Pilot Region Gorenjska

Status Quo Report and Masterplan

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Status Quo Reports are contributing to AlpStore WP4, Action 4.2
Masterplans are contributing to AlpStore WP5, Action 5.2

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Region SI022: Gorenjska
Status Quo and Masterplan

**AlpStore Status Quo- and Masterplans:**

**Status Quo Reports:** All subconsortia describe the regional situation in their pilot region concerning the current impact and future trends of hybrid, electric and gas powered vehicles, energy storage systems, Smart Grids and renewable energy sources - taking planned demonstration sites as representative examples and considering transnational opportunities (e.g. roaming with electric cars, cross border aggregation of flexibility of mobile storages).

**Masterplans:** All subconsortia develop holistic masterplans for their respective regions with the specific emphases listed in Table 1. The masterplans build on the overarching STORM principle as developed in WP4 (see Appendix). With the masterplans developed in WP5 decision makers in the involved regions are to receive long-range concepts to enhance their regional and municipal development planning. With many different types of regions being involved many other decision making and planning processes in the Alpine Space can be informed by these masterplans as blueprints.

**Table 1: Overview of AlpStore Status Quo- and Masterplans:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Region</th>
<th>Specific Emphasis of Masterplan according Application</th>
<th>Resp. PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>West Milan</td>
<td>EV fleet management and VPS, involvement of ESCO and PAES for efficient energy management</td>
<td>EU-IMP</td>
</tr>
<tr>
<td>2</td>
<td>Aosta</td>
<td>“AOSTA Valley Regional Energy Plan 2011-2020”</td>
<td>AOSTA</td>
</tr>
<tr>
<td>3</td>
<td>Lombardy</td>
<td>electric public transport integration of VPS long term plan (gas, PV) with sustainable mobility needs and storage opportunities</td>
<td>AGIRE</td>
</tr>
<tr>
<td>4</td>
<td>Alsace</td>
<td>fleet management with EV and fuel cell vehicles in office buildings</td>
<td>FRESH UTBM</td>
</tr>
<tr>
<td>5</td>
<td>Vorarlberg</td>
<td>small hydro pump vs. mobile and stationary battery storage, mass roll-out of EV</td>
<td>VLOTTE</td>
</tr>
<tr>
<td>6</td>
<td>Güssing</td>
<td>mobile vs. stationary use of biogas</td>
<td>EEE</td>
</tr>
<tr>
<td>7</td>
<td>Haslital Brienz</td>
<td>controlled charging with 2nd life batteries in semi-public areas (supermarkets)</td>
<td>KWO</td>
</tr>
<tr>
<td>8</td>
<td>Gorenjska</td>
<td>off grid situations of small mountain villages</td>
<td>UL RDA JEZ</td>
</tr>
<tr>
<td>9</td>
<td>Allgäu</td>
<td>integrated storage and mobility for public transport, electric car and e-bike charging infrastructure fully integrated plus energy houses</td>
<td>BAUM EZA</td>
</tr>
<tr>
<td>10</td>
<td>Ebersberg</td>
<td>managing biogas and wind energy in Ebersberg</td>
<td>BAUM FFE</td>
</tr>
<tr>
<td>11</td>
<td>Berchtesgaden</td>
<td>small hydro pump, pressed air storage in salt mines in Berchtesgaden</td>
<td>BAUM FFE</td>
</tr>
<tr>
<td>12</td>
<td>Ticino</td>
<td>Ticino RE Platform</td>
<td>USI</td>
</tr>
<tr>
<td>13</td>
<td>Liechtenstein</td>
<td>potential for RES in various settlement forms (masterplan focused on potential for RES in various settlement forms)</td>
<td>LIECH</td>
</tr>
</tbody>
</table>
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List of acronyms and abbreviations

AMI  Advanced Metering Infrastructure
AMM  Automated Meter Management
AMR  Automatic (or Automated) Meter Reading
CNG  Compressed Natural Gas
CWWT Center for Waste and Water Technology
DG   Distributed generation
DMC  Distribution Management Centre
DS   Distribution Station
DSO  Distribution System Operator
DSI  Demand Side Integration
DSM  Demand Side Management
EC   European Council
EDC's Electricity distribution company
EU   European Union
EV   Electric vehicle
GIS  Geographic Information System
HPP  Hydro Power Plant
ICT  Information and Communication Technology
IIS  Integration of information systems
IT   Information Technology
NEP  National Energy Programme
NPP  Nuclear Power Plant
PDSG Program for Development of Smart Grids in Slovenia
PHPP Pumped Hydroelectric Power Plant
RES  Renewable Energy Sources
TSO  Transmission System Operator
VPP  Virtual Power Plant
1 Summary

In the development of electric power system, Slovenia must achieve ambitious targets to meet key environmental commitments for 2020, which are:

- 20% reduction in greenhouse gas emissions,
- 20% share of final energy consumption from renewable sources and
- improve energy efficiency by 20%.

This will increase the reliability of energy supply, reduce the impact on the environment, and also provide economic growth and the development of jobs and employment. Thus, the energy future is not only a great challenge but also a great opportunity.

Today it is generally accepted that Smart Grids are key element of the future power systems and an enabling factor to meet the above commitments. The concept of Smart Grids is an upgrade of the existing concept of operation and design of the power system. It involves the individual elements of the system, both classical (centralized large scale production units, transmission and distribution networks) and new elements, such as the distributed production resources, advanced measurement systems, flexible prosumers, virtual power plants, electric cars and energy storage systems [1].

Electricity storage technologies are part of the Smart Grid concept. Since these technologies are at different stages of development, the primary aim of this document is to bring them together into a unified concept of development. This document aims to prepare a plan for the development and deployment of storage technologies in Gorenjska region, with an emphasis on those elements and concepts that can be introduced in the near future and from which we can expect concrete benefits. It is necessary to take into account the financial constraints as well as sociological and regulatory factors. The key principle of the document is to make use of technologies that are available today.

The first part of the document, which includes the first three chapters, provides an overview of the situation in the energy system, with special emphasis on the Gorenjska region. In the second chapter the pilot region is described. The third chapter gives a concise overview of energy production and consumption data and describes transmission and distribution network and status quo of the energy storage technologies in Slovenia.

Second, the central part of the document, covering fourth, fifth and sixth chapter, gives an overview of future energy system, description of future storage systems and plan of development of the framework for future storage systems.

The last, seventh chapter, presents the Master Plan for storage systems in Gorenjska region, Slovenia.
2 The Pilot Region

Gorenjska lies in the northwest of Slovenia (see Figure 1). To the north it borders Austria (Carinthia) along the Karavanke mountain range; to the west Italy (the Friuli-Venezia Giulia province) and the Gorica developmental region; to the east the Savinja region, and to the south it opens up towards the central Slovenian region. Gorenjska is crossed by the 10th European motorway and railway corridor. The town of Brnik hosts Slovenia's central airport, i.e. Ljubljana Airport (1.3 million passengers a year, 10% growth in 2006 over 2005). All this contributes to Gorenjska's favourable geo-traffic position and its relatively good accessibility [3].

Gorenjska is an Alpine region with a characteristic diverse mountainous landscape. Seventy percent of the region is a mountainous world, while only 29.8% lies in the depressed/lowland part of central Slovenia. As much as 40.2% of Gorenjska lies more than 1,000 metres above sea level, 59.4% is covered with forests, 30.6% is agricultural land and 10% infertile land. Additionally, 44.4% of the surface area is incorporated into NATURA 2000 sites [3].

In Slovenia, when we talk of the Gorenjska region, we think of the Alps: the two thousand-metre summits of the Julian Alps which extend from the northwest of Slovenia across the border into Italy; the peaks of the Karavanke range and the Kamnik-Savinje Alps which link the north of Slovenia with Austria, and also, the connected Subalpine region full of surprisingly varied cultural and natural peculiarities. The Slovenian Alps are the northwest of Slovenia.

Covering 2,137 square kilometres which is 10.5% of the Slovenia’s total surface, Gorenjska is the sixth in size of all Slovenian regions. Population density is under national average (93.4 inhabitants/km2). However, some parts represent larger densely populated and urbanized areas such as the regional centre of Kranj [3].

*Figure 1: The Gorenjska region and Slovenia [src.: BSC Kranj].*
2.1 About regional development

Since Slovenia joined the European Union, the structural and regional policies have become important issues that concern Gorenjska and its competitiveness as well.

The concept of regional development, institutions and sorts of developmental incentives are determined in the Promotion of Balanced Regional Development Act (OJ RS, No. 93/2005), and regulation acts. However, the implementation depends on the regions and their own development ambitions.

Gorenjska wants to become one of the most dynamic regions in the Alpine area, with the development based upon partnership, entrepreneurship, knowledge, innovativeness, and openness. Gorenjska wants to go up. In the light of the established developmental paradigm and in compliance with the law, the region has organized its operation, and determined its Gorenjska Regional Development Programme 2007-2013 as well as its key projects.

The development region of Gorenjska with NUTS (Nomenclature of Territorial Units for Statistics) level 3 has the population of 199.085. The region comprises 18 municipalities: Bled, Bohinj, Cerklije na Gorenjskem, Gorenja vas - Poljane, Gorje, Jesenice, Jezersko, Kranj, Kranjska Gora, Naklo, Preddvor, Radovljica, Šenčur, Škofja Loka, Tržič, Železniki, Žiri in Žirovnica. [3].

2.2 Statistical data

Table 1: Basic statistical information of Gorenjska in comparison to Slovenia [3], [4].

<table>
<thead>
<tr>
<th></th>
<th>Gorenjska</th>
<th>Slovenija</th>
<th>% v Slo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>2.137 km²</td>
<td>20.273 km²</td>
<td>10,5</td>
</tr>
<tr>
<td>Population (Jan. 2010)</td>
<td>202.903</td>
<td>2.046.976</td>
<td>9,9</td>
</tr>
<tr>
<td>No. of citizens / km² (Jan. 2010)</td>
<td>94,9</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>Aging index of people (Jan. 2010)</td>
<td>110,3</td>
<td>117,8</td>
<td></td>
</tr>
<tr>
<td>GDP per person (2007)</td>
<td>14.497 €</td>
<td>17.123 €</td>
<td></td>
</tr>
<tr>
<td>No. of working people per residence (May 2010)</td>
<td>83.404</td>
<td>838.870</td>
<td>9,9</td>
</tr>
<tr>
<td>Registered unemployment rate (May 2010)</td>
<td>7,9 %</td>
<td>10,5 %</td>
<td></td>
</tr>
<tr>
<td>No. of registered unemployed people (May 2010)</td>
<td>7.106</td>
<td>98.401</td>
<td>7,2</td>
</tr>
<tr>
<td>No. of companies (2009)</td>
<td>4.923</td>
<td>53.897</td>
<td>9,1</td>
</tr>
<tr>
<td>No. of self-employed (2009)</td>
<td>7.044</td>
<td>69.982</td>
<td>10,1</td>
</tr>
<tr>
<td>Added value per employee in companies (2007)</td>
<td>32.184 €</td>
<td>33.538 €</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Metric</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Percentage 1</th>
<th>Percentage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average monthly net salary per employee (May 2010)</td>
<td>931 €</td>
<td>957 €</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of farmers (May 2010)</td>
<td>1,485</td>
<td>29,091</td>
<td>5,1</td>
<td></td>
</tr>
<tr>
<td>No. of tourists (2009)</td>
<td>497,337</td>
<td>2,722,002</td>
<td>18,3</td>
<td></td>
</tr>
<tr>
<td>Share of foreign tourists (2009)</td>
<td>72,5 %</td>
<td>61,3 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of permanent bed places (2009)</td>
<td>17,687</td>
<td>84,602</td>
<td>20,9</td>
<td></td>
</tr>
<tr>
<td>Share of NATURA 2000 areas</td>
<td>44,3 %</td>
<td>35,5 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3 Status quo of Energy System

In the following sections a concise overview of energy production and consumption data is given and transmission and distribution network and status quo of the energy storage technologies in Slovenia are described.

