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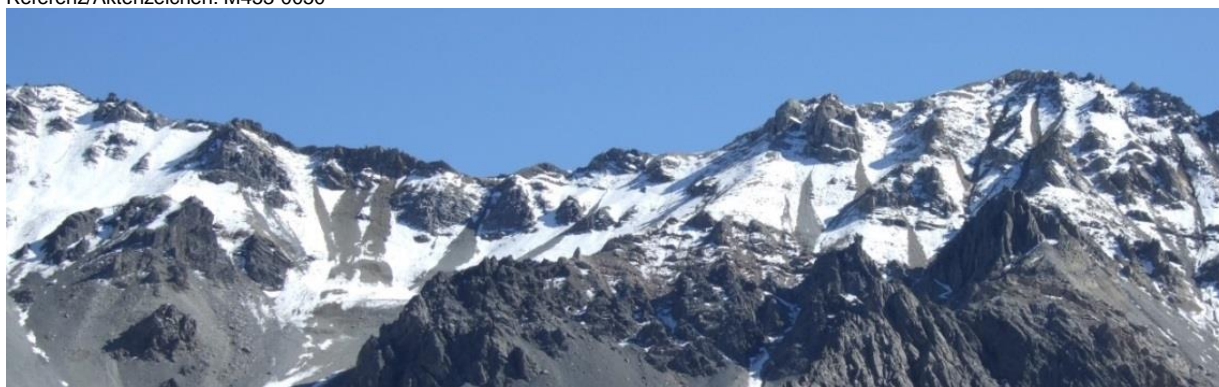
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Background report of the Alpine Convention Energy Platform

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Executive Summary

The Alpine Convention is an international treaty between the alpine countries (Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland) as well as the EU, aimed at promoting sustainable development in the alpine area and at protecting the interests of the people living within it.

Being conscious of the importance of the energy topic for the Alps, the XII. Alpine Conference in 2012 established the Energy Platform and entrusted Switzerland with its presidency for the years 2013 and 2014. According to its mandate, the Energy Platform focuses on the alpine context of the following energy topics: first, energy usage, second, energy production and third, the energy system. For in-depth discussions of each of these three topics, meetings and workshops of experts, NGOs and representatives of the member countries of the Alpine Convention took place from 2013 to 2014.

In the field of **energy usage**, the main focus was put on the building and housing sector, with its consumption being a main driver of the total energy consumption of a community. At the same time buildings offer an important potential for improvements. Three basic strategies to improve the sustainability of the alpine building stock were analyzed: reducing energy consumption, improving energy efficiency and substituting fossils by renewable energy sources. Already today, all governing bodies of the alpine countries have put into force a series of regulations that aim at reducing energy consumption. However, most regulations are not specifically targeted for the Alps. Different countries and regions in the alpine area have further implemented building renovation programs or put in place incentives (e.g. in spatial planning) in order to promote investments in energy efficiency measures and increase the renovation rate. The discussions that took place in the framework of the Energy Platform suggested that **«alpine-specific» energy awards** might be a good approach to motivate people and organizations to support energy efficient buildings and to improve the visibility of lighthouse projects. Further, **networking and exchange of experience** were assumed to be important factors for innovation and a successful implementation of measures/actions towards an energy efficient and sustainable alpine region. Since the alpine regions are particularly sensitive to impacts of climate change, their interest in changing energy consumption patterns must be substantial. Moreover, the alpine regions are rich in resources and knowhow that could play a **pioneering and innovative role** on the way to more sustainable energy systems. Against this background, there was a controversial discussion whether the alpine region and its citizens should aim at reaching set targets (at EU or national levels) earlier than planned or even set more **ambitious alpine-specific targets** to foster the reduction of energy consumption.

The alpine area provides a substantial potential for renewable **energy production**. The alpine area is, however, also a unique natural and cultural area and the production of renewable energy is often in conflict with environmental protection and social considerations. Therefore, the different renewable energy technologies were discussed with special emphasis on their spatial requirements and possible conflicts with other land uses in the Alps. It became clear that **common guidelines and relevant criteria** can help to better handle conflicts and to enhance

social acceptance. **Regional concepts for land use and protection** in the context of renewable energies were discussed and could be an important key for dealing with trade-offs between land use and protection. Treating existing infrastructures as well as **landscapes and technologies with low conflict potential as first priority** was defined as one of the leading principles for renewable energy production in the alpine context. From an economic perspective, it became clear that the alpine regions could benefit from positioning themselves with their characteristic strengths on the energy market. The renewable energy production potential and especially the large regulative capacities of hydropower plants might become even more valuable on the European energy market of the future. Finally, there was an agreement about the fact that thinking shouldn't be limited by regional or national borders when solutions for the sustainable use of renewable resources in the Alps are developed. Hence, the establishment of **common «energy visions»** for the whole alpine area on the issues discussed was suggested as a task for the community of the alpine countries. Such a process could also foster the exchange of knowledge and experiences between the various regions and **give useful impulses to the rest of Europe** as well.

Regarding the development of **the energy systems** in the alpine regions two parallel trends were identified: First, the trend towards a **regionalization of the energy system** and second, the trend towards a **stronger transnational integration of the energy distribution**. The regionalization describes an energy system with rather small-scale renewable energy production from local sources. Especially the technology of district heating and the development of «smart» technologies could help to better balance the energy system regionally. From a transnational perspective many of the challenges in the alpine countries are similar and interconnected and **call for a coordinated approach of the alpine regions** to be solved. Currently, two aspects are particularly in the focus of the debate. First, the **development of the electricity grid** in order to meet the requirements of a more renewable energy landscape and second, the energy storage capacity, especially of **pumped storage hydropower**, which could play an important role in balancing the less regular electricity production in the future. However, it became very clear that the build-up of new storage and transmission capacities will have substantial impacts on the alpine regions and its citizens. Approaches discussed to better deal with these challenges include a smarter regulation of consumption and production (e.g. through smart grids) and a better geographical distribution and interconnection of energy production and consumption. For alpine communities, energy projects can create significant benefits but also generate major losses in ecosystem diversity and touristic value of a region. The claim for the Alps being the «battery of Europe» was critically reflected upon. It might be in the very interest of the alpine countries and regions and their population to **define a strong common position, taking into account economic, social and environmental sustainability**, and speak up for «fair and sustainable» conditions for alpine (pumped) hydropower and transnational transmission lines in the new European energy landscape.

The Energy Platform's work regarding the analysis of the three topics energy usage, production and energy systems in their alpine context is documented in this background report. It builds a strong basis for the synthesis and the final conclusions which are subject of discussion at the fourth core group meeting. Ultimately, all insights will lead to a suggestion of principles for the attention of the forthcoming XIII. Alpine Convention.

1 Introduction

The Alpine Convention is an international treaty between the alpine countries (Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland) as well as the EU, aimed at promoting sustainable development in the alpine area and at protecting the interests of the people living within it. It embraces the environmental, social, economic and cultural dimensions¹. Specific measures implementing the principles laid down in the framework Convention are contained in the protocols to the Alpine Convention. The Energy Protocol defines the objectives of the member countries as well as specific measures in the field of energy². Accordingly, the contracting parties shall commit themselves to creating framework conditions and adopting measures for energy saving, production, transport, distribution and utilization in order to establish sustainable development in the energy sector, compatible with the alpine region's specific tolerance limits.

Being conscious of the importance of the energy topic for the Alps, the XII. Alpine Conference in 2012 established the Energy Platform and entrusted Switzerland with its presidency for the years 2013 and 2014. The energy platform's activities are organized in workshops and core group meetings and will lead to a final report, presented at the XIII. Alpine Conference in 2014.

Workshops on energy usage, energy production and energy systems took place in the meeting calendar of the platform presidency in order to concretize the discussion. As a basis for the discussions and to prepare the participants, an input paper was written for each workshop. Both these input papers and the results of the three workshops are documented in this background report.

