 R&D activities

In the Aosta Valley some research and development activities are in progress regarding the energy topic, most of them are related to European programmes such as:

- POR FESR Program for regional competitiveness 2007-2013: the Region has approved a contribution to the Society Telcha S.r.l. for a project aimed at building a new co-generative thermal plant in order to recovery the heat coming from primary sources. The produced energy will feed the Aosta district heating network giving a contribution to the improvement of the environmental conditions and the attractiveness of urban areas.

- Deval SMART GRID project: installation of an integrated smart grid system aimed to search a solution for the problem of electric power inversion from low to medium voltage. This, through modification in the conversion cabins, innovative voltage regulation systems, line protection systems, and power regulators.

- Reve Grand Paradis project: installation of feeding columns for charging 2 electric vehicles and 66 electric bikes in 5 municipalities (Cogne, Valsavarenche, Rhémes-Saint-Georges, Rhémes-Notre-Dames, Introd).

6.4 Stakeholders

The main stakeholders are constituted by energy producers, grid operators and energy consumers; of course, the former need to play a more active role in the project, since they are probably required to modify their traditional vision of the energy system according to the new panorama proposed by the authorities. The main stakeholders are:

- CVA Spa: it is the main electric producer in the Aosta Valley with a share of more than 99% of the electric production. CVA owns the Cignaia basin and power plants;

- Cogne Acciai Speciali: it is a steel industry and it has the regional larger consumer of electric energy with about 25% of the total regional electric consumption;

- MAVEL: it is a recently born manufacturing activity in the sector of power engineering with a strong interests in storage technologies;

Apart from these large scale stakeholders every home owner may in the future play an important role as owner of decentralized power plant or energy storage systems.
7 Master Plan

As specified in the Status Quo, the Aosta Valley region produces almost 3,000 GWh of hydro-electric energy, of which approximately 1,000 GWh represent the self-consumption. Therefore, the region can be considered as a great exporter of renewable electric energy, a great amount of which results programmable, being produced by basin. The energy produced is of high quality electric energy, also in terms of the primary frequency control over the interconnection with high voltage.

An important part of the regional Gross Domestic Product includes this important industrial activity. The regional energy plans (PEAR) elaborated in the last 10 years have always been turned to the development of electric energy production from renewable sources and to the reduction of the internal consumptions in order to keep - and possibly increase - the role of Aosta Valley as a “green power station” for the electric system in the national and European environment.

In the future, this fundamental motivating element will be interpreted not only in terms of total amount of exported energy, but more and more in terms of energy quality, intended as the capacity of precisely controlling the power in view of the network stability.

The less the capacity of modulating and rapidly intervening of the hydro-electric power plants will be employed to satisfy the internal requirement, the more these services will be available for the national and the cross-border networks. This means that the sold energy will assume a higher environmental and energetic value and will obtain an increased economic value, as it responds to a dynamic requirement more and more important.
7.1 Objectives

7.1.1 Vision
According to the regional energy policy the Aosta Valley region has the following vision aims to improve the regional energy balance according to the European and National directives and targets and to become a model region for energy and environmental sustainability.

In this vision, the implementation of the STORM concept (Smart sTORage and Mobility, intended as a model to develop and decide upon holistic solutions to increase regional RES supply and outbalance volatility with appropriate energy buffering means) is seen as a completion and integration of the regional energy plan. The STORM model may allow a virtuous management of the distributed generation system with the purpose to stimulate local consumption and increase energy production from RES. The application of the STORM strategies will concur to reach the national and regional objectives with particular regard to the Burden Sharing objectives. Moreover, the grid stabilization will increase the level of safeness, efficiency and flexibility of the regional and national electric grid.