3.1 Energy Production

In 2011 a total of 14,878 GWh of electricity was generated in Slovenia, which was 382 GWh less than in 2010. The hydroelectric power plants connected to the transmission network generated 3,314 GWh of electricity, which was 934 GWh less than the year before. The thermoelectric power plants generated 4,787 GWh of electricity, or 120 GWh less than in 2010. The Krško Nuclear Power Plant generated 5,899 GWh of electricity, which was 528 GWh more than in the previous year. Production of electricity of the small producers (with production units less than 10 MW) connected to the distribution network, compared with the production in 2010, remained at the same level and amounted to 734 GWh. In 2011 the domestic demand was not completely covered by the production sources in the Republic of Slovenia, including losses in the network, and taking into account the 50-percent share of installed capacity of the Krško Nuclear Power Plant, which belongs to Slovenia. Thus, the Slovenian consumption was covered by the domestic source in total of 89%. Through the transmission and the distribution networks 8,409 GWh of electricity was exported, and imported 7,029 GWh of electricity in 2011. Above mentioned amounts are taken from the balance sheets of the transmission and distribution networks operators. The share of hydroelectric power plants and other production facilities on renewable energy sources (hereinafter referred to as RES) in Slovenia in 2011 slightly fell, mainly due to bad hydrological conditions; it amounted to 28% of the whole production. The power plants using fossil fuels contributed about 32% of total production and Krško Nuclear Power Plant 40%. The highest hourly load was noted in March; it amounted to 1,950 MW [5].

Table 2: Installed net power (MW) by energy sources in Slovenia [5].

<table>
<thead>
<tr>
<th>Slovenia – installed net power (MW)</th>
<th>2008</th>
<th>2010</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total installed power capacity in the country</td>
<td>3112</td>
<td>3363</td>
<td>3608</td>
</tr>
<tr>
<td>Total installed capacity of thermal power stations</td>
<td>1282</td>
<td>1276</td>
<td>1258</td>
</tr>
<tr>
<td>Nuclear power stations</td>
<td>696</td>
<td>696</td>
<td>696</td>
</tr>
<tr>
<td>Hydro plants</td>
<td>924</td>
<td>1114</td>
<td>1142</td>
</tr>
<tr>
<td>Other small suppliers</td>
<td>210</td>
<td>277</td>
<td>512</td>
</tr>
</tbody>
</table>
Table 3: Gross production (GWh) by energy sources in Slovenia [5].

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>2008</th>
<th>2010</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total country gross production</td>
<td>15032</td>
<td>15317</td>
<td>14544</td>
</tr>
<tr>
<td>Total thermal power stations</td>
<td>4868</td>
<td>4851</td>
<td>4691</td>
</tr>
<tr>
<td>Nuclear power stations</td>
<td>5970</td>
<td>5371</td>
<td>5232</td>
</tr>
<tr>
<td>Combined heat and power stations:</td>
<td>3511</td>
<td>4305</td>
<td>3768</td>
</tr>
<tr>
<td>Other small suppliers</td>
<td>683</td>
<td>790</td>
<td>853</td>
</tr>
</tbody>
</table>

Figure 2: Shares of energy sources in gross production [5].

Figure 3: Energy production in Slovenia [5].
3.1.1 Renewable Energies

In the area of renewable energy sources, Slovenia must achieve ambitious targets. Promoting renewable energy sources and prioritizing efficient use are defined as energy policy goals. The programming document for Slovenia’s energy policy – the Resolution on the National Energy Programme (ReNEP) – which was implemented in 2004, defines the mechanisms for promoting renewable energy sources and sectoral goals for renewables up to 2010. The new National Energy Programme, which is in the final stage of drafting and should replace the existing ReNEP, will define the goals of energy policy up to 2030 and the mechanisms for implementing these goals, including the targets Slovenia has set itself in the EU climate and energy package up to 2020 and other international obligations [2], [8], [9].

Some of the objectives of Slovenia’s energy policy for renewable energy sources are [2], [8], [9]:

- ensuring a 25% share of renewable energy sources in final energy consumption and a 10% share of renewables in transport by 2020, which under current predictions will involve a doubling of energy generated from renewable sources relative to the year 2005;
- implementing efficient energy use and renewable energy sources as economic development priorities;
- in the long term, increasing the share of renewable energy sources in final energy consumption.

In order to achieve these renewable energy source objectives, the Slovenian Government will ensure an adequate support environment for [2], [8], [9]:

- energy rehabilitation of existing buildings, mainly in the public sector, and construction of active buildings representing what are technologically advanced structures;
- replacing heating oil with wood biomass and other renewable energy sources;
- district heating systems based on renewable energy sources and heat and power cogeneration;
- replacing electricity for producing sanitary hot water with solar energy and other renewable energy sources;
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- generation of electricity from renewable energy sources;
- increasing the share of railway and public transport;
- introducing biofuels and other renewable energy sources in transport and farming and introducing electric vehicles;
- developing distribution networks for incorporating distributed electricity generation, including the development of active/smart networks;
- developing industrial production of technologies for efficient energy use and renewable energy sources.

Below follows review of renewable energy sources in Slovenia [10].

Figure 5: Installed power of RES in Slovenia [5].

Figure 6: Net capacity in MW of production facilities with issued declarations in 2011 [5].
Water

Slovenia's generation capacity from renewable energy resources is mainly from hydro, representing 28.7% of the total electricity production in 2009. Hydropower plants have the largest share among the RE sources in Slovenia. Besides the large hydroelectric generating units, there are approximately 400 small units (2006) with a total capacity of 85 MW. Refurbishment of existing small scale hydropower, and increasing the capacity of the large-scale units, are part of the Slovenian renewable energy strategy. The technically feasible hydropower potential of the Slovenia is estimated to 8,800 GWh/yr, of which a third has currently been exploited. An additional 40 MW of small hydro capacity is also estimated to be unexploited.

Wind

Slovenian wind power is in its infancy, with minor installations present for recording purposes, as well as some limited use for water pumping/feed grinding. Average wind speeds across the country vary, but can be as high as 4.5 m/s in the Portoroz region. A large number of potential sites for wind power in the country are, however, situated in ecologically sensitive mountain regions, which are under consideration for national parks. Approximately 40 MW of wind capacity is in the planning process. The total estimated power generation potential for the country, as of 2006, was 600 MW.

Photovoltaic

Studies have shown that with existing technologies Slovenia can harness 960 GWh per year, which is about half the power Krško nuclear power plant produces at the moment. The total installed capacity of photovoltaic installations was 120 MW in 2011. Average daily insolation across the country is in the region of 3.0 – 4.0 kWh/m2.

Combined heat and power generation [1]

Geothermal energy represents large energy potential in Slovenia, also due to its environmental compatibility. Today, we estimate that Slovenia has theoretically 50,000 PJ available, of which 12,000 PJ is exploitable supply of heat, which is located in geologically sensitive aquifers. It is necessary to bear in mind that thermal aquifers are local in character. Production of electricity on economic basis is now possible only in north-eastern Slovenia, which has not yet been studied a lot.

Two-phase (liquid-vapour) system is the most appropriate, if the pressure of thermal water equals the saturation pressure, so that the geothermal fluid appears in both phases: liquid and gas.

The mixture of water and water vapor is introduced via the expansion nozzle, in which the potential energy is converted into kinetic energy, which is transferred to a rotary separator, which drives an electrical generator. After the separator, the water vapor is transferred to the condensation steam turbine and the water is transferred to the water turbine, which both drive electrical generators.

With steam system, geothermal water is fed into the steam generator used to produce steam, due to the pressure difference. This steam is conducted into the steam turbine, which drives an electrical generator.

The number of available geothermal resources with a high enough temperature that would be suitable for the direct production of electricity is not high and mainly located in areas of active volcanism and in very large depths (typically over 5 km). On the other side, there is a lot of available thermal water at a
lower temperature range. To utilize this thermal water for generation of electricity, it is necessary to carry out the conversion via a medium with lower boiling point.

In the last decade (since 1994), Slovenia had planned six large geothermal projects. With the exception of the project Murska Sobota, which uses heat for heating, yet none of them has been realized.

Figure 7: Geothermal energy in Slovenia – projects [1], [11].

<table>
<thead>
<tr>
<th>Project name</th>
<th>Installed power [MW]</th>
<th>Annual production [GWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal project Ljutomer</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Comprehensive utilization of geothermal energy for sustainable development (Lendava) - IGES</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Geothermal project Tolmin</td>
<td>0.34</td>
<td>2</td>
</tr>
<tr>
<td>Geothermal project Benedikt</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>17.34</td>
<td>121</td>
</tr>
</tbody>
</table>

### 3.2 Energy Consumption

In 2011 the electricity consumption in Slovenia amounted to 12,682 GWh of electricity (excluding the losses in the network). In comparison with 2010, the consumption increased by 524 GWh, or 4.1%. The customers connected to the transmission networks used 1914 GWh of electricity, or 36.8% more than the previous year. The consumption of the customers connected to the distribution network increased by 0.6%, and amounted to 10.575 GWh. The hydroelectric pumped-storage power plant Avče (hereinafter referred to as PSPP Avče) used 193 GWh for accumulation of water. The electricity losses in the transmission and distribution networks amounted to 816 GWh, or 6.2% of transmitted electricity, including transit, export and import of electricity [5].

<table>
<thead>
<tr>
<th>Number of consumers</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of business clients</td>
<td>102661</td>
<td>102479</td>
<td>103187</td>
<td>103955</td>
<td>105046</td>
</tr>
<tr>
<td>No. of private and small business clients</td>
<td>802693</td>
<td>811282</td>
<td>817724</td>
<td>821328</td>
<td>825198</td>
</tr>
<tr>
<td>Consumption / kWh/citizen</td>
<td>6145</td>
<td>5491</td>
<td>5931</td>
<td>6076</td>
<td>6135</td>
</tr>
</tbody>
</table>
3.2.1 Gorenjska Region

Elektro Gorenjska, d. d., the company for the distribution of electricity, daily provides electricity supply to distribution network users. The surface of the supply area is 2,091 km$^2$ and for comparison the area of the Republic of Slovenia is 20,256 km$^2$ [12].