To support the discussions at the workshops, it was important to provide at least some information on country specific data regarding energy systems, energy usage and energy production in the input papers. However, the research work revealed important tradeoffs between availability, comparability and timelines of the data. As giving a broad overview was set as a priority for this report, in some cases not the most recent data could be used, especially in the case of overview-tables.

1 <http://www.alpconv.org/>

2 The Energy Protocol of the Alpine Convention has been ratified and entered into force by all member countries except Switzerland and Monaco.

2 Energy usage

The first part of the chapter on energy usage (chapters 2.1 and 2.2) addresses aspects of energy usage in the alpine region as well as the findings and conclusions of the first workshop. The second part (chapter 2.3) presents the current energy demand, possible future developments as well as an overview of the energy policies for each member country of the Alpine Convention participating in the process of the Energy Platform (Austria, France, Germany, Italy, Liechtenstein, Slovenia, and Switzerland).

2.1 Aspects of energy usage in the alpine region

In the following paragraphs some fundamental considerations about energy usage in the alpine region are presented. Characteristics of alpine communities and their importance for energy demand and supply are addressed. The second chapter focuses on the residential sector, as residential energy consumption is a main driver of total energy consumption. Buildings offer an important potential concerning the improvement of energy efficiency.

The current situation concerning energy consumption, as well as an overview of specific energy strategies for the member countries of the Alpine Convention participating in the Energy Platform is presented in chapter 2.3. Furthermore, future scenarios regarding energy consumption are described in chapter 2.3.8.

2.1.1 Alpine peculiarities

To begin with, it has to be stressed that the alpine region is very heterogeneous. Various big cities (e.g. Grenoble, Innsbruck, Lucerne, Salzburg, Trento or Maribor) lie within the Alpine Convention perimeter. In the larger valleys the population density is similar to the non-alpine regions of Europe (s. figure below) and almost any type of industry or service sector from heavy industry to high-tech can be found. The energy consumption patterns in the main valleys are therefore expected to be similar to non-alpine regions of Europe.

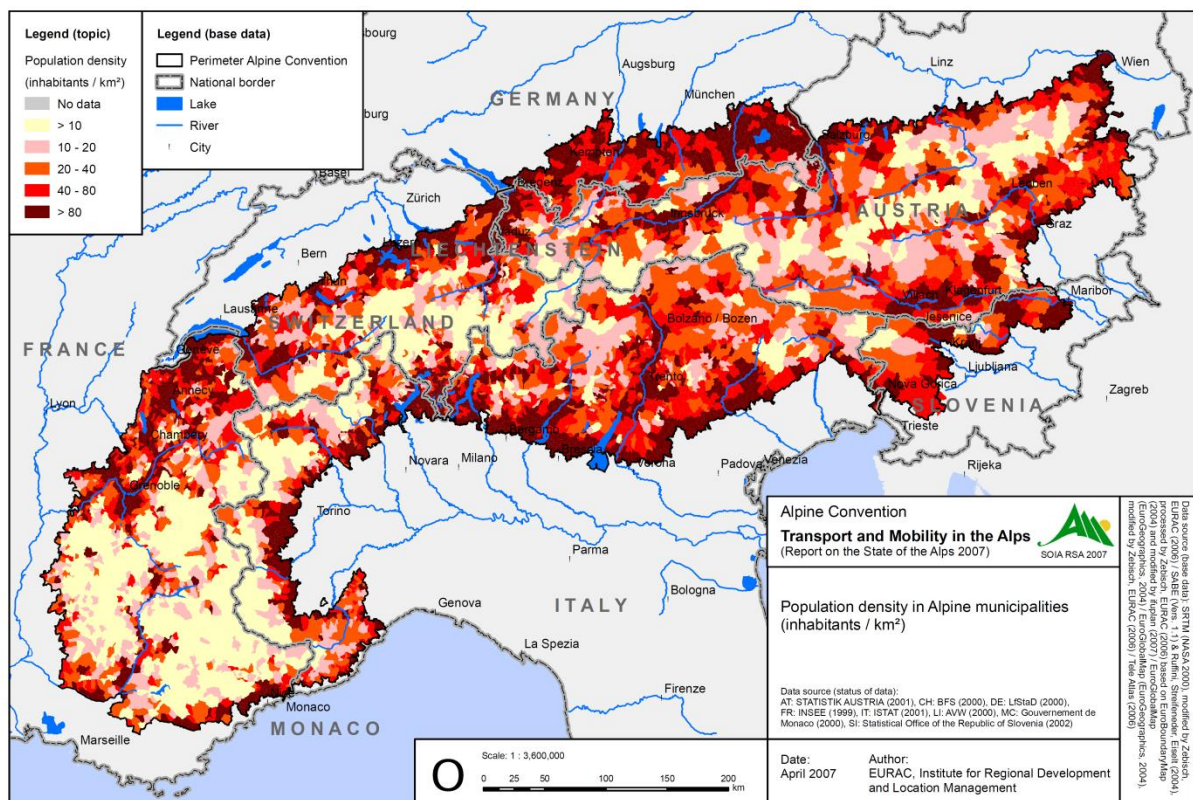


Figure 1 Population density (inhabitants/km²) within the perimeter of the Alpine Convention in 2007 (data and figure: Alpine Convention, Report on the State of the Alps 2007)

Outside the larger valleys, the main drivers for energy consumption are *buildings* (especially due to harsher climate conditions, smaller or scattered building units and an often older building stock compared to non-alpine regions), *local traffic* (due to the remoteness, the percentage of individual motor car traffic is higher and travel distances are longer) and in some specific areas *tourism* (visitor traffic, hotels, wellness and spa facilities, snowmaking installations and mechanical transport, etc.). Furthermore, *transit traffic* plays an important role in the alpine region, also with regard to energy consumption. However, the consumption hubs causing transit traffic lie mainly outside of the alpine region.

Different sources (e.g. CIPRA 2009b) state that the energy consumption per capita is roughly 10% higher in the Alps compared to the European average. However, these figures could not be verified with official statistics on energy consumption as there is no comprehensive regional data on energy consumption available. Some authors provide approximations to alpine energy consumption. However, these figures are in fact just extrapolations based on the countries' energy demand per capita and the respective alpine population. Therefore, it is not appropriate to draw conclusions on alpine specific patterns of energy demand from these approximations.

2.1.2 Buildings in the alpine region

Improvements in the building sector present an important and large potential for energy savings throughout the entire alpine region. As described in chapter 2.3 of this report, residential energy consumption is a main driver of overall energy consumption in the alpine countries. Measures in the field of residential energy consumption have a long-term impact on the overall energy consumption due to the long lifespan and the low renewal rate of buildings. Due to these facts, the

core group of the Energy Platform decided in its first meeting to make the energy consumption of buildings the main focal point of the first workshop.

Three basic strategies should be considered in order to improve the sustainability of the alpine building stock: reducing energy consumption, improving energy efficiency and substituting fossils with renewable energy sources. These three main courses of action will be discussed in the following reflections.

In order to move toward highly energy efficient buildings it is important to take into account all aspects of a building's lifecycle. Reducing the energy consumption for heating and operation of a building drastically increases the relative importance of the embodied energy (sum of all the energy used to produce the materials and to build the structure). Less heat energy loss means more insulation material and often more technical equipment which also needs energy to be produced and operated. Smart building concepts and selection of building materials therefore greatly matter in reducing the overall energy consumption including the embodied energy (often called grey energy). The long tradition in the alpine region of using (local) wood as a building and heating material, in combination with modern manufacturing and building technologies, offers great opportunities for sustainable buildings.

When looking at the energy consumption of buildings in the alpine region, not only the quantity but also the quality of the energy consumed is of importance. In other words, it should be questioned which types of energy supply systems are suitable for specific alpine regions in order to provide energy from renewable, and possibly local, sources or from available waste heat. Therefore, reducing the energy demand of buildings (insulation and building standards) and substituting fossil resources (district or local heating, heat pumps, photovoltaics, solar heat) should both be addressed (see chapter on energy production).