7.1.2 Goals
According to the previously described vision the following goals can be listed:

- Achieve the regional Burden Sharing objective 52% (ratio between the energy production from RES and the total energy consumption)
- Increase the energy production from unexploited RES and promote the RES integration in the electric system
- Decrease the energy consumption with special reference to the transport sector
- Study the practical application of the STORM model in the pilot region
- Implement the STORM model as a completion and integration of the regional energy plan.
- Promote the spreading of sustainable mobility (Electric Vehicles) in the Pilot Region
- Increase the energy self consumption
- Promote the use of more efficient technology for energy production (CHP and heat pumps)
- Increase the energy efficiency, stability and flexibility of the whole electric system
• Design, implement and study the “smart node”, with particular regard to residential applications. The smart node includes a RES power production, a consumption building, an EV, a stationary storage electrochemical system

• Supporting local companies and enterprises which are active in the storage and smart grid sector.
7.2 Regional Storage Park

The AlpStore project introduces and tries to deal with the issue of electric power storage, understanding that the network stability constitutes the real limit to the extensive exploitation of the RES and thus to their sustainable development.

The development of the future regional electric system should provide an increasing storage capacity at different levels, and the exploitation of their potential to be implemented in the region. However the actual future development and market penetration of storage technologies cannot be accurately predicted.

The storage forms that we believe technically compatible with the territory, including the economic, ecological, social aspects and institutional affairs are the following:

- hydraulic plants pumping storage
- distributed smart-nodes equipped with stationary batteries
- low temperature thermal storage by the exploitation of buildings thermal inertia
- mobile batteries on electric vehicles.

7.2.1 Hydraulic plants pumping storage

The exploitation of the hydro-electric resource is almost complete. By the moment, it is not possible to give a prevision of the effective implementation of large pumping system because it depends mainly on economical, political and environmental factors. Given the current scenario the increase of the storage potential is not expected or planned in the next future.

However, the increase of the existing storages can be effected through the installation of larger size turbo-machinery. The benefits deriving from the new plant configurations with increased power should be evaluated through specific dynamic simulation.

7.2.2 Distributed smart nodes and stationary batteries

The local electro-chemical storage, managed by smart devices (named smart boxes) serving users/producers, driven by softwares providing local and/or coordinated supervision (by the network operator) is defined as “smart node”. Other than in terms of innovation, the smart node is relevant also in quantitative terms, due to the high presence of individual PV plants of small size.

The smart node is surely expected to provide a positive contribution to the objectives delineated in the PEAR, being an effective way to allow an increase of the installed power from stochastic renewa-
ble energy sources (with particular regards to solar and wind). The total installed power and energy production is described in chapter 5.

The effect of the introduction of smart nodes in the regional system will have to be evaluated after specific simulations. It will probably provide benefits due to the lower power insisting on the network which will make possible the introduction of higher amounts of energy from RES. A prevision for the possible installed power is provided in chapter 4.

### 7.2.3 Thermal storage in buildings

The climate and urban context of the Aosta Valley Region is suitable for the installation of small CHP units able to satisfy the thermal requirements of users, producing as by-product electric energy with an incremental heat rate near unity.

Due to the energy saving made possible by the synergic production of electricity and heat, these energy production units are classified as RES by the norms, and enjoy of the network access priority, being the electric energy generated when heat is required.

Thanks to the thermal inertia of the heat distribution network and of the materials as concrete and stones of the buildings, the heat generation may be opportuneely shifted during the day. Therefore, these units represent a virtual form of storage for the produced energy. The quantitative effect may be relevant considering the number of users able to implement this form of intervention.

Also in this case, opportune numerical simulations allow to evaluate the effects on the system for different penetration degrees of this intervention. In the simulation phase, a quantification of these effects will be provided.

Considering some thousands of smart node homes may be equipped by a thermal solar plant (with a hot water tanks of 500 l), a temperature drop of 40°C will correspond to a thermal energy storage of almost one hundred MWh by 2030.

### 7.2.4 Mobile batteries

In the Aosta Valley region the issue of sustainable mobility was faced through different projects and insights. One of these individuates as the condition for the maximum penetration of the electric mobility the realization of a recharge infrastructure comprising recharge points, inter-exchange parks between conventional and electric vehicles, places for the loading spread over the territory, providing a grid compatible with the vehicles autonomy, and an ICT infrastructure aimed to manage low weight vehicles conceived for urban and extra-urban traffic.
The feeding of the loading structures may be effected through PV generators and the loading centres constitute smart nodes as afore described. The diffusion up to 2030 of the EV mobility in the urban centres, and the consequent limitation of the traditional traffic, suggests an accelerated development of the electric traction concept afore described in the following years.