Activities:

- Distribution of electricity;
- Other activities in the field of electricity, especially the design, consulting, construction and maintenance of electric power facilities and other services for the needs of the company itself, as well as for external customers.
Figure 10: Map of DSOs in Slovenia [12].

Table 5: Basic data of DSO Elektro Gorenjska [12].

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of consumers</td>
<td>87727</td>
</tr>
<tr>
<td>Number of households</td>
<td>76713</td>
</tr>
<tr>
<td>Number of DER units</td>
<td>334</td>
</tr>
<tr>
<td>Total distributed energy in 2011</td>
<td>1002761955 kWh</td>
</tr>
<tr>
<td>Consumption - households</td>
<td>326310071 kWh</td>
</tr>
<tr>
<td>Average consumption per household</td>
<td>4254 kWh/hous.</td>
</tr>
<tr>
<td>Consumption - business</td>
<td>676451924 kWh</td>
</tr>
<tr>
<td>Average consumption per business</td>
<td>61417 kWh/business</td>
</tr>
</tbody>
</table>

Table 6: Emergy consumption of DSO Elektro Gorenjska [12].

<table>
<thead>
<tr>
<th>Energy consumption</th>
<th>kWh</th>
<th>share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>transmission network</td>
<td>934781491</td>
<td>88,4</td>
</tr>
<tr>
<td>DER (Gorenjske elektrarne)</td>
<td>47419549</td>
<td>4,5</td>
</tr>
<tr>
<td>DER other</td>
<td>75813386</td>
<td>7,1</td>
</tr>
</tbody>
</table>
3.2.2 Business clients

3.2.3 Private consumers and small-scale business clients
3.3 Energy Transmission and Distribution

Electricity distribution network is a system of connected devices that are intended for distribution of electricity from the transmission system to the final consumer or producer of electrical energy.

In Slovenia the distribution system operates at the following voltage levels:

- high-voltage level (HV) with a rated voltage of 110 kV,
- medium-voltage level (MV) with a rated voltage of 10 kV, 20 kV and 35 kV (being phased out),
- low-voltage level (LV) with a nominal voltage of 0.4 kV (230/400 V) and 1 kV.

The most important elements of the distribution network are:

- distribution transformer station with transformation voltages 110 / X kV and MV / MV kV,
- distribution station (DS),
- transformer substations with transformation voltages MV / LV kV and LV / LV kV,
- power lines in above and below ground version and with bare conductors and insulated conductors,
- carrying pillars (wood, concrete, iron, aluminium).

In addition to the basic (primary) infrastructure to implement the distribution of electricity, also other (secondary) infrastructure is needed, such as:

- distribution management center (DMC)
- meters and measurement systems,
- telecommunication infrastructure for the needs of the energy distribution,
- automation of the network,
- remote control switches.

110 kV network normally operates in closed loops. The network is implemented in the aboveground and rarely with the cable conductors in the ground, especially in urban areas. For overhead lines conductors Al / s 240/40 is most frequently used and for underground conductors cables are used, which represent the thermal equivalent (eg XLPE 630) [13].

Medium-voltage grid is operated radially with the possibility of reconnection, where this possibility exists. In urban areas the network is carried out mainly in the underground version. Overhead line conductors are typically 25 mm2 to 150 mm2 and of different materials (Al / Fe, Cu, PAS). The cables are typically 35 mm2 up to 240 mm2 (Al and Cu). The most common structure of the network is open loop [13].

Low-voltage network operates predominantly radial. Possibility of emergency power supply is possible only for large customers. Overhead line conductors are from 25 mm2 to 70 mm2 and of different materials (Al, Al / Fe, Cu). The cables are from 16 mm2 up to 240 mm2 (Al and Cu) [13].

3.3.1 Power grid

Total length of the network of all voltage levels is 62,525 km, of which 72 % is the LV network and 27 % is the MV network [13].
Length of the 110 kV network is 806 km and is almost entirely aboveground, underground version is less than 1 % of the 110 kV network. There is 81 110 kV/MV transformer stations in operation with 177 HV / MV power transformers and with an installed capacity of 4,901 MVA [13].

Length of MV network is 16,740 km, of which 26 % of the lines is underground. On the MV level operates 19 transformer station MV/MV. In 14,640 substations 16,198 transformers are installed with an installed capacity of 3,769 MVA [13].

Length of LV network is 44,979 km, of which 43% is underground [13].

➢ *High-voltage*

Connection of smaller & larger unit is feasible but with some assumptions (size dependent):

- 2 X 400 kV transmission lines Krško – Beričevo (already under construction in 2011),
- Upgrade of existing 220 kV to 400 kV,
- Phase shift transformer in Divača,
- 400 kV transmission lines to Italy and Hungary.

Electricity transmission:

- additional national 400 kV transmission networks,
- additional trans boundary connections with neighbouring countries.

*Figure 14: 400 and 220 kV network and power plants in Slovenia [ELES].*
**Region SI022: Gorenjska**

Status Quo and Masterplan

---

**Figure 15:** 2 X 400 kV transmission lines Krško – Beričevo being constructed [ELES].

**Figure 16:** Transmission network length.

---

**Table 7:** Transmission and distribution network length [13].

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total length of transmission network / km</strong></td>
<td>2572</td>
<td>2571</td>
<td>2614</td>
<td>2603</td>
<td>2682</td>
</tr>
<tr>
<td>400 kV</td>
<td>508</td>
<td>508</td>
<td>508</td>
<td>508</td>
<td>508</td>
</tr>
<tr>
<td>220 kV</td>
<td>328</td>
<td>328</td>
<td>328</td>
<td>328</td>
<td>328</td>
</tr>
<tr>
<td>110 kV</td>
<td>1736</td>
<td>1735</td>
<td>1778</td>
<td>1767</td>
<td>1846</td>
</tr>
<tr>
<td><strong>Total length of distribution network / km</strong></td>
<td>63208</td>
<td>63518</td>
<td>63862</td>
<td>64062</td>
<td>65858</td>
</tr>
<tr>
<td>110 kV</td>
<td>793</td>
<td>805</td>
<td>814</td>
<td>835</td>
<td>846</td>
</tr>
<tr>
<td>35, 20 and 10 kV</td>
<td>17455</td>
<td>17540</td>
<td>17545</td>
<td>17571</td>
<td>17738</td>
</tr>
<tr>
<td>0,4 kV</td>
<td>44960</td>
<td>45173</td>
<td>45503</td>
<td>45656</td>
<td>47274</td>
</tr>
</tbody>
</table>

---

[Image of map showing transmission network lines]
3.3.2 Metering points

For users with the power up to 41 kW, most meters (80%) are still induction. The proportion of meters that can be remotely read (AMR, AMM, AMI) is 13%, whereas the proportion of AMM and AMI meters is app. 6%. Some of installed meters are static (electronic), which came into use about 10 years ago, but still does not have the functionality of AMR. In the area of customers with an installed capacity of 41 kW or more, where the 15 minute data monitoring is mandatory, meters with the possibility of remote reading (AMR) are installed [13].

In meeting the new energy and climate requirements, which the RS is committed to, the network conditions will become increasingly complex. Today's "conventional" system will inevitably become more and more active. It is crucial, therefore, to prepare and implement the SmartGrids concept that defines the necessary upgrading of existing concepts of operation and design of the distribution network.

DSO has therefore in the middle of 2010, subjected to the requirements of Directive 2009/72/EC, prepared the analysis: economic evaluation of long-term costs and benefits of implementing advanced metering systems and the timetable for economically reasonable and cost-effective introduction of advanced measurement systems in the Slovenian power system. The analysis take into account interoperability, appropriate standards and best practices for deployment of advanced metering systems that are essential in the development of the internal market of electricity.

The analysis showed that advanced metering systems for measuring electricity (AMI) offer much more than just measurements and transmission of measurement data, and that due to lower operating costs their introduction to all Slovenian customers is feasible. With its additional features they represent one of the basic energy information infrastructure technologies, which enable [13]:

- significantly improved quality of supply for customers or users of the network,
- efficient use of energy,
- competitive and transparent energy markets,
- development of innovative energy services,
- the implementation of smart electricity networks (SmartGrids) at low voltage levels,
infrastructure for connecting monitors of the use of other energy sources (natural gas, heat and water).

Due to staffing constraints and mass deployment of advanced metering systems across the EU DSO proposes that mass introduction of advanced metering systems in Slovenia is carried out in 5 years, from 2012 to 2017. Due to the massive introduction throughout the EU it is to assume that towards the year 2020 the delivery time of the equipment, software and probably also the price are likely to increase, so the introduction timing is very important. Economic evaluation of the introduction of advanced metering systems in 5 years shows that the introduction is justified solely in terms of the benefits of the distribution system operator [13].

With the introduction of advanced metering systems positive environmental effects are also expected, since informing customers about their actual consumption increases their awareness of the power consumption.

Given the topicality of the issue and the positive effects brought by advanced metering systems, distribution system operators participate in activities and demonstration projects in this field. Thus, in Slovenia various pilot projects of advanced metering systems were carried out or are still running. In early 2010, the distribution companies equipped 115,863 customers (13% of all customers) with the power up to 41 kW with AMR or AMM / AMI meters, which was a significant improvement compared to the year 2008 [13].

Companies therefore have experience with the introduction of the system of meters and remote data capture for households or for network users with a power up to 41 kW. Scope of the projects in terms of the number of the measurement points is small, although some projects went beyond the scope of pilot projects and actually mean gradual introduction of AMI system. In most cases systems are used for remote collection of metering data (dominated by AMR functionality). Some pilot projects include display of consumption and related information to consumers via the web portal [13].

3.3.3 (Smart) grid issues and development status

Given the growing number of renewable and distributed energy sources it is becoming necessary to fundamentally change the structure of the grid. It will be necessary to enable a reliable and secure connection of renewable and distributed energy resources in the network and the possibility of a simple balancing of consumption and production of electricity. System operators will need uniform technical rules and procedures for maintenance, renovation and construction. Introducing SmartGrids will allow for flexibility (to meet the needs of customers with their responses to changes and requirements), access (enabling connection to the network for all users, especially the production of energy from renewable and distributed energy resources and high-efficient local production), the reliability of electricity supply (provision and improvement of the reliability and quality) and efficiency (efficient energy management, competition and regulation). It will also be necessary to modify the current complicated administrative procedures for the connection of renewable and distributed energy resources to the grid with the introduction of simple, clear and safe standardization of connection [13].

When connecting renewable and distributed energy resources, the concept of SmartGrids plays an important role, since it ensures a better chance of connecting smaller units.
Alongside the existing elements of the power system, the smart grids introduce many new features, among which the following are crucial [13]:

- development of new concepts of operation of the electricity system,
- development of new concepts of electric power system planning,
- advanced metering systems,
- concepts of power management for the needs of the network and the electricity market,
- electric vehicles,
- energy storage systems,
- the concept of integration of distributed generation,
- virtual power plants,
- information and communication technology,
- standardized data exchange and integration of information systems;
- power quality and
- modern compensation devices.