However, not only the energy efficiency of buildings and the type of energy supply system should be addressed when aiming at reducing energy consumption, but also the aspect of sufficiency is of importance. The average requirement of living space per person has increased in the past, and especially in alpine regions secondary residences account for a substantial share of the building stock. Spatial planning in alpine regions should address these factors.

For the analysis and in order to assess adequate measures and systems it seems to be important to distinguish between the main alpine valleys with larger cities and the regions outside the main valleys (smaller, remote communities).

Reducing the energy consumption of buildings

According to different sources, a substantial percentage of the alpine building stock is in need of renovation. Even if there is no such thing as a typical «alpine building», it is assumed that the building stock is generally older in alpine regions. Apart from general barriers to building renovation, some additional barriers might exist in the alpine regions. Many buildings in the alpine regions, particularly in remote areas, have a cultural value or are listed on heritage protection lists, making their renovation technically and legally difficult. Additionally, the higher percentage of secondary residences and strict local building regulations (e.g. concerning materials, building geometry and window surface) can have a negative effect on renovation measures. In the light of such obstacles, the role of public administrations in creating outstanding examples of sustainable construction by flagship projects is crucial.

Beside national and international initiatives to encourage energy-optimized retrofit of existing structures and the construction of energy efficient buildings, there are various programs focusing on fostering sustainable construction and renovation, especially in the alpine regions. The «AlpHouse» project on alpine building culture and ecology³ aims at understanding the principles of traditional alpine architecture and integrating them in present-day construction. Renovations performed according to its quality criteria are oriented towards the preservation and development of the cultural heritage of the alpine area as well as the optimization of energy efficiency and overall lifecycle costs of buildings and settlements. The AlpHouse project explores and collects knowledge and skills in various regions and passes them on to craftsmen, architects, planners, and decision makers. The funding period of AlpHouse ended in December 2012. The project «AlpBC»⁴ continues the work of AlpHouse, carrying on its activities. The central elements of AlpBC are:

- the implementation of inter-municipal planning concepts,
- the stimulation of regional closed loop economies in the building sector,
- the implementation of a network of regional centers and contact points for the transfer of knowledge and technologies on building renovation to SMEs, decision makers and administration, and
- the implementation of participative governance processes and consultancy instruments for policy makers and regional authorities.

In line with these goals and approaches is the «ENERBUILD» project⁵ from the European Union's «Alpine Space Program». Its key topics are (1) providing the latest technical know-how for craftsmen and architects, (2) developing tools for public builders which act as decision guidance and (3) providing customers with innovative financing tools concerning the energy production of buildings.

There is also a range of non-governmental programs that encourage the reduction of buildings' energy consumption in the alpine regions. For instance, the project «MountEE» supports municipalities in European mountain regions to build and renovate their public buildings in a sustainable way by involving relevant players, such as politicians, administrative staff and local companies. «MountEE» helps them to use existing knowledge to develop regional strategies, financial tools and support for building projects. The program has already been implemented in Vorarlberg (Austria), and two alpine regions will follow soon: Rhône-Alpes (France) and Friuli-Venezia Giulia (Italy). «MountEE» will help municipalities in the alpine regions to achieve the goal of Nearly Zero Energy Building (NZEB) set by the Energy Performance of Buildings Directive of the European Union (EPBD). Another example is CIPRA's «climalp» program, an information campaign supporting energy efficient construction and renovation of buildings with regional wood in the alpine area. One of the goals of this program is also to show that these principles have a positive effect on the regional economy as well. All those initiatives help addressing issues particularly important in mountain regions, such as extreme climate, low accessibility, low population density, small entities and a lack of critical mass.

Existing and new building standards could play an important role in reducing building energy consumption in the alpine regions as well. Different standards and labels already exist; however,

³ <http://www.alphouse.eu/>

⁴ <http://www.alpbc.eu/>

⁵ <http://www.enerbuild.eu/>

they vary quite considerably from country to country. Examples of such labels and standards are: «Niedrigenergiehaus»⁶ (low energy house), «Plusenergiehaus»⁷ (plus energy house), «Passivhaus»⁸ (passive house), «Minergie» and «Minergie-ECO»⁹, «Energiesstadt Gebäudestandard»¹⁰, «KlimaHaus/CasaClima»¹¹. Even if some of these labels and standards take into account alpine particularities, an alpine-wide standard for energy efficient buildings does not exist.

Last but not least it should be noted that reducing energy consumption and switching to renewable energy sources is best addressed with comprehensive initiatives that take on board as many stakeholders as possible. An example of such initiatives is the European Energy Award and its national implementations (Energiesstadt in Switzerland, e5 in Austria, or cit'ergie in France). The architecture award «Constructive Alps», with its second edition in 2013, can be added as a further, alpine-specific example of an initiative promoting sustainable construction. Such initiatives pave the way towards an «alpine model area for sustainable architecture».

Usage of renewable energy and waste heat

Focusing on the energy supply of single buildings, fossil resources can for instance be replaced by heat pumps, solar heating systems or firewood. For remote alpine communities, all three options could provide the advantage of an increased autonomy and local value generation. However, the suitability depends very much on the region. Air source heat pumps lose their efficiency if the outdoor temperature is too low. Therefore, in alpine regions of higher altitude with a larger number of cold days per year, ground source heat pumps might be the better option. Solar heat and photovoltaics are well suitable in alpine regions because radiation and sunshine duration are generally higher at higher altitudes, especially in wintertime. However, not only altitude but also the orientation and steepness of a valley are factors. Some valleys receive very little direct sunlight in winter. Another issue can be snow and ice on solar panels, preventing the operation of the installation even if radiation is high. If installed on a tilted roof, snow is likely to slide down by itself. In order to clear panels from snow on a flat roof, several different devices are available.

⁶ The low-energy house is defined by its heating energy consumption. The standard can be achieved both for new and refurbished buildings. Nowadays in many alpine countries the low-energy house is regarded as a minimal efficiency standard for new buildings. The technical definition, however, varies between the countries (e.g., in Germany 40-70 kWh/m²/y, in South Tyrol less than 50 kWh/m²/y).

⁷ Over the whole year, the plus-energy house produces more energy than it needs. The energy is produced for instance by using solar power and photovoltaics.

⁸ The passive-house uses mainly passive energy sources such as solar irradiation, waste heat from persons and technical devices to cover its heating need. This is possible due to a very energy efficient construction concept, reducing the heating need below 15 kWh/m²/y.

⁹ The «Minergie» label is a Swiss sustainability brand for new and refurbished buildings. «Minergie» uses the specific energy consumption as the main indicator and is therefore an objective-oriented approach. Builders and planners are, to a certain extent, free in how to reach the values needed for the label. Additional labels exist, such as «Minergie P» (buildings with low energy consumption) and «Minergie A» (zero-energy buildings). The add-on «ECO» extends the «Minergie» label with health and environmental standards.

¹⁰ The building standard of the Swiss «Energiesstadt» label is a meta standard for municipalities based on the Minergie labels and wants to promote measures in the field of energy efficiency and the use of renewable energy sources. The standard defines a wide range of criteria in the following areas: new buildings, refurbished buildings, efficient use of electricity, renewable energy for heating, health and environment, submissions and building management.

¹¹ The «KlimaHaus/CasaClima» is an Italian certification system for energy efficient and sustainable buildings. «KlimaHaus/CasaClima»-buildings are characterised by high insulation, compact construction and the use of solar energy.

If local wood resources are available, replacing fossil fuel with firewood might be an option. The use of advanced filter technologies can reduce problems deriving from small particles of wood-fired heating systems, especially for the use on a large scale, such as municipal heating systems.