In the simulation phase, the nodes behaviour will be taken into account to evaluate, for different scenarios, the environmental benefits obtainable, respecting the economical competitiveness.

About this, it should be underlined that a massive presence of loading devices without an intelligent management of the peripheral nodes would lead to a very important increase of the network instability. In this sense, an incentives policy of the sustainable mobility presupposes what expressed in the former paragraphs.

The Aosta Valley currently lacks a regional traffic plan hence no objectives related to electric mobility exits. In the following, some evaluations of what will reasonably be implemented up to 2020/2030 are reported for different storage technologies.

**Mobile energy storage up to 2020**

In the Aosta Valley there are about 60,000 families, assuming that 66% of the families own two cars and 15% the second cars will be electric, a total of 6,000 EVs would be present in the Valley. If each vehicle is equipped with a 10 kWh battery, the total storage carried by this technology would be 6 MWh.

**Mobile energy storage up to 2030**

Assuming that, by 2030 the percentage of second cars will grow to 25%, the total number of electric vehicles will be 10,000 corresponding to a storable energy of 10 MWh.
7.3 Storage Roadmap

7.3.1 Measures and Projects

7.3.1.1 Shift, Storage and Drive – ALPSTORE Pilot Project

The pilot project that will be realized within the AlpStore project is named SHIFT, STORE AND DRIVE. The project is a real implementation that foresees the connection of a stationary storage system to a photovoltaic systems and a small load; an electric vehicle will be part of the load. The project’s main goal is to demonstrate through the monitoring effected during exercise, the efficacy of a smart node. The technology that will be applied sees its origin within the Aosta Valley, and is already in the market not requiring development but only an adequate application engineering. Each electric user connected to the low voltage (even being not provided with a production and uptake capacity from RES), can be equipped with a smart box and an opportunely sized storage as realized in the pilot project. An opportune supervision software will drive the smart box interacting with the end-user, the network, the storage, the EVs and the stochastic production (RES) source in order to minimize the power peaks exchanged between user and producer with the network. In this way the node will be less unbalanced and on the low voltage electric grid the sum of users/generators, fairly balanced, will reduce the back flow towards the low voltage and so on.

7.3.1.1 Zero Emission Vehicles (ZEV)

The Zero Emission Vehicles (ZEV) project is a sustainable electric mobility project dealing with an integrated mobility system, based on electric vehicles of features suitable for the Aosta Valley Territory.

The projects is based on an infrastructure of battery charging points spread over the territory with a centralized management. Being the electric vehicles very different from the commercial vehicles and not suitable for the long-haul missions, a car-sharing service and a series of inter-exchange parking areas, needs to be provided over the Valley territory.

7.3.1.1 The Green Road Project

The project aimed at promoting an integrated electric mobility framework in the Aosta Valley area, with the installation of 24 charging columns in addition to the 8 already existing in the territory.
7.3.2 Timelines, milestones and Controlling

For the pilot projects "Alp Store Smart Box" and for the "ZEV" project on sustainable mobility, a programme needs to be defined together with the related milestones. At present the deadlines of the projects are still to be defined; the overall control activity of controlling can be carried out by the Regional Structure in charge.

The implementation of the initiatives related to the energy storage needs to be included within the regional programmes for energy, as each of them will contribute to reach the above mentioned regional objectives. The diffusion of storages and the development of the related operational logics is thus coherent with the energetic objectives reported in the plan, i.e. the diffusion of the RES plants, the containment of the CO₂ emissions, the reduction of the fossil fuels consumption. A diffusion programme for the initiatives connected to the energy storage is required, and has to be coherent with the energetic objectives and in line with the realistic potential estimated for 2020 (and successively for 2030).
8 References