The concept of SmartGrids in Slovenia has recently been introduced with [1] and will serve to:

- definition of SmartGrid,
- setting strategic goals that the Republic of Slovenia wishes to achieve through smart grids with an indication of the benefits for individual participants,
- assessment of the investment required for the implementation of smart grids,
- a detailed analysis of the current state of the transmission and distribution networks,
- assessment of the necessary human resources, a review of the participants and their roles,
- overview of technologies and their economic reach,
- a definition of scenarios for the possible development of individual areas of smart grids in Slovenia (slow, medium and fast),
- scenario analysis with technical, economic, regulatory, sociological and environmental aspects and
- terminology.

The concept of SmartGrids in Slovenia is in some segments already being implemented (pilot AMM / AMI projects, concrete industrial projects in the field of VRTE, DSM studies and the introduction of new tariffs). Projects themselves are divided into several subgroups and are limited only to the secondary systems and subsystems of the power system and do not interfere with the primary equipment.

The introduction of the concept will require funding for both the incentives to producers of renewable energy sources, for pilot and demonstration projects, projects for mass implementation and monitoring of the system itself. It is necessary to set up the regulatory framework for investing in the research and pilot projects [13].

### 3.4 Energy Storage

Construction and operation of the power system was since its beginnings marked by the fact that electricity cannot be stored economically justifiable at a sufficiently large scale. Therefore, the system with all the primary elements and superior regulation systems is adapted to the fact that the production
must follow the consumption at all times. Many efforts have been given in the past to the development of technology and algorithms that allows stable operation of the system; however it still happens that sometimes it collapses, due to the imbalance between the production and the consumption. It will be necessary therefore to introduce the possibility of energy storage in near future, since this technology allows for better integration of modern energy sources and other aspects of the SmartGrids [1], [12].

In the past 20 years, engineers have been working intensively on developing new technologies for storing electrical energy that would allow different lengths of storage time. In recent years the results of these efforts can be seen, since certain energy storage units of sufficiently large scale are available on the market, being at the same time also commercially interesting [1], [12].

### 3.4.1 Current status in Slovenia

Pumped hydro power plant is the most developed and used technology of energy storage in Slovenia (on large scale). In the future, when a sufficiently large number of EVs will be in operation, EV batteries could also be used as an energy storage element.

Pumping hydro power plant Avče with an installed power of 185 MW (turbines) and an installed power of 180 MW (pumping) is currently the only HPP operating in Slovenia. Annual electricity production is 426 GWh while the annual energy consumption for pumping amounts to 553 GWh, which means 77% efficiency [14]. Another HPP is being built (starting in 2011), i.e. power plant Kozjak with an installed power of 400 MW, and it is estimated to start with the operation in 2018. By 2028, several small hydroelectric pumped (storage) power plants are planned at various locations with a total installed power of 185 MW [15].

According to the foreign studies Slovenia might expect till 2030 four hundred thousand hybrid vehicles, two hundred thousand “plug-in” hybrids, hundreds of thousands of electric (battery) vehicles, hundreds of thousands of electric hybrids on hydrogen and batteries and hundreds of thousands of hydrogen vehicles [16]. For example, 100 000 EVs with a battery capacity of 16 kWh [17] means 1.6 GWh. This is the theoretical maximum amount of energy stored under the given assumptions. The overall efficiency of the batteries is between 80% and 90% [17], depending on the technology and the age of the batteries. Of course, from total capacity of the batteries we need to subtract the energy needed for driving, so the available EV battery capacity that could be used for storage is much less than the full capacity.

Below is a brief overview of a current status of the storage technologies in Slovenia.

### 3.4.2 Biogas digesters and storage tanks

- **Market availability / number of units in operation:**
  
  First biogas plant was built in 1993 for the anaerobic digestion on municipal central wastewater treatment plant. In 2009 8 CWWT (total: 20 MW) systems were installed in Slovenia for biogas production, but only 4 of them were using biogas for production of heat and/or electricity.

- **Local future options:**
Potential from animal wastes on farms is estimated at 1.1 PJ per year for production of electricity. Economical potential for the next year on municipal biogas plants and farm biogas plants is estimated on up to 30 MW [19]. Up-to-date no assessment of the need to extend the natural gas network to integrate biogas into the network has been carried out. A legal framework and incentives will also need to be prepared for this possibility [2].

3.4.3 **Power-to-Gas (methane in gas grid)**
- Market availability / number of units in operation:
  Not available as a storage system.
- Local future options:
  In 2011 Slovenia's first compressed natural gas (CNG) filling station has been opened for CNG powered public buses in Ljubljana. Future policy in this field is focused in
  - increasing the competitiveness and sale of private, light goods and heavy goods vehicles powered by RES,
  - greater share of RES in public transport,
  - promoting the development of filing infrastructure, etc.

3.4.4 **Pump storage (regional in Alpine Space)**
- Market availability / number of units in operation:
  There is currently one pumped storage hydroelectric power plant (PHPP) in Slovenia. PHPP Avče is operational since 2009 and it produces 426 GWh of electricity annually and consumes 553 GWh for pumping. The installed turbine power is 185 MW.
- Local future options:
  A 400 MW Kozjak PHPP on the Drava River is being built. Project started in 2011 and it is scheduled to be completed in five years.

3.4.5 **Thermal energy storage system**
- Market availability / number of units in operation:
  Only short-term thermal energy storage is now being used in households in Slovenia and some units in the industrial sector, but exact number of units (or total power) is not available.
- Local future options:
  There is a big potential for development especially in combination with district heating systems. A public tender for co-financing district heating using geothermal energy is being drafted.

3.4.6 **Mobile batteries (electric vehicles)**
- Market availability / number of units in operation:
  Slovenian electric vehicle (EV) market is in its early stage of development. However, the number of EV is growing and so is the number of charging stations. Currently Slovenia has approximately 45 charging stations, allocated in major cities.
- Local future options:
  The Society for Electric Vehicles of Slovenia has called on all competent institutions to give as much support as possible to the project of setting up new charging stations. At the start of the
year the Society and 89 partners submitted a project bid for the opening of new charging stations for electric vehicles. If the project is accepted, they will open 150 new charging stations in Ljubljana over the next four years [21].

3.4.7 Stationary batteries

- Market availability / number of units in operation:
  A few projects with stationary batteries have been started in recent years. There are also some R&D projects which deal with the integration of stationary batteries to a home system or with the integration of stationary batteries to the energy system.
4 Future Energy System

Smart grids that are key element of the future power systems represent third large investment cycle of the power system. The concept of smart grids is an upgrade of the existing concept of operation and design of the power system. It effectively involves the individual elements of the system, both classical (centralized large scale production units, transmission and distribution networks) and new elements, such as the distributed production resources, advanced measurement systems, flexible prosumers, virtual power plants, electric cars and energy storage systems.

The key are information and communication technologies that link all elements in the system into a functional whole. Existing information links are primarily between the operators and centralized production units, in the concept of smart grid it is necessary to establish a connection with the final information system users (customers, manufacturers or their distributed sources) and other elements of the system, such as the energy storage and infrastructure for electric cars. Information technology (IT) will play an important role and it will provide IT support to all processes within the concept of smart grids [1].

The key document for future development of the Slovenian energy system is the National Energy Programme of the Republic of Slovenia for the 2010–2030 (NEP). Currently Slovenia is conducting a public consultation of the draft version of the document. The document follows European and International obligations for the Republic of Slovenia. Slovenia has to fulfil national and international targets regarding energy efficiency, renewable energy sources and greenhouse gas emissions, which are also main goals of the NEP.

The targets which have to be fulfilled according to the NEP are mainly determined by the EU climate and energy package, which is focuses on measures to increase the use of RES and energy efficiency. The goal of the climate and energy package is the development of sustainable energy supply systems with less greenhouse gas emissions.
On the national level, Slovenia is strongly focusing on the long-term exploitation of nuclear energy. The key measures in the NEP proposal are the extension of the operational lifetime of Krško NPP and the construction of a new nuclear power plant, Krško NPP [20].

Basic elements of NEP:
- strategy for energy demand and supply,
- long-term energy balances.

Basic results of NEP
- instruments of energy policy,
- development of energy infrastructure.

Below is a short overview of the new National Energy Program (2011+) [24].

**Key drivers**
- Energy intensity in Slovenia is 54 % higher than in EU-27.
- Electrical consumption decreased, but needs to be further decreased.
- Energy consumption in the transport sector went up by 48 % from 2004 to 2008.

**Long-term goals**
- To double the cogeneration capacity by 2020.
- Increase energy efficiency for at least 20 % by 2020 and 27 % by 2030.
- Renewables share in final energy use 25 % by 2020 and 30 % by 2030.
- Reduction of greenhouse gas emissions for 9.5 % by 2020 and 18 % by 2030.
- Reduction of energy intensity for 29 % by 2020 and 46 % by 2030.
- Have 100 % energy neutral buildings among new built and renovation in public sector by 2018 and elsewhere by 2020.
- Limit energy dependence on imports to less than 45% by 2030.
- More international / regional interconnections.

**Legal Background**
Legal background for country's energy policy is Energy Act which requires the adoption of National Energy Program (NEP). NEP is prepared by the Government and adopted as resolution by the Parliament.

**The main objectives of national energy policy contained in NEP are:**
- Security of supply: long term stability of supply, diversification of energy sources, minimal share of domestic energy sources, reducing import dependency, sufficient generation capacities, sufficient transmission and interconnection capacities, etc.;
- Competitiveness: to assure competitiveness in providing energy services;
- Sustainability: to stimulate sustainable environment and to deploy mitigation measures for climate changes related to supply of energy;
- Social cohesion: to uniformly spread the burden of costs connected with energy supply and mitigation of harmful influences on the environment.

![Diagram of objectives]

**Figure 19:** Strategic objectives of the National Energy Programme [22].

![Bar chart]

**Figure 20:** Current production of renewable electricity, expected production according to NEP by 2020 and potential according to the OPTRES study by 2020 [23].

### 4.1 Regional Energy Production

#### 4.1.1 Conventional Power Plants

Scenarios used in NEP – Starting point: National energy efficiency action plan and Renewable energy national action plan [NEP].

Two assumed approaches for the use of renewable energy sources and end-use energy efficiency:

- reference: business as usual;
- intensive: proactive policy, high economic growth of the country, intensive energy saving projects, launching projects for deployment of renewable energy sources and cogeneration.
Three scenarios for electricity supply are foreseen:

- **Basic scenario:** continuation of use of refurbished fossil power plants, phase out of the oldest fossil plants, new thermal power plant on indigenous coal, intensive construction of hydro PP, life extension of Krško nuclear power plant.
- **Nuclear scenario:** option for long-term use of nuclear energy for electricity generation: replacement of certain projects in the basic scenario with a new nuclear power plant starting operation between 2022-2027.
- **Natural gas scenario:** replacement or delay of certain projects in basic scenario with additional diversification of energy sources and construction of two natural gas fired power plants till 2030.

**Specific issues related to nuclear energy:**

Assure appropriate regulatory and public acceptance framework for:

- life extension of Krško NPP
- construction of low and intermediate nuclear storage
- long-term use of nuclear energy in Slovenia for electricity generation – new NPP at Krško site using the state of the art technology.