Concerning district heating, it can be assumed that for the main valleys there is no big difference compared to the lowlands, since the density of buildings is similarly high and using waste heat from incineration plants, sewerage treatment plants, industry, computing centres, etc. can be an option. For smaller and more remote communities, the suitability and economic effectiveness of district heating depends very much on the local characteristics. If there are enough key consumers such as hotels, schools or hospitals, which usually is the case in tourist areas, district heating can be an adequate option even in remote areas. In many alpine regions fuel-wood can be supplied regionally and used to fire district or local heating plants. In many cases the energy efficiency and the environmental impact of a big centralized heating plant is better than the one of small-scale wood-fired installations. Examples show that the operation of district heating systems is possible in alpine regions as well: Since 2009, one of the biggest woodchip heating systems of Switzerland has been operational in a touristic region of the Alps (Saanen-Gstaad), supplied mainly from local wood resources. It produces a maximum of 28 GWh of heat energy per year, half of which is used by key consumers such as hotels and public buildings. As a side effect of this installation, the CO₂-output was reduced by 8'000 tons per year.

Another interesting example of an alpine peculiarity in the field of residential energy use is electric heating. A few decades ago, due to the large capacity of hydropower (including pump-storage) and of large power plants (e.g. nuclear) in perialpine areas producing surplus energy at times, electric heating was seen as an environmentally friendly and CO₂-free system for residential buildings. Hence, especially in the alpine regions, direct electric heating was promoted heavily and is still quite common. Today, however, the use of this heating system is questioned, since e.g. heat pumps provide a much more efficient heating solution, using roughly only one quarter of the electric energy. In a research project conducted by the Swiss Energy efficiency Agency it could be shown that the efficiency and substitution potential concerning electric heating is substantial, as today 6-12% of the Swiss energy consumption comes from electric heating systems. Especially in the alpine regions the electricity saving potential is high, since a lot of buildings are used for holiday purposes only. Heating these buildings throughout the whole year to ensure a minimal temperature consumes (and wastes) a lot of energy. A possible solution to avoid such inefficient energy consumption could in some cases be provided by remote control systems, which allow operating the heating only if temperatures reach a minimum level in order to prevent damages to the building from the cold. Further, the heating can be turned on in time before a holiday visit, ensuring comfort without wasting energy when not needed.

2.2 Workshop on energy usage

On August 30th, 2013, the first workshop of the Energy Platform took place in Bern (Switzerland). Delegations and experts from all participating countries of the Energy Platform were present and shared their knowledge, experience and expectations concerning measures to reduce energy consumption in the alpine regions. The objectives of the workshop on energy usage had been defined as follows:

- To promote the exchange of policymakers in the field of energy usage.
- To find solutions to reduce energy consumption that fit the Alps, especially in the area of buildings.
- To provide a fundament for the report on behalf of the XIII. Alpine Conference.

Two input sessions on «national policies in the field of buildings and housing» and «regional policies and case-studies in the field of buildings and housing» were framed by an introductory keynote on energy usage in the Alps and a final panel discussion.

In his «Flashlight on energy usage», M. Hänggi, a Swiss journalist active in the thematic fields of climate change and energy, set the scene for the workshop. With the help of examples from countries of the South and examples of «old» alpine structures, he pointed out that energy saving architecture has to take into account endemic materials and necessities – and is not just a question of money. He tried to give some general hints about so-called «vernacular architecture» by showing the success of round designs that take into account the advantageous proportion of surface to volume in terms of heating and cooling. He stressed the need of sufficiency to tackle the important issue of climate change and pointed out that a more sufficient lifestyle could also be achieved in a liberal society.

In the following sections the inputs and learnings of the workshop on energy usage are summarized. The summary only includes the measures and examples presented and discussed at the workshop (see Table 1). The sections are structured as follows:

- Possible public regulations and incentives
- Examples from the alpine region
- Participation and social acceptance
- Results of the panel discussion

Country/Organization	Presentation title
Germany	Focus of German national energy policy on energy consumption reduction
Liechtenstein	Cost-efficient strategies to implement the EU 20-20-20 targets in the Alps focusing on heating systems
Switzerland	The Swiss Federal Building Program: tackling the building stock with the cantons
Slovenia	Energy efficient spatial planning – promoting links between building and spatial planning policies
Italy	White certificates in the national energy policy and their benefits in terms of energy usage
Club Arc Alpin	Energy efficiency for alpine huts: developing a decision matrix to assess energy efficiency measures in huts
Autonomous Province of Bolzano (South Tyrol)	Incentive scheme from South Tyrol concentrating on the house owner: Transposition of a EU directive
Solčava, Slovenia	The Rinka center – an example of knowledge transfer in the field of sustainable construction
Region of Vorarlberg	Towards energy neutral Vorarlberg

Table 1 Overview of the presentations held at the Energy Platform Workshop 1.

2.2.1 Public regulations and incentives

Regulations

All governing bodies of the alpine countries have put into force a series of regulations that aim at reducing energy consumption to meet energy consumption targets on the international and national level (see chapter 2.3). Some of those efforts were presented at the workshop. It must be stressed, however, that most regulations are not specifically targeted for the alpine area and that a differentiation of regulations and laws between alpine and non-alpine regions is generally not feasible.

At the national level, **Germany** argues that it has been able to demonstrate that it is possible to raise the economic output whilst reducing the absolute energy consumption. There has, however, been some criticism about the calculation of energy intensity, i.e. whether importations are integrated or not. This has been achieved by a steady increase of energy efficiency. Buildings are also a crucial factor for energy consumption. The recently amended building code puts strict requirements on new buildings and thereby significantly reduces the energy consumption of new constructions. For all buildings mandatory energy certificates have to be presented when buildings/apartments are being let or sold. This allows future tenants to include energy efficiency performance into their decision making. This creates an additional push for investments into energy efficiency.

In **Slovenia**, a set of measures and regulations to increase energy efficiency in all sectors including buildings and households has been put in place. One focus lies on including energy-relevant aspects in spatial planning through the enforcement of local energy concepts and sustainable transport plans. In addition, the reduction of energy poverty is an important goal, as often poorer households live in energetically inefficient buildings. They therefore spend more money on heating energy and are overly affected by increases in energy prices. The benefits of investments in energy efficiency for the GNP are important. They create 3-4 times more employment than investments in energy production and at the same time reduce the money outflow for fossil energy imports.

Italy implemented energy efficiency certificates (white certificates, WhC) in 2004. White certificates are issued by a state owned company (GSE) only for additional energy savings. Electricity and natural gas distributors with more than 50'000 customers are obliged to produce or buy a certain quantity of certificates per year in relation to their energy sales. The WhC can be created either by the energy distributors themselves (or jointly with third party providers) through the implementation of measures among their customers or the certificates can be bought from the market. Energy service providers and big energy end-users can also create WhC and sell them on the electricity market. There is no authorization needed for trading certificates in order to keep market entry barriers as low as possible. The system with white certificates is working, with the general tendency of large companies often preferring to trade WhC and to delegate energy efficiency investments to SMEs rather than investing themselves into energy-efficiency. and the cumulative primary energy savings were equal to 6 Mtoe/a in the year 2012.

Incentives

Different countries of the Alpine Convention have implemented building renovation programs in order to promote investments in energy efficiency measures and increase the renovation rate.

In Switzerland for example one third of the national CO₂-levy revenue is used to finance the so-called «building program». 2/3 of these funds are used for building envelope retrofit measures (same conditions apply all-over Switzerland). The remaining third of the federal contributions are used for measures regarding renewable energies, heating systems etc. and are only paid if the same amount is raised by the cantons. This part of the program is different from canton to canton and therefore allows for regional differentiations. The program is currently leveraging private investments of approx. CHF 1 billion/a. Tax deductions for building renovation measures are currently already in place in some cantons and have been discussed as additional measure at the national level, but it is disputed if this measure creates mainly windfall profits for building owners.

The building program of Lichtenstein limits support for complete refurbishments of the building envelope to buildings older than 1993. Additionally it focuses on Photovoltaic (PV) and heat pump systems. So far Lichtenstein has achieved a higher increase in PV production than the additional electricity demand induced through new heat pumps. From a cost point of view investment support for PV proved very attractive as it resulted in CO₂-mitigation costs (subsidies only) of approx. 60 CHF/t which is still expected to further decrease (compared to subsidies for building envelope refurbishments which amount to 120 to 165 CHF/t).

The autonomous province of Bolzano (South Tyrol) has implemented an incentive scheme for house owners that «trades» building volume for energy-efficiency: House owners are allowed to build larger building volumes (or can increase the volume of retrofitted buildings) if energy standards beyond the requirements are applied. This incentive favors the compacting of the residential areas, in accordance to the target of actual spatial planning strategies. The experience shows that this measure has had a very positive effect on the share of buildings that adhere to certified high energy efficiency standards.

2.2.2 Examples from the alpine region

The 3^d place winner of the Architecture award «Constructive Alps», the **multifunctional center «Rinka»**, is an example of how a building can create a local cultural and economic stimulus. The new construction forms the nucleus of the small mountain village Solčava, Slovenia and serves several purposes: It is town hall, café and local produce shop, tourist information, cultural and start-up center under one roof. The building is made from local material (mainly wood) and complies with advanced energy standards.

The **construction of alpine huts** shows that sustainable solutions need to be framed in the respective local context. Different framework conditions (climate, access, energy supply, sewage treatment etc.) make uniform solutions impossible. Therefore the Club Arc Alpin (CAA) is developing an assessment tool for the energy efficiency of (remote) alpine huts. All energy-relevant aspects from building/retrofitting the hut to operation and also dismantling have to be included. The most sustainable and energy efficient solution for an alpine hut might differ quite a lot from what would be expected from a building in a valley. For instance, cogeneration plants proved to be a solution that is especially adapted to low-accessibility areas.

2.2.3 Participation and social acceptance

The region of Vorarlberg stands out in many aspects. It has the world's highest passive house density, a renovation rate of almost 3% and the share of bicycle in traffic is 17%. Also the architecture competition «Constructive Alps» revealed how widespread energy efficient is in Vorarlberg with many of the 400 submissions originating from there. The participative vision-building process towards the vision of climate-neutral Vorarlberg has served as a normative base. The process is open to anyone except for lobbyists. Members of the provincial parliament take part in workshops and discussions. All results and agreements are worked out in public discussions, written opinions are not allowed. The program management only provides the experimental process itself.

2.2.4 Lessons learnt

The discussion at the end of the workshop brought up some important ideas and inputs which shall be retained here.

Awards and competitions: Awards and competitions (such as the architecture competition «Constructive Alps») have been mentioned several times as a good approach to motivate proactive persons and organizations and improve the visibility of such lighthouse projects all over the alpine regions. Awards could include topics like innovative local/regional energy and spatial planning concepts, participation processes, sustainable tourism initiatives etc. Valuable lessons can be learnt from former «alpine» examples with their success factors and difficulties: e.g. from the «Alpine Pearls» initiative for sustainable transport solutions in tourism resorts or the recent «pilot regions» approach of the Alpine Convention Ecological Networks platform.

Networks and knowledge: Networking and exchange of experience have been mentioned as crucial factors for innovation and successful implementation of measures/actions towards an energy efficient and sustainable alpine region. Possible approaches could be the collection of best-practice examples, networks of trades (crafts) and research institutions etc. These activities are part of different former and actual European projects, namely the Alpine Space projects «NENA», «Enerbuild», «CABEE», «Visibel» and «AlpBC». Additionally the current territorial energy and CO₂-accounting should be transitioned to a consumption based accounting. This would include overall consumption and better reflect imports of outsourced energy-intensive goods.

Ambitious targets and innovation: The alpine region is especially sensitive to impacts from climate change and therefore has a vital interest in changing its energy consumption patterns, fostering resilience and self-sufficiency strategies (e.g. better insulated buildings means being less vulnerable to temperature changes). This is reflected in the ambitious goals of the Energy Platform mandate and the energy protocol of the Alpine Convention itself. Additionally the alpine region is seen as a region rich in resources and knowhow and should therefore play a pioneering role in the energy discussion. As a result of those considerations, the alpine regions could aim at reaching set targets (on EU or national levels) earlier than generally planned or even set more ambitious alpine-specific targets to foster the reduction of energy consumption. Possible targets might be:

- Turn the Alps into a model region for sustainable buildings by defining clear objectives (e.g. a «100 sustainable tourism destinations» program, transform public buildings to a low energy standard).
- Follow the «(nearly) zero energy» and «plus energy vision» which offers opportunities to the Alps in terms of value-added and of the efficient use of resources.
- Moving significantly towards (nearly) zero energy buildings could mean reducing the energy demand for heating purposes by a figure of 30% up to 2030.

2.3 Current situation and future development in the countries participating in the Energy Platform

As an important basis for the reflections in the previous chapters, in the following the current situation is described for each member country of the Alpine Convention participating in the Energy Platform (Austria, France, Germany, Italy, Liechtenstein, Slovenia, and Switzerland). The description is focusing on the current energy consumption and on the development of the energy demand, as well as on specific energy strategies of the countries involved. To ensure comparability, the following figures are all based on OECD/IEA country reviews, whenever such reviews were available. As already mentioned in the introductory chapter of this report, for some countries data from more recent statistics may be available from other sources.

A common basis for the energy strategies of European countries is defined by the 20:20:20 goals: increasing energy efficiency by 20%, increasing the share of renewable sources to 20% of the total demand and reducing GHG emissions by 20% compared to 1990 by the year 2020.

Regarding the reduction of energy consumption and related GHG emissions it should be kept in mind that the embodied energy (sometimes also called «gray energy») is generally not included in the national statistics on energy usage. Embodied energy is the energy required to produce goods or services and in this context refers to the energy consumed in a country by importing goods and services that have been produced in other countries. The amount of embodied energy and therefore also of embodied GHG emissions is substantial as the following figures show: A study of Peters et al. (2011) shows that in the time-span between 1990 and 2008 net emission-transfers are at the rise and, that they tend to exceed the Kyoto Protocol emission reductions (for the countries assessed by the global CO₂ database of Peters et al.).

2.3.1 Austria

The population of Austria counts 8.5 million inhabitants. It is expected to grow up to 9.5 million by the year 2050. Approximately two thirds of the country's area is within the perimeter of the Alpine Convention.

The final energy consumption of Austria was 26 Mtoe¹² (1'100 PJ) in 2009 (s. Figure 2). The highest shares of consumption are attributed to the industry sector (28%) and the transport sector (30%). Residential use accounts for 24% of the total consumption. The energy demand has been

¹² Megatons of oil equivalents: One mtoe equals 41.87 petajoule (PJ) or 11'630 gigawatt hours (GWh)

increasing steadily in all sectors since the 1970s. Yearly electricity consumption amounts at 66 TWh in 2009, corresponding to a consumption of 7900 kWh per capita.