**Challenges:**

NEP is a very ambitious plan, taking into account rather fast recovery of national economy, intensified efficient use of energy as well as wider implementation of renewable energy sources. It also anticipates a favourable public acceptance for the a long-term continuation of Slovenian nuclear program.

### 4.1.2 Renewable Energies

Distributed generation sources of electricity are mostly renewable energy sources (RES), but also non-renewable resources (gas, oil, coal) can be used as a source of energy. Non-renewable technologies are used exclusively as a combined heat and power. The basic characteristics of DG sources are small installed capacity, modularity and geographical dispersion. They are mostly connected to the electricity distribution network.

Most renewable DG sources do not require fuel that would need to be supplied. Exceptions are Cogenerations on biological fuel (wood waste, animal droppings). The main added value of the renewable energy sources is that the fuel is free, so there are no variable costs. In addition, as it is well known the environmental impact of such sources is relatively small.

From the system point of view, the DG sources can rarely be used as a reliable support during peak load demand or voltage support in rural areas (long radial lines). In most cases, the purpose of these sources is production of "green" electricity and the contribution to reducing dependence on large production units.

Size, location and type of unit are determined according to geographical circumstances: terrain, weather, proximity and network characteristics. Network characteristics are in particular important for connect of small DG units because they determine the reliability of service and also the economics of small units.
With the recent amendments to the energy legislation and the adoption of appropriate bylaws main framework has been established for connection and operation of DG units that produce energy from renewable sources and for getting incentives for investing in RES. Active policy of the country in terms of promoting the production of electricity from renewable sources is reflected in the annual increase in the quantity of electrical energy supplied by DG sources connected to the distribution network. Especially after 2007, production from RES was in a steep increase. The total amount of electrical energy produced by DG in 2009 amounted to 687 GWh, representing 6.4 % of total energy on the distribution network level. The share of DG installed capacity in the peak load of the distribution system amounted to 11% in 2009. Data of issued approvals for the connection of DG to the distribution system shows that the interest in distributed generation is rising. The installed power of the DG units was 108 MW (2011), which represented 59 % of the total installed power of units connected to the distribution network [13].

In the future, the largest increase in the number of DG sources is expected in the field of photovoltaic power plants and combined heat and power plants. In the period 2010-2020 expected additional capacity of DG from RES amounts to 544 MW (CHP without natural gas). In particular, we can expect a greater increase in micro cogeneration in residential buildings [13].

![Figure 21: Dynamics of past DER connection to distribution network [13].](image)

<table>
<thead>
<tr>
<th>Projects</th>
<th>New capabilities 2010-2020 (MW)</th>
<th>New capabilities 2020-2030 (MW)</th>
<th>Production in 2030 (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Power Plants</td>
<td>119</td>
<td>235</td>
<td>570</td>
</tr>
<tr>
<td>Small Hydro Power Plants</td>
<td>43</td>
<td>18</td>
<td>225</td>
</tr>
<tr>
<td>Photovoltaic Power Plants</td>
<td>337</td>
<td>358</td>
<td>694</td>
</tr>
<tr>
<td>Geothermal Plants</td>
<td>0</td>
<td>25</td>
<td>150</td>
</tr>
<tr>
<td>Biomass</td>
<td>14</td>
<td>11</td>
<td>110</td>
</tr>
</tbody>
</table>
### 4.2 Regional Energy Consumption

Assessment of the future consumption and peak loads in a given area is one of the most important factors necessary for successful and effective long-term planning of system development. Predicting electricity consumption is a complex problem, which contains a number of uncertainties. Processes of predicting energy consumption base on different methodologies, form experimental...
methods and extrapolation of trends, to highly specialized mathematical tools (intelligent systems, neural networks, fuzzy logic).

We expect that in the future the electricity consumption and peak load power will continue to grow. Growth rates are expected to be higher in the near future as a result of recovery from the economic crisis. According to the average expected growth rate of 2.8 %, the electricity consumption in 2020 will amount to 14,715 GWh, which is 44 % more than in 2009, when consumption was lowest. Slightly higher growth rate is expected for customers on the MV level. Expected average annual growth of the peak load is 2.7 %, meaning peak power of 2,320 MW by the 2020, which is a 39 % increase compared to 2009.

Table 9: Consumption and peak load predictions by 2020 [13].

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>LV consumption</td>
<td>6049</td>
<td>6191</td>
<td>6372</td>
<td>6552</td>
<td>6736</td>
<td>6909</td>
<td>7077</td>
<td>7238</td>
<td>7411</td>
<td>7578</td>
<td>7742</td>
</tr>
<tr>
<td>MV consumption</td>
<td>4734</td>
<td>4989</td>
<td>5207</td>
<td>5427</td>
<td>5651</td>
<td>5883</td>
<td>6105</td>
<td>6328</td>
<td>6545</td>
<td>6759</td>
<td>6973</td>
</tr>
<tr>
<td>Total</td>
<td>10783</td>
<td>11180</td>
<td>11579</td>
<td>11979</td>
<td>12387</td>
<td>12792</td>
<td>13182</td>
<td>13566</td>
<td>13956</td>
<td>14337</td>
<td>14715</td>
</tr>
<tr>
<td>Total annual increase</td>
<td>5.7</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
<td>3.4</td>
<td>3.3</td>
<td>3</td>
<td>2.9</td>
<td>2.9</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Peak load</td>
<td>1727</td>
<td>1780</td>
<td>1833</td>
<td>1895</td>
<td>1961</td>
<td>2025</td>
<td>2085</td>
<td>2144</td>
<td>2203</td>
<td>2261</td>
<td>2320</td>
</tr>
<tr>
<td>Annual peak load increase</td>
<td>4</td>
<td>3.1</td>
<td>3</td>
<td>3.4</td>
<td>3.4</td>
<td>3.3</td>
<td>2.9</td>
<td>2.8</td>
<td>2.8</td>
<td>2.6</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Figure 24: Prediction of energy consumption (blue) and peak load (red) by 2030 in % [13].

Table 10: Consumption prediction in GWh of different regions by 2030 [13].

<table>
<thead>
<tr>
<th>Year</th>
<th>Region of DSO Elektro Gorenjska</th>
<th>Average annual increase in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1009</td>
<td>2.9</td>
</tr>
<tr>
<td>2011</td>
<td>1047</td>
<td>2.9</td>
</tr>
<tr>
<td>2012</td>
<td>1085</td>
<td>2.9</td>
</tr>
</tbody>
</table>
4.3 Transmission and Distribution Grids

The transition from the traditional electric power system to a modern power system or. to the Smart-Grids requires major changes and adjustments to the operation and management of electric power systems at all voltage levels. In current power network the flow of energy is predictable and it is directed from the transmission network to the distribution network and from the distribution network to the end user, which is not the case in SmartGrids.

Traditional power system consists of a centrally controlled transmission network and large power plants that are connected directly to the transmission network. The distribution of electricity is carried out through the distribution network, which operates passively. Voltage regulation on the distribution network is simple and the flow of energy is one-way. It should be noted that certain sources of electricity that are being connected to the distribution network already require some changes in the traditional mode of operation. The greater the number of DG sources and with the development of other technologies and power system operation, the traditional power system slowly converts to modern power system [1].

Figure 25: Prediction of regional energy consumption in GWh by 2030 (region of DSO Elektro Gorenjska) [13].
In Europe two different concepts of SmartGrids have developed. The first is the Scandinavian model and second is Central European.

Scandinavian active network operation splits global control area into several local control areas. Each individual control area consists of DG sources of energy, energy storage, information and communication technology and other elements that allow operation of such power system. Local control area is integrated into the transmission network that controls power flows, frequency and voltage.

With the Central European model the centrally controlled transmission network continues to form strong support to the system. The number of DG sources of electrical energy connected to the distribution network will increase and electrical energy will flow in both directions. Distribution system evolves from the system for the distribution of electricity into the system for the exchange of electricity. It is expected that electricity networks in Slovenia will develop accordingly to the European model.

Figure 26: Traditional power system [25].

Figure 27: Modern power system or SmartGrid [26].
4.3.1 Stressors for the Regional Power Grid

In the following sections future challenges of the regional power grids (distribution system) are presented.

4.3.1.1 Changed Conditions in SmartGrids and Their Influence on Network Planning

The essential difference in the operation of intelligent networks compared to the conventional ones is the direction of power flows, which are in modern distribution networks due to the production from DG sources bidirectional. In this respect, new questions are arising in the design concepts of smart grids, especially in the following areas:

- voltage regulation in MV and LV networks,
- local congestions in distribution networks,
- selective action of protection in a distribution network,
- the possibility of improving the reliability of operation,
- development of information technologies and services,
- development of telecommunication infrastructure.

In traditional networks power flows are directed from a power source to a customers and are with known configuration of the network and its parameters completely predictable and manageable. Measurements with automatic voltage regulation under load are present on the MV feeder in transformation station, where also the protection is appropriately set. Voltage profile along the MV and LV lines depends on the load and the transmission capacity of the line. As the network is radially, the voltage drop along the network increases. Where the network is “stronger”, the higher short-circuit power causes lower voltage drops along the line. All this shows that the voltage profile in the classical networks is entirely predictable.

The presence of distributed sources in smart grids leads to bi-directional power flows. This means that along the line both voltage drops and voltage rises can appear. Given that the nature of the RES is highly fluctuating, these voltage drops and raises are even more pronounced. In addition to the unpredictable DG sources also consumers are becoming increasingly unpredictable and this large number of random variables can cause local congestions in the network.

Once peak production from DG sources reaches a significant portion of the overall peak demand (about 30% or more), this may cause problems with the stability of the power network. Operation of protection with existing settings can lead to malfunctions and selectivity. The DG sources alter the size and direction of short-circuit currents, which can cause unnecessary operation of circuit breakers, reduce the sensitivity of the protective relays and prevent proper functioning of the automatic breakers. Increased short-circuit currents can exceed the nominal value of the existing equipment.

All these factors call for new approaches to the design of the network and some of them are presented in the next section.

4.3.2 (Smart) Grid Solutions

The main document that describes the SmartGrid concepts in Slovenia is recently adopted Program for development of SmartGrids in Slovenia [1]. According to this document, Slovenia will integrate technologies described in the following sections.
4.3.2.1 Advanced metering infrastructure - a system of advanced metering

The introduction of the advanced metering infrastructure (AMI - Advanced Metering Infrastructure) or advanced metering systems for households is needed mainly because of the following requirements [1]:

- to save energy,
- for efficient use of energy,
- a greater proportion of energy from renewable sources,
- to integrate new technologies, such as EV infrastructure,
- to increase transparency of the energy market,
- to offer innovative services for users of networks and
- to fulfil the requirements of the regulation, such as Directive 2009/72/EC concerning common rules for the internal market of electricity, which requires Member States to establish by 2020 a system of advanced metering at least 80% of customers for which an economic analysis shows positive results.

4.3.2.2 Integration of active consumption

The field of active consumption is very complex and during the implementation phase we will face a number of challenges that arise in the technological, regulatory, economic and sociological area. The program for integration of active consumption can be technology-based and economically viable, but it can go totally wrong in the execution, if no adequate communication with customers and end-users is set in place. Only the successful functioning in all the areas will give the final result that will satisfy all parties [1].

4.3.2.3 Distributed generation

Most DG sources are renewable, but also non-renewable resources (e.g. gas, oil, coal) can be used as a fuel for electrical energy production. Non-renewable technologies are normally used as a combined heat and power. The basic characteristics of DG sources are small installed capacity, modularity and geographical dispersion. They are connected to the distribution network.

Most renewable DG sources do not require fuel to generate electricity. Exceptions are co-generations units on biological fuel (wood waste, animal droppings). The main “added value” of the renewable energy is that the fuel is free, so there are no variable costs. In addition, the environmental impact of such sources is relatively small [1].

4.3.2.4 Electricity storage systems

Construction and operation of the power system was since its start influenced by the fact that electricity cannot be stored at a sufficiently large scale and economically viable at the same time. Therefore, the system with all the primary elements and superior regulation equipment must adapt to the fact that the production must follow the load at all times, under constantly changing conditions. Many efforts have been given in the past to the development of technology and algorithms that enable stable operation of the system, but it still happens that the it collapses, due to the imbalance between the produc-
tion and the consumption. That is why there is need to storage the electricity in larger amounts, which will simplify almost all the operational problems that the system is facing today [1].

### 4.3.2.5 Virtual power plants

In the context of SmartGrids the term "virtual power plant" appeared very soon. Virtual Power Plant (VPP) is a set of distributed energy sources such as small hydropower, PV, cogeneration and other technologies. It can also include clients who can at the request of the operator adjust their consumption. The VPP is controlled from a common control centre.

Virtual power plant aggregates the power of multiple DG sources that can be different by the technology. Produces power is aggregated into a single, centrally controlled profile. Its production is a result of the various parameters that each contributes to the characteristics of each source involved in virtual power plant. In this way, a virtual power plant markets its profile in the electricity market, or participates in the management of the system by system operators (both distribution and transmission network and system). On this basis, the concept of virtual power plants can be divided in two versions:

- Commercial VPP
- Technical VPP

Of course, the virtual power plant can be both. Virtual power plant practically exists only as software and hardware that controls all DG sources involved in it. Due to their properties, regulation should allow the virtual power plants to equivalently participate in the electric power system and electricity market [1].

### 4.3.2.6 Geographic information system

Geographic Information System (GIS) falls within the concept of SmartGrid because it is a computerized system for digital presentation and analysis of the geographical features of objects and events. The main tasks of GIS as an integrated system are:

1. To ensure the integrity of data on infrastructure, which includes the collection, storage, processing and presenting data collected in the geographical database. It is location, which must be georeferenced, that represents a key figure on which to base all GIS systems. Request for georeferencing the objects, also provides a way to display the results of GIS systems. The content of GIS systems are normally presented with maps or charts.

2. To provide GIS data infrastructure to different users: which includes either direct access to GIS system via various work interfaces or purpose-built interfaces for data access to other information systems.

In the context of SmartGrids, the two main functions of a GIS do not change, however the role of the GIS system expands and deepens. Expanding due to the entry of new network elements (DG sources, advanced metering, AMM / AMI, charging stations for electric cars, storage of energy, compensation device... ), and deepens because we expect that the technical and business processes within the concept of SmartGrids need to have good IT support for efficient [1].
4.3.2.7 Information communication technologies

Information and Communication Technology (ICT) is one of the key building blocks of SmartGrids. The full realization of the concept of Smart Grid requires ICT links to each element of the power system.

ICT plays an important role in SmartGrid concept by increasing efficiency, reducing losses and ensuring stability and security of electricity network. We will need to build a sufficiently powerful, scalable, reliable, resilient and secure ICT infrastructure.

As described in the previous sections, the electricity networks will become more intelligent with automated control and the use of decentralized methods, which will rely on ICT infrastructure that will be required to provide:

- real-time communication between suppliers, distribution and customers,
- communication between the smart points (meters, controllers) in real time (M2M),
- access to the network status in real time,
- distributed algorithms for achieving autonomy, scalability and reliability to support the chosen solutions,
- algorithms to build and maintain a virtual network over an existing IP network and
- protocols for internet security against malicious attacks.

For many of the above requirements corresponding solutions exist already in the existing ICT systems. We will need to adapt and supplement the existing algorithms according to the requirements of energy sector. Further development of the telecommunications network is needed towards convergence, two-layer architecture of optical transport systems and service layer based on IP / Ethernet technologies [1].

4.3.2.8 Power quality

Electricity is one of the most important services today. With the opening of the energy market, electricity has become a commodity. Customers of electricity require in particularly reliable supply in terms of uninterrupted power supply, adequate voltage quality and reasonable price. Network user expects to be able to use the distribution network of electricity when needed, the quality defined in a transparent and effective manner and that all user devices operate safely and satisfactorily [1].

DSO is obliged to provide the user with high-quality power supply. This is divided into:

- the commercial quality,
- reliability (continuity), which refers to the number and duration of interruptions detected by the client and
- the voltage quality, which refers to the frequency, amplitude, shape and symmetry of the three-phase system voltage wave at the PCC.

4.3.2.9 Modern compensation devices

Traditional solutions to the problems that occur in the distribution networks (incorrect voltage profile, too small transfer capacities, power flow problem, power quality ...) includes upgrading the grid with additional power lines and transformers, which is usually expensive and, due to environmental reasons and legal constraints, sometimes very difficult to implement. In order to limit the adverse impact
of connected loads and to improve the level of quality of electricity supply, passive LC filters are still most widely used. Disadvantages of these filters are mainly fixed compensation characteristics (compensation of only one harmonic), the possibility of resonance occurrence with other elements of the system and the physical size, which all greatly limit their usefulness and efficiency [1].

4.3.2.10 Electric vehicles

In the near future we expect the development of electric vehicles (EVs) and their widespread use due to the development of EV technologies, higher fuel prices, increased environmental awareness, the requirements for achieving energy independence and other reasons. With the increased number of EVs, power systems will have to undergo great changes: the requirements for the use of new technologies, the construction of charging stations and grid reinforcements, increased consumption and changed load characteristics, due to the growing number of EVs charging in the network.

In the area of energy use in transport, electricity as an energy source will join fossil fuels and biofuels. The transition to a broader inclusion of EV in the transportation fleet will be gradual, and according to some forecasts, it is expected that by 2030 all new vehicles will be EV. Compared to internal combustion engines, energy efficiency of the electric motor is much higher. As an added benefit of the EV, we can also mention significantly lower and localized emissions of greenhouse gases. Nevertheless, it is necessary to take into account the additional emissions from their own production. It is estimated that by using only EV CO2 emissions will decreased by about three times. EVs have of course are also many disadvantages, which are mainly related to the battery itself and the price of EV. These weaknesses will be reduced with the development of EV technology [1].
5 Future Energy Storage

Planning and operation of electric power system has been since its inception marked by the fact that electricity cannot be stored in a sufficiently large scale in an economical way. Therefore, the electric power system with all the primary components and the superior control systems must operate in such a way that the production can follow the ever changing load. Major efforts have been therefore devoted to the development of technology and control algorithms, which today allows stable operation of the system; however it still sometimes happens that the imbalance between the production and the consumption causes blackout.

5.1 Storage Requirements

In most countries, energy storage technologies are part of the SmartGrid concept, however development priorities of individual SmartGrid topics and the introduction timeframe for various technologies can be quite different from country to country. Among other, it depends on the natural resources and the specifics of the power grid.

The EU market for large electricity storage systems (e.g. PHPP) recently slowed down due to the fact that the demand for electricity from conventional power plants that cover the need for electric energy in trapeze and at peaks in the daily diagram, decreased (due to production from renewable energy sources - solar, wind) and therefore the differences between the highest and lowest prices at the European electricity market are lower than ever before. Because prices generally reached very low values (e.g. 3-4 cent / kWh), the investment in new capacities for storing larger amounts of energy and sometimes even the continued operation of the existing systems is not profitable.

An exception to this general trend is the emerging market for batteries in photovoltaic systems that enable greater self-sufficiency to owners of these plants. This segment developed due to the fact that in some countries the prices of electricity from small scale solar power plants have achieved lower values than the tariffs for households.

There is also a small market for energy storage systems to compensate peaks in the daily diagram. For example, some biogas plants that have sufficient storage capacities for biogas, heat and electricity cogeneration, which gives them the flexibility, can be competitive in the market of balancing power.

At present, the market situation does not encourage mass deployment of electricity storage technologies, but if the growth in the share of production from renewables will continue at the same pace as in recent years (especially photovoltaic systems), large storage systems will become necessary very soon. Production from conventional sources will have a smaller contribution to the daily diagram (especially in the middle of the day when the output of a PV is at maximum), power generation from hard coal and lignite will be reduced, and the production of gas fired power plants will increase. Due to the increasing uncertainty of production capacity, the need for short-term and long-term storage of energy will become more and more pronounced, if we want to maintain the present levels of reliability and quality of power supply. Various foreign studies have shown that the increased need for energy storage and other ways of ensuring flexibility in power supply will occur, when the share of electricity supply from renewable energy sources becomes greater than about 50 %.

In Slovenia, market conditions and trends are similar to this general situation - the mass deployment of storage systems is still not profitable. Due to the relatively low price of electricity for households and
subsidized feed-in tariffs for energy from renewable sources, the introduction of battery systems to provide self-sufficiency is currently not profitable.

Exceptions are the customers in remote areas, where there are frequent interruptions in the electricity supply. At this local level there are opportunities for a wide variety of actors, investors, regional energy agencies and local authorities. These options are non-regret, because they can be implemented in a short time without the risk of committing a big mistake if the development of electricity production from renewable energy sources, energy storage technologies, and the development of policy and legal frameworks takes a different path than currently expected.

5.1.1 Regulatory framework

The key elements of the support environment in Slovenia up to 2020 are as follows [2], [8]:

- economic incentives (continuing the established scheme of support for generation of electricity from renewable sources and high-efficiency cogeneration of heat and power, with the preparation of a similar scheme for heat), direct financial stimuli and appropriate tax policy;
- regulations for methods of heating and cooling (introducing a compulsory share of renewable sources of energy in district heating systems, updating regulations for the use of renewable energy sources in buildings);
- improved planning: stepped up preparation of the expert basis for the physical placement of renewable energy sources on the national and local level; checking the possibility for improving administrative procedures for carrying out investments and checking the effectiveness of procedures through demonstration projects;
- a system of quality management in planning and implementing projects and of biofuel quality;
- incentives for developing financial markets and a range of appropriate financial mechanisms;
- support for establishing a wood biomass market;
- measures in the areas of education and training, research and development and promoting the development of industrial production for renewable sources;
- systematic promotion of best practices of efficient energy use and renewable energy sources, and ensuring high-quality information for evaluations involved in all decisions relating to the use of RES.

A range of measures to promote renewable energy sources is already being implemented as part of the adopted programme documents, especially under the Operational Programme for Developing Environmental and Transport Infrastructure 2007-2013, the Operational Programme for Reducing Greenhouse Gas Emissions up to 2012 and the Action Plan for Green Public Procurement.