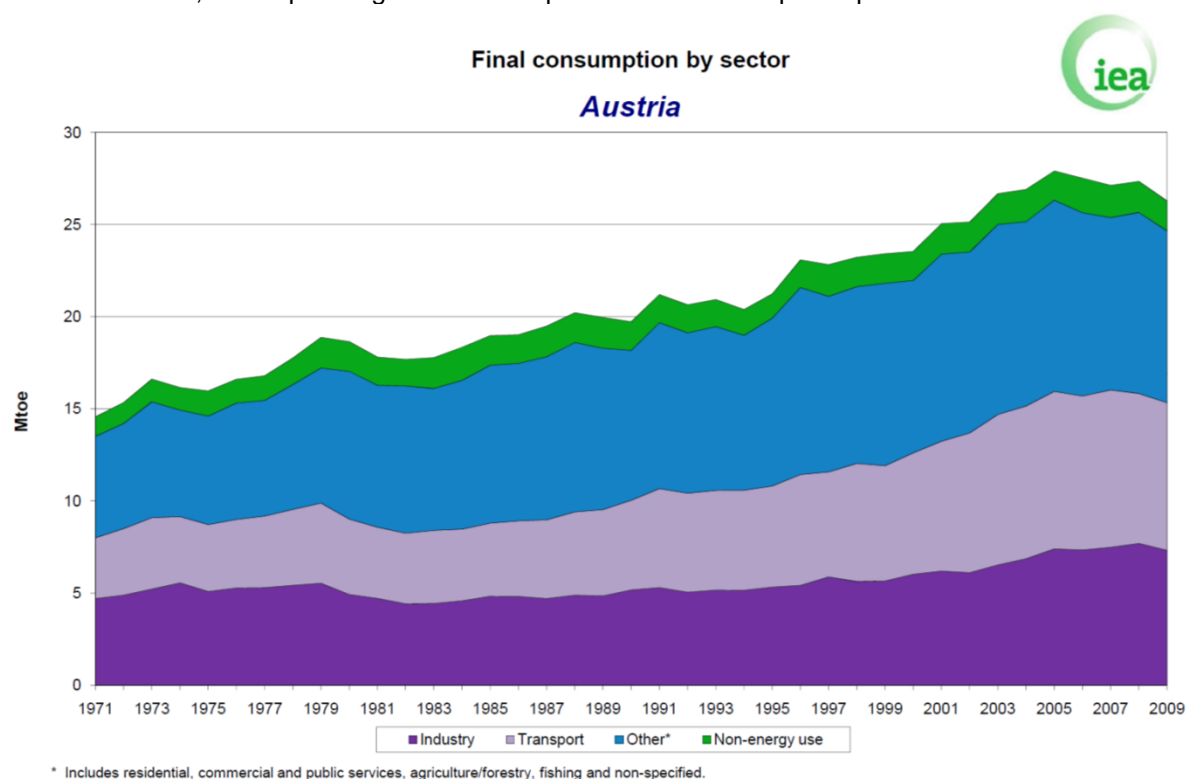


Figure 2 Final energy consumption (Mtoe/year) of Austria by sector (industry, transport, other, non-energy use) 1971-2009 (OECD/IEA 2011)

Renewables directly contribute over 10% to industrial energy demand and 19% to energy demand in the other sectors. 40% of the final consumption is covered by oil resources, followed by electricity with 19%, natural gas with 16% and biofuels and waste with 14% (s. Figure 3).

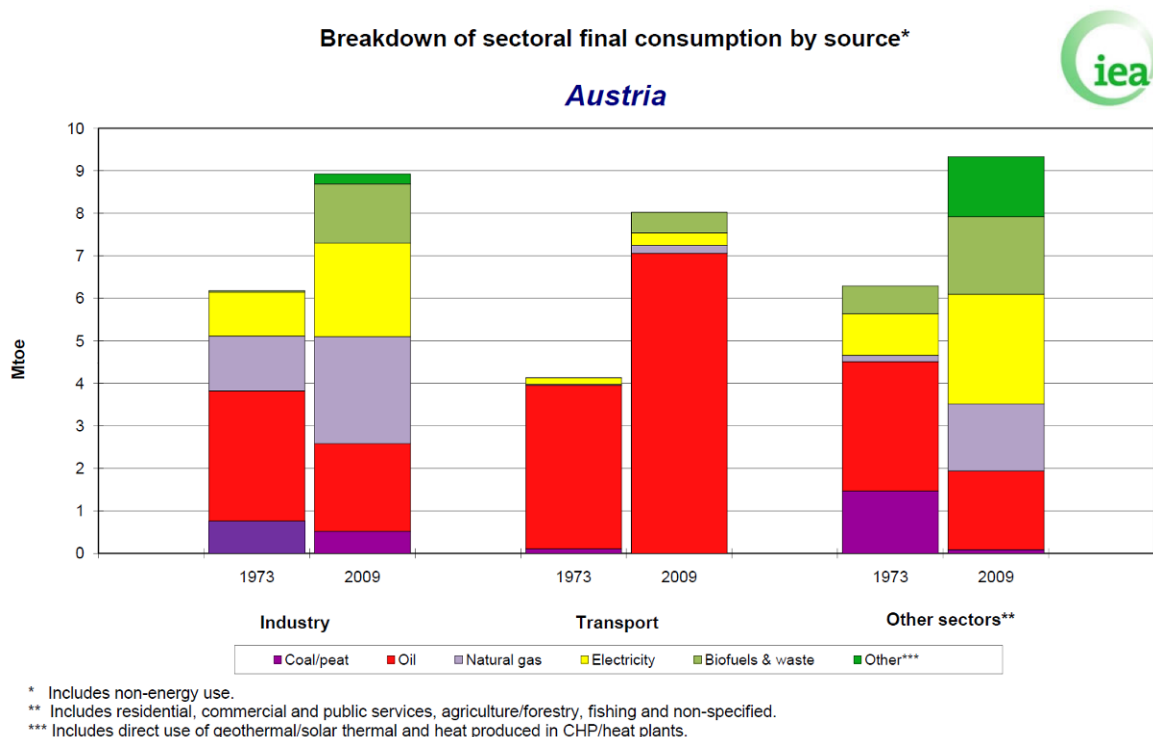


Figure 3 Final energy consumption (Mtoe/year) of Austria by sources (coal, oil, natural gas, electricity, biofuels & waste, others) 1973-2009 (OECD/IEA 2011)

During the period from 1973 to 2004, Austria's overall energy intensity decreased by about 26%. The 2005 rate of energy consumption per capita of 175 GJ is significantly lower than the average rate of the IEA, which stands at 215 GJ. Sectorial forecasts predict an increase of energy consumption in stationary uses by 2020. The most rapid increase is expected in the «Other Sectors», where an increase of 28% is assumed, primarily driven by electricity demand which is expected to increase by 102% until 2020. In the industrial sector, the increase of electricity consumption is predicted to be 9.5% over the same time period. In the transport sector, a small decrease in energy consumption is expected.

The Austrian energy strategy for 2020 has the target of stabilizing the yearly energy demand at 26 Mtoe (1'100 PJ), increasing the share of renewables to 34%. The predicted growth of the energy demand in a business as usual scenario should be prevented by energy efficiency measures.

Austria has implemented environmental policy instruments and measures such as laws, subsidies and initiatives for reducing energy-related emissions. Since Austria's accession to the European Union (1995) the country's energy efficiency policy is based primarily on EU policy. The Austrian government is supporting efficiency improvements through research and funding programs in all sectors of the economy.

Especially in researching efficient building solutions, Austria is one of the leading countries. The federal government's program is committed to promote low energy and passive house standards by implementing strict energy efficiency regulations. Building related targets from the program are that 50% of new buildings should meet the «Klima:Aktiv» standard. The standard defines criteria for energy-efficiency, the quality of the planning and execution, the building material and construction quality as well as the comfort and ambient air quality. These are neutrally assessed and need to be fulfilled in order to achieve the standard. The klima:aktiv building standard exists for residential and office buildings, for new buildings and also for renovations. From 2015, only those residential buildings meeting the standard should receive government financial support for their construction.

2.3.2 France

The French Alps spread on a surface of 40'800 km², located in the states Provence-Alpes-Côte d'Azur and Rhône-Alpes in the south-east of the country. The alpine region counts approximately 1750 communities.

The final energy consumption in France was 160 Mtoe (6'700 PJ) in 2009. The transport sector and residential use contribute a similar share of roughly 28% each, followed by the industry with 17% and commercial and public services with 13% (s. Figure 4). The demand of the industry has been decreasing, while the total demand has been increasing since the 1970s.