Due to the diversity of electricity storage technologies there are also a variety of directives in this area, each covering different individual technologies. Directive are covering different technologies depending on the development, construction and decommissioning.

Below we present the main EU directives, where the first set of directives relates to the security of the energy storage and the second set to prevent the use of hazardous substances. Directive 87/404/EGS covers the rules in the construction of simple pressure vessels. Directive 97/23/ES, which describes
the pressure equipment, will in the future replace Directive 87/404/EGS. Both these directives are covering also compressed air storage systems.

For manufacturers of electrical components used in energy storage systems Directive 2006/95/ES is relevant, which applies in relation to electrical equipment designed for use within certain voltage limits. Directive 2004/108/ES describes the electromagnetic compatibility of equipment, which is necessary for the proper functioning of superconducting magnetic storage tanks.

Batteries represent the largest share of electricity storage system in addition to the HPPS, therefore, the Directive 2006/66/ES is specifically designed for batteries. Directive 2006/66/ES describes the batteries and accumulators and waste batteries and accumulators and is repealing Directive 91/157/EGS. The Directive prohibits the use of hazardous substances in the batteries manufacture.

Directives 2002/96/ES and 2000/53/ES, which determine the proper treatment of waste electrical and electronic equipment and the management of end of life EV, require proper handling of batteries as a storage element in EV.

5.2 Benefits of Regional Energy Storage

In Slovenia and all around the world, we can expect next major investment cycle of the development of the power system in near future, i.e. introduction of the SmartGrid concept. According to the Programme for the development of smart grids in Slovenia, the energy storage is one of the six elements of SmartGrids in Slovenia. The main challenges to be faced in the future power system are:

- Further growth in electricity consumption, which is projected to grow for 35 % by 2035;
- Aging production facilities - thermal and nuclear power plants are aging;
- Aging equipment of the transmission and distribution networks - in the US they intend to invest around 150 billion $ in the upcoming years;
- Development of the infrastructure of the power system is dictated by the peak demand - 10 % of production capacity is used less than 400 hours per year;
- Increasing the share of electricity produced from RES, which are unpredictable and can lead to instability and in some cases production curtailments or negative prices.

To cope with the above challenges energy storage systems offer a wide range of benefits for network end users (customers) and society as a whole. Benefits can be divided into five areas:

- energy supply,
- ancillary services,
- infrastructure,
- end-user,
- integration of renewable energy sources.

It is today generally accepted that the high share of RES in final electricity consumption is only possible with the use of economical energy storage technologies. In addition to promoting the integration of RES, energy storage also provides:

- improved efficiency and profitability of production capacities;
- postponed costly upgrades of the transmission and distribution networks;
avoiding unnecessary investments in production capacity needed for peak loads;
balancing of peak loads (see figure below);
added flexibility in the supply;
frequency control;
voltage support;
increased transmission capacity;
improved reliability and quality of power supply.

Figure 28: Peak load shaving concept.
6 Framework for future Storage Systems

6.1 Governance

In the legislation the focus is on energy efficiency and on creating conditions for a competitive and transparent energy market, however new technologies are seldom mentioned as a possible means to achieve these goals. Since the strategic direction of the country is to achieve environmental commitments, the legislation emphasis RES.

The main legislative documents in the Slovenian energy sector are the Energy Act and the Resolution on the National Energy Programme. These documents include all the guidelines for the energy development that were also partly outlined in the EU directives (e.g. 96/92/EC).

- Energy Act

The Energy act is the main act in the energy sector establishing common rules relating to its organization and functioning. It also defines the basic structure of the system operating instructions that shall regulate the operation and the manner of management of transmission and distribution networks for electricity.

- National Energy Programme

The Resolution on the National Energy Programme (NEP) was adopted by the National Assembly in April 2004. The National Energy Programme lays down long-term development goals and strategic guidelines for energy systems and energy supply, investments in public infrastructure, incentives for investment in renewable energy sources and efficient use of energy, the utilisation of economically justified technologies for the extraction of fuels and the generation of energy, and the anticipated extent of investment by private investors in energy-related activities.

TSO

- Decree on the method for implementing public service obligation relating to the activity of transmission system operator in the field of electricity

The Decree [12] lays down the rights and obligations of the provider of the public service of transmission system operator, the organization of the public service, the manner and conditions of providing required services, the rights and obligations of the customers and means of financing.

- Instructions on the systemic operation of electricity transmission network

The Instructions [13] lay down the instructions for the transmission network operation and conditions for electrical energy transmission from producers to customers. Minimum requirements for operation of interconnected networks set by UCTE and ETSO are also enclosed. These Instructions incorporate rules for customer connection to the transmission network and do not directly address distributed generation.

DSO

- Rules on the system operation of electricity distribution network

The Rules [10] stipulate technical and other requirements for safe operation of distribution networks with the aim to provide reliable and quality energy supply. These Rules lay down the rules for systemic
operation of the electricity distribution network, the duties of the distribution network operator, the terms and conditions for customer connection to the distribution network and define ancillary services of the distribution network.

- **Decree on general conditions for the supply and consumption of electricity**

  The Decree [11] determines the requirements and procedures for customer connection to the network. It also stipulates the network operator obligations regarding reliable and quality energy supply. The customer is required to obtain an approval for each individual connection to the network. In the Approval for Connection the customer connection point, the transferred power, the short circuit power at the connection point, etc. are defined. The customer energy facilities and installations must meet the requirements of technical standards and regulations to prevent disturbance of other customers. If the customer disrupts energy supply to other users, the operator can disconnect this customer. The Decree defines protective devices required for small energy sources. In the field of the quality of energy supply the network operator must observe the limits defined in the SIST EN 50160 standard (EN 50160). The maximum number and duration of short and long term interruptions are also defined.

- **Decree on the requirements to be met for obtaining the status of a qualified electricity producer**

  The Decree [14] defines the types of qualified producers and establishes the requirements and procedure to obtain the status of a qualified electricity producer. The status is given to electricity producers that use RES and those who produce electricity in facilities of cogeneration at above-average efficiency.

**Other relevant legislation**


Any producer that produces electricity from RES, or in the process of cogeneration, can apply for a guarantee of origin of electricity. The process of issuing guarantees is still being developed.

The Energy Agency prepared the **Act Regarding the Mode of Determining the Shares of Individual Production Sources and the Mode of Their Presentation** that came into force on 1st January 2006. Suppliers of electricity to end users are obliged to publish (on the electricity bills and in promotional materials) the shares of individual production sources within the whole structure of electricity production. They are also obliged to include at least the URLs of web pages or details of other information sources, where it is possible to obtain information on the influence of the production-source structure on the environment.

**6.2 R&D activities**

Distribution networks must develop in accordance with changes in technology, society, environment, and of course in accordance with the requirements of the market. From the activities in Slovenia, we can see that the development is moving in the right direction. Businesses and institutions in Slovenia are actively involved in several European projects. Slovenia has in comparison with other European countries, notably insufficient number of projects implemented in practice, missing mostly large demonstration projects that would allow testing of new solutions in practice. This is not for lack of ide-
as and solutions, as for now Slovenia successfully follows development trends, but unfortunately, mainly for lack of funds. The fact is that the launch of pilot projects and the development of smart grids in the initial phase requires major investment, more resources needed, and the positive effects are not immediately visible. From studies carried out in Slovenia, we can assume that such systems deliver a number of positive economic effects for all actors in the electricity market. It would also be a major step towards meeting the ever stricter environmental requirements. Some distribution companies can already report certain positive economic results based on the deployment of advanced metering AMI. The effects are therefore positive, but mostly long-term and indirect. Passive scenario, i.e. not investing in SmartGrids, means the risk that we will be unprepared for the new technologies that will sooner or later befall (such as EV). Accordingly, we should invest more resources in national pilot projects, because this can provide the development of new products and technologies and thus increase long-term competitiveness of the domestic industry.

New challenges in energy, fast-growing global markets, energy efficiency and renewables, bring more and more opportunities for penetration of Slovenian companies in the field of energy technologies and services. Global markets for energy-efficient services, products, machines and systems are among the fastest growing. Slovenia is a highly competent; it has superb skills and a competitive, globally oriented industry that is capable of developing technologies in the field of RES as well as new concepts and systems in the field of energy efficiency. A significant opportunity and competence of Slovenia can be seen in the development of comprehensive secondary systems, where the potential for upgrading are great. Faster development and transfer of knowledge can be achieved through greater integration of the European research area in the projects of the European Research Programme [1].

Some of the current R&D projects focused in the field of Smart Grids:

SMARTV2G – Smart Vehicle to Grid Interface
- The main objective targeted by the SMARTV2G Project aims at connecting the electric vehicle to the grid by enabling controlled flow of energy and power through safe, secure, energy efficient and convenient transfer of electricity and data.

ICT 4 EVEU - ICT services for Electric Vehicle Enhancing the User experience,
- is a project born with the aim of deploying an innovative set of ICT services for electric vehicles (EV) in different and complementary pilots across Europe.

The scope of the ICT services is the integration of different management systems operating on the existing EV infrastructures in the cities where the pilots will be run, so that related services are deployed making use of these interconnected infrastructures.

MOBINCITY - Smart Mobility in Smart City
- Main specific objectives are: To develop a system to be installed within the vehicle able to receive information from the surrounding environment, which can have influence in the vehicle performance (traffic information, weather and road conditions and energy grid). To optimize the trip planning and routing of FEV using information from these external sources including alternatives from other transport modes adapted to user’s needs. To define efficient and optimum charging strategies (including routing) adapted to user and FEV
needs and grid conditions. To implement additional energy saving methods (as driving modes and In-Car Energy Management Services) within the FEV interaction with the driver.

**KIBERnet** - Development of prototype system for industrial load management in electricity distributed network

- The aim of the KIBERnet project is to develop a high-technology product to control the loads and distributed power generation, as well as to optimise the management and operation of electricity distributors, based on which the electricity distribution companies will introduce a new service to industrial customers/producers of electricity.

**CC-SURE** - Advanced Systems of Efficient Use of Electrical Energy

**ELIH Med** - Energy Efficiency in Low-income Housing in the Mediterranean

- The mission of ELIH-Med is to identify innovative technical solutions and financing mechanisms to improve energy efficiency in low-income housing in the Mediterranean area. Moreover, demonstration projects will be implemented to verify these innovative findings. As a strategy project, additionally, ELIH-Med shall put its efforts to develop and get a political consensus on a transnational operational program on energy efficiency in low-income buildings, as a component of a macro regional strategy in the Mediterranean area.

**GreenITNet** - Green IT Network Europe

- Governmental, scientific, industrial and many other institutions seek to reduce the energy consumption of ICT. This is also the basic goal of this project. A systematic policy framework for “Green IT” and collected number of good practices and effective policies will be developed as a result in this project.

**HiperDNO** - High Performance Distributed Network Operation.

### 6.3 Stakeholders

Overview of the relevant institutions:

- **The Ministry of the Economy**

  Has overall responsibility for energy policy in Slovenia through its Directorate for Energy headed by the State Secretary for Energy. It is particularly responsible for the preparation of the national energy strategy as well as for programmes to promote the efficient use of energy. Furthermore it is responsible for energy tariffs, legislation and exploitation licenses.