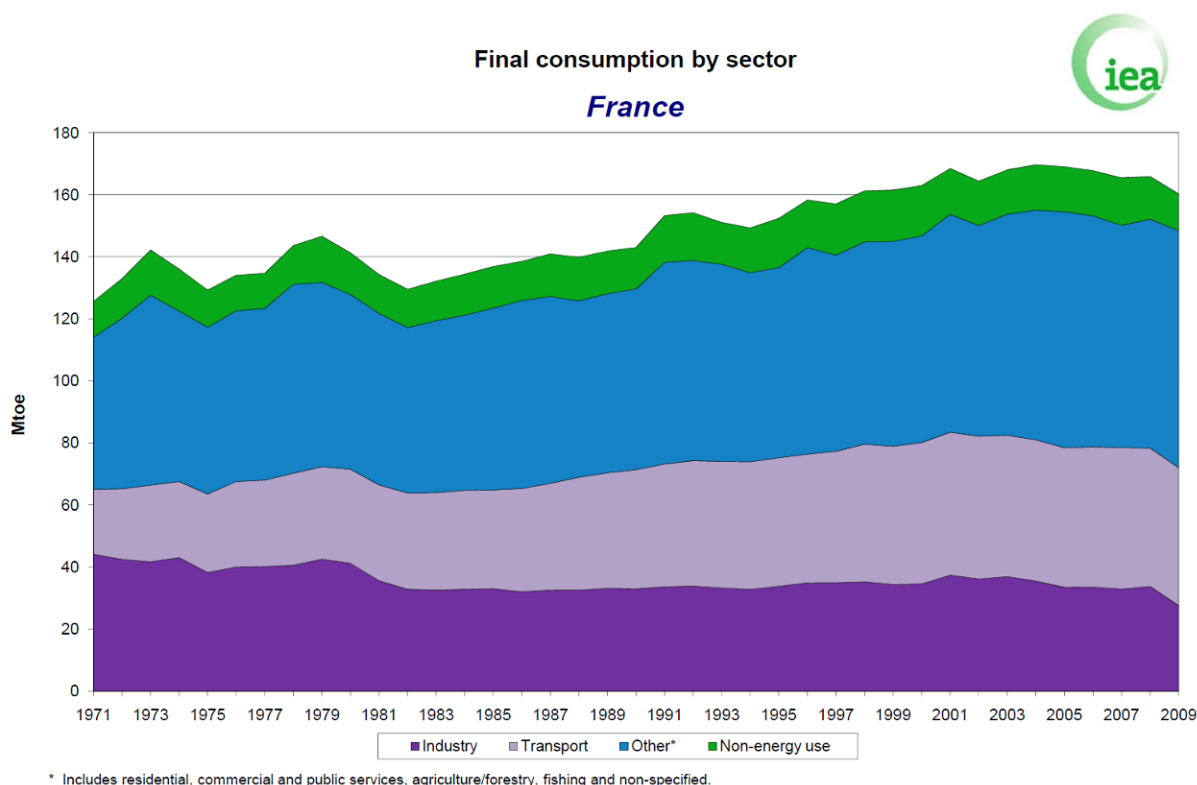


Figure 4 Final energy consumption (Mtoe/year) of France by sector (industry, transport, other, non-energy use) 1971-2009 (OECD/IEA 2011)

France is a net exporter of electricity, but net exports have declined recently, because of cold winters and the country's reliance on electricity for heating. The IEA review 2009 states that the French electricity system has surplus base load capacity; electricity demand shows increasing peaks because of growing heating loads.

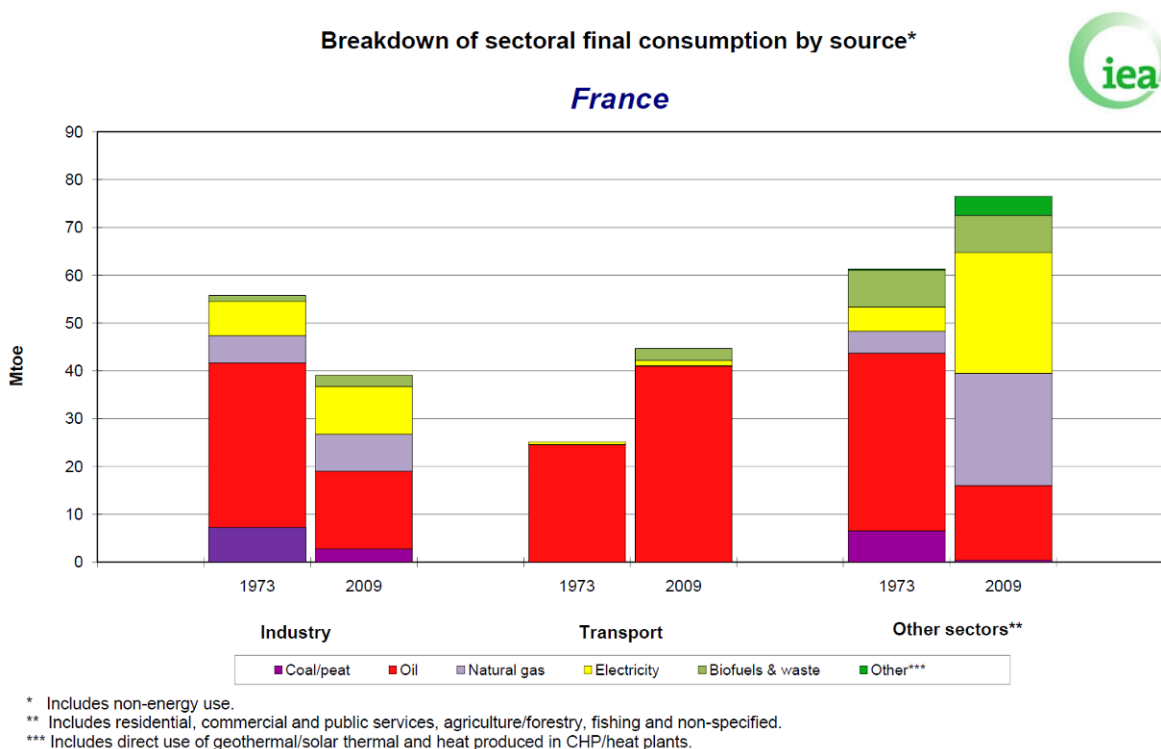


Figure 5 Final energy consumption (Mtoe/year) of France by source (coal, oil, natural gas, electricity, biofuels & waste, others) 1973-2009 (OECD/IEA 2011)

The four key principles of the French energy policy are security of supply, competitive energy supply, sustainable energy development and equal level of energy service to all territories and citizens. The French government set ambitious goals at combating climate change, such as a 75% reduction in CO₂-emissions by 2050 and a reduction in GHG emissions in the transport sector to 1990 levels by 2020. The government developed the environmental program, «*Grenelle de l'Environnement*», which prioritizes the reduction of emissions in the buildings and transport sectors. The law especially puts emphasis on supporting renewables-based heating systems. In France, the buildings sector accounts for nearly one-quarter of all CO₂-emissions. The Grenelle law defines the main strategies to reduce the energy consumption in the buildings sector. From the end of 2012, the energy consumption in all new buildings is limited to less than 50 kWh/m² per year. As a comparison, the energy consumption of buildings constructed before 1970 is estimated on average at 200 kWh/m² per year, for buildings constructed in the 1990s at 100 kWh/m² per year. In existing buildings, the energy consumption should be reduced by 38% until 2020.

2.3.3 Germany

The alpine area of Germany, the Bavarian Alps, is located in the southern region of the country. Germany has a population of 80.5 million inhabitants of which only 2% live in the alpine region.

Germany's final energy consumption was 227 Mtoe (9'500 PJ) in 2011 and showed a modest decline over the past three decades (s. Figure 6). The industry sector accounts for the highest energy consumption with 40% of total final consumption in 2011, increasing from 32% during the recession in 2009. Today's shares of the other sectors are: transport sector 24%, residential use 23%, commercial and other services 13%.