- **The Ministry of Finance**

  Has the ownership rights of state enterprises.

- **Eles** (Elektro-Slovenija),

  The Transmission System Operator (TSO) in Slovenia, is the public utility for transmission network management and is 100% state owned. Ownership control is exercised by the Ministry of the Econo-
my (Directorate for Energy). As a national operator its primary responsibility is to reliably operate the Slovenian electric power system and to offer quality electricity supply to consumers.

- **Individual distribution companies**

  The distribution companies supply all users except for five large industrial consumers supplied directly by ELES. In line with the Decree on the method for the implementation of public service obligation relating to the electricity distribution system operator, and public service obligation relating to the electricity supply to tariff customers, the operation of DSO's is organized in two public services: the activity of the system operator, and the activity of supply of the tariff customers (both have separate accounts). In addition to these public services the DSO's also carry on market-based activities (supply of electricity to eligible customers) and service activities that also have separate accounts. Electricity production is carried out in legally separated subsidiary companies [9].

- **Borzen**

  The Slovenian Power Market Operator is responsible for running the electricity exchange, clearing and settlement of transactions concluded on the organised market, maintaining records of bilateral contracts, drawing up schedules, accounting deviations, and publishing market movements. Borzen, which was previously owned by ELES, passed into direct ownership of the Government of Slovenia in December 2007.

  The Centre for RES/CHP support, incorporated in Borzen, is the support scheme operator for the generation of energy from renewable energy sources and highly efficient cogeneration of heat and power. In addition, in December 2009, the responsibilities for raising and managing the funds for electricity efficiency programs were incorporated within Borzen.

- **Energy Agency**

  The Energy Agency regulates the distribution companies, for their provision of the public service of the DSO, and the transmission company, or its provision of the public service of the TSO. The costs of providing the public services of TSO and DSO's are covered from the revenues from the network charge.

  The connection of electricity production facilities to the distribution network is defined by the Rules on the system operation of the electricity distribution network [10] and the Decree on general conditions for the supply and consumption of electricity [11]. Additional rules for connection and operation of power stations with an installed power of less than 10 MW are set by the DSO. The Licence for Operating Energy-Related Activities must be obtained from the Energy Agency.


- **The Environmental Agency**

  Performs expert, analytical, regulatory and administrative tasks related to the environment at the national level. Thus the Agency`s mission is to monitor, analyse and forecast phenomena and processes in the environment, and to reduce natural threats to people and poverty.
7 Master Plan

In the development of electric power system, Slovenia must achieve ambitious targets that will increase the reliability of energy supply, reduce impact on the environment, and provide economic growth and the development of jobs and employment. The most important is successful transition to renewable energy sources, where hydro-energy dominates in Slovenia, while in recent years development has been most dynamic in the area of solar energy and biogas. The potentials of these energy sources and the potentials of biomass, wind and geothermal energy, will contribute to increased consumption of energy from renewable sources.

According to [34], the strategy of increased use of renewable energy sources in the Gorenjska region should pursue the following objectives:

- Striving for 33 % of heat from RES by 2020;
- 12 % of DG from RES by 2020;
- Provide 20 % of RES in district heating systems by 2020;
- At least one 100 % renewable municipality by 2020.

These objectives will require integration of energy storage technologies; however the Programme for the development of SmartGrids in Slovenia estimates that today energy storage systems are not yet ready to be used at the level of the distribution network. First step, which should not be delayed, is certainly implementation of pilot projects, to gain experience and implementation practice for storage technologies.

7.1 Objectives

7.1.1 Current Status

Over the very short-term Slovenia does not expect increased demand for storage systems. Currently, the driving force for the introduction of the energy storage is increasing share of renewables in final energy consumption. Slovenia has a commitment to increase this share to 25 % by 2020, which is not yet a critical level. Due to the relatively low price of electricity for residential customers, also battery systems to increase the self-sufficiency do not pay-off.

The Programme for the development of SmartGrids in Slovenia estimates that today energy storage systems are not yet ready for mass use at the level of the distribution network. Storage technologies are not yet economically viable, and some additional progress is also needed on the sociological and regulatory areas. Status of this technology in Slovenia is represented in the table below.

Table 11: Overview of the four main areas of SmartGrids in Slovenia [1].

<table>
<thead>
<tr>
<th>Technology</th>
<th>Sociology</th>
<th>Economy</th>
<th>Regulation</th>
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</thead>
<tbody>
<tr>
<td>Electricity storage technology</td>
<td>Early phase of development</td>
<td>Not ready</td>
<td>Not ready</td>
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The program envisages that by 2020, pilot testing of systems for self-sufficient operation with RES will be carried out. For this purpose, various battery systems are the most suitable, especially flow-batteries, which are, despite different expectations from a few years ago, still quite expensive.

The HPPS Kozjak construction started in 2011 and will be finished by 2016.

7.1.2 Goals

According to [1], Slovenia plans to invest 320 million euros by 2020 in development of SmartGrids, which includes both research as well as implementation. However, more than 90% of these funds will be spent for the implementation projects. The program does not anticipate large integration of storage technologies in the network, only some research and pilot testing will be performed, so by 2020 we do not expect major investments in this technology (according to [1], probably <1% of the budget).

Increased investment will certainly be needed in the next ten years. One should be aware of the fact that after 2020 the EU will require setting higher targets for the share of renewable energy sources and efficient use of energy, which can only be achieved with the progressive introduction of energy storage technologies. By increasing the share of renewables (and a higher price of electricity in Slovenia), some technologies will very soon become interesting for the market, which is in certain segments already happening in the countries of northern Europe.

Main objectives in the area of energy storage that Gorenjska can start introducing immediately can be summarized as follows:

- Small sized energy storages in home energy-systems together with PV systems can be a good solution for remote areas, where there are frequent interruptions in supply of energy;
- Attract attention of general public and improve the acceptance of energy storages through promotion;
- Discuss potentials for large-scale storage options in the region and present them to possible investors;
- Promote storage R&D and pilot projects;
- Keep an eye on the development in the field of storages;

7.2 Regional Storage Park

Below only a short summary of individual storage potentials in Gorenjska region is given. Today, storage systems are still at the research or pilot level and one cannot be certain that broader commercialization of this technology will happen soon. Therefore there are only common recommendations in this chapter how to act in the next few years and the aspects which should be taken into account for decision making.

There is a big potential for HPPS in this area, especially for small units, since larger units have big impact on the environment and also good location for big reservoirs it is not so easy to find. Acceptability of these plants in the general public can also be quite a challenge, thus a lot of effort invested in promoting this technology is required.

In the last few years, many PV systems have been installed and at some places, distribution companies are already facing technical problems, caused by the operation of these systems. To avoid these problems in the future, it will be essential to install stationary batteries at the location of large PV sys-
tems. In this way, also costly grid extension could be avoided by charging the batteries at the times of peak production.

It is expected that electric vehicles will play a very important role in the power system in near future. This fleet of EV can act as a storage system and support to some extend the grid.

The exact amount of the different storage types is not known at the moment and depends on many different factors. Bellow one example of a pilot project is given, to illustrate that the technology is available and that there is no excuse to postpone the implementation of pilot projects and R&D activities.

- **Pilot project example: Storage for remote areas**

There are many (electrically) remote areas in the Gorenjska region (small villages, farms, tourism infrastructure…) and many of them are supplied by a long distribution line that is subjected to environmental and other external influences. Thus, power outages in such remote areas are quite common.

The aim of the pilot project is to show the benefits of energy storage system operating with renewable energy sources in remote areas of the Alpine region. The project will demonstrate the feasibility and effectiveness of such system, from where guidelines for future implementations can be derived.

**Objectives:**

- Demonstrate PV system with REDOX flow batteries to enable off-grid operation of the public building;
- Demonstrate load balancing and voltage profile support;
- Demonstrate how to increase the penetration levels of RES into the distribution networks by using energy storage systems;
- Define and quantify performance requirements, operating practices and cost/benefits levels associated with the system;
- Display the benefits of using RES-battery systems to general public and future users;
- Promotion of renewable energy sources.
7.3 Storage Roadmap

7.3.1 Measures and Projects

Below recommendations and possible actions are given that can be implemented in short-term [34].

- Substituting electricity for hot water production with RES.
- Accelerated construction, expansion and renovation of district heating systems using RES, waste heat from industrial processes and cogeneration of electricity and heat with high efficiency.
- Support the introduction of EV.
- The development of distribution networks for the integration of DG of electricity, including the development of SmartGrids.
- Promotion of RES and other green technologies aimed at reducing energy consumption.
- The development of local biomass supply chains and logistics centres for biomass.
- Replacing oil with RES.
- Upgrade existing biogas plants with CHP and increase gas and heat storage capacities, which will enable operation in flexible mode and selling electricity on the spot and balancing energy market.
- Installation of various RES that will generate also need for storage technologies. Generally RES in final consumption has not reached critical levels that would require large grid reinforcements and upgrades.
- Energy utilities should invest in RES, since ownership will allow them to have more control over future decentralized generation capacities.
• Investments in pilot storage facilities to manage local grid bottlenecks and to gain experience with different storage technologies.
• Set up regional support programs for storage technology, e.g. for battery stores in PV plants. According to [1], the required projects in the area of storage systems in Slovenia are given in table below.

Table 12: An overview of the required projects in the field of energy storage.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Project type</th>
<th>Anticipated results</th>
<th>Deadline</th>
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| Storage significantly affects the operation of power system. They can compensate for variability in RV and collaborate with ancillary services | Analysis of the impact of large-scale storage systems on the operation of power system | Research | • Opportunities and the role of the energy storage in the provision of ancillary services  
• Possibilities of compensating the variability of RV with energy storage  
• Possibilities of consumption modification, including DG  
• Impact of storage on the reliability of electricity supply | 2014 |
| Storage significantly affects the operation of power system. They can compensate for variability in RV and collaborate with ancillary services | Practical test of the impact of the energy storage on the power system operation | Demonstration | • Opportunities and the role of the energy storage in the provision of ancillary services  
• Possibilities of compensating the variability of RV with energy storage  
• Possibilities of consumption modification, including DG  
• Impact of storage on the reliability of electricity supply | 2015 – 2017 |
| Customers, including households, could become self-sufficient by installing a combination of PV and storage | Ensure self-sufficiency with the help of PV and energy storage | Research | • The actual customization options off the energy storage and PV  
• Starting points for creating incentives for customers that are self-sufficient | 2018 |

7.3.2 Timelines, milestones and Controlling
Many of the energy storage systems include new technologies that are still very expensive and thus operation of storage systems is not economical. A huge development in this area is expected in the next years, and in order to be prepared, the installation of pilot projects should start as soon as possible. According to the PDSG, the following pilot actions are expected by the year 2020, however at the region level, many more should be implemented.

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<td>Analysis of the impact of storage systems on the operation of power system - pilot</td>
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<td>Off-grid operation of consumers using PV and storage - research</td>
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Figure 30: Timeline of activities in the area of storage technologies according to the PDSG.
8 Sources and literature

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