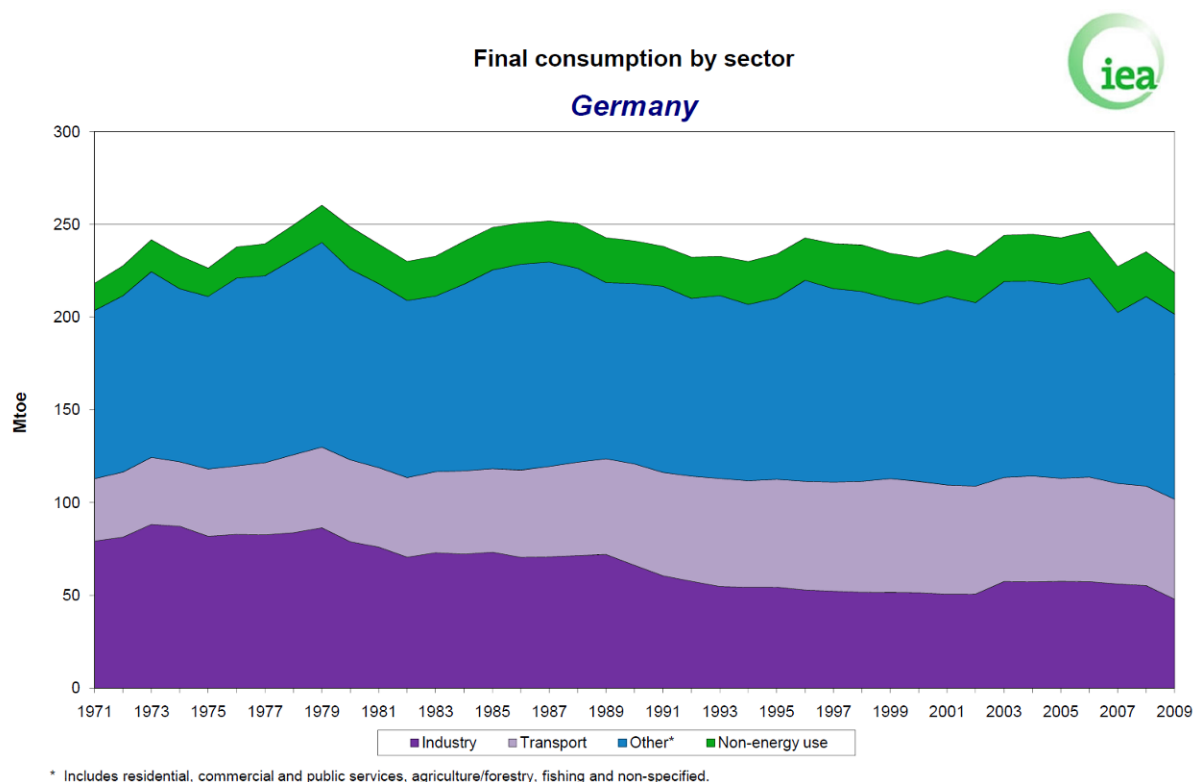


Figure 6 Final energy consumption (Mtoe/year) of Germany by sector (industry, transport, other, non-energy use) 1971-2009 (OECD/IEA 2011)

The major energy carriers consumed are oil (42%), natural gas (21%) and electricity (20%) (s. Figure 7). The total electricity consumption in Germany amounts at 555 TWh in 2009, corresponding to a consumption of 6781 kWh per capita.

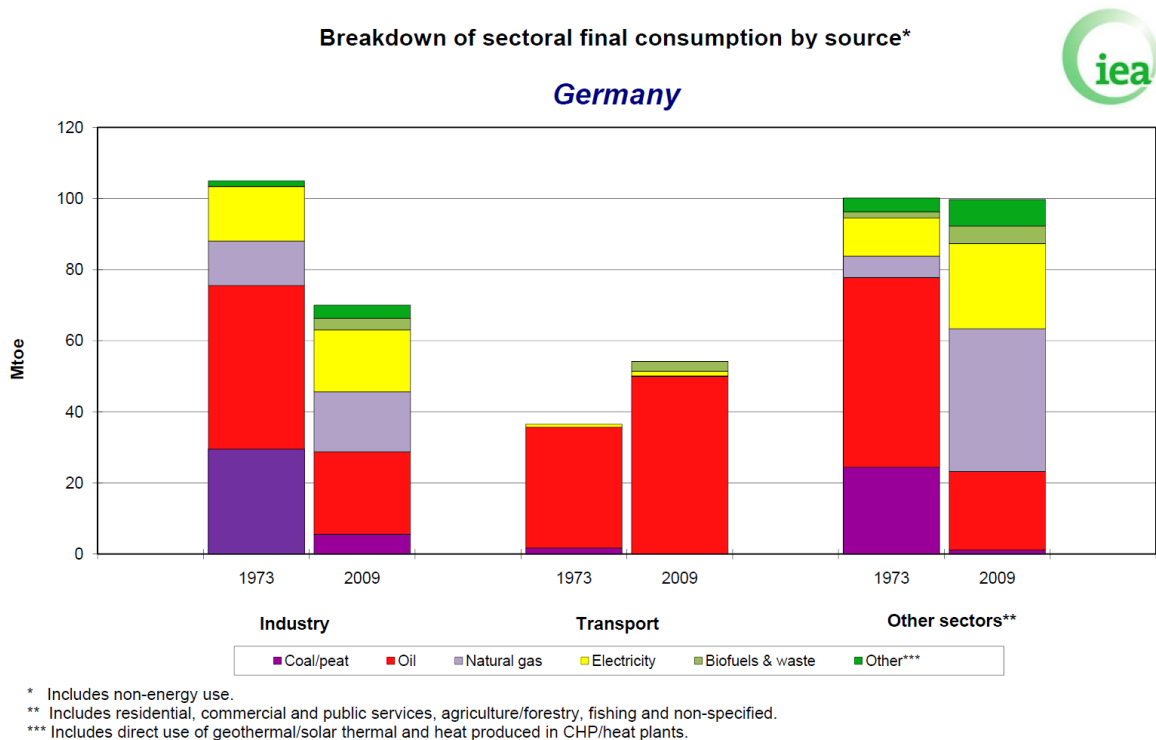


Figure 7 Final energy consumption (Mtoe/year) of Germany by sources (coal, oil, natural gas, electricity, biofuels & waste, others) 1973-2009 (OECD/IEA 2011)

As a first major step towards reducing consumption, Germany implemented the ecological tax reform on fossil fuels and electricity consumption in 1999. Thus, energy consumption and GHG emissions, most notably in the transport sector, could be reduced.

Following the tax reform, the country introduced the integrated energy and climate program in 2007. The goals of the federal government were to reduce GHG emissions by 40% compared with 1990 and increase renewable electricity generation by 30% until 2020.

With the energy concept 2010 Germany set its goal to obtain the greater part of the energy supply from renewables through the year 2050. The concept is a long-term strategy for the transformation of the energy system by increasing energy-efficiency, expanding renewable energy sources and reducing GHG emissions. The energy concept provides a comprehensive package containing policies for electricity, heating and the transportation sector.

After the «Fukushima» nuclear accident in 2011, the decision to abandon the generation of electricity from nuclear power plants by 2022 was reaffirmed. As an immediate consequence the seven oldest power plants were definitely disconnected from the grid. Therefore, the process of reorganizing the energy supply system needed to be accelerated by a comprehensive package of legislation, the energy package 2011 (called «Energiewende»).

Targets	2012	2020	2050
Reduction of primary energy consumption	-5%	-20%	-50%
Reduction of electricity consumption	-1%	-10%	-25%
Reduction of final energy consumption in the transport sector		-10%	-40%

Table 2 Targets on the reduction of energy consumption of the Energy Concept 2010/Energy Package 2011 (base year 2008)

The aim of the energy concept 2010 was to make Germany one of the world's most energy efficient economies at affordable level of energy prices. The energy efficiency increased by 19% since 2000. Germany is among the world leaders in energy efficient buildings, applying strict energy requirements for the existing building stock as well as for new buildings. Since 1995 all new buildings are obliged to be issued with an energy certificate. Since 2012 the federal government constructs only ultra-low energy buildings for the public sector as an example of good practice.

2.3.4 Italy

Italy has a population of 60.6 million inhabitants, the perimeter of the Alpine Convention lies in the northern part of Italy, stretching from the French to the Slovenian border.

The final energy consumption in Italy amounted at 127 Mtoe (5'300 PJ) in 2009. The transport sector contributes the largest share of 31%, followed by the industry and the residential sectors, each contributing 23%. The share of commercial and public services is 13% (s. Figure 8).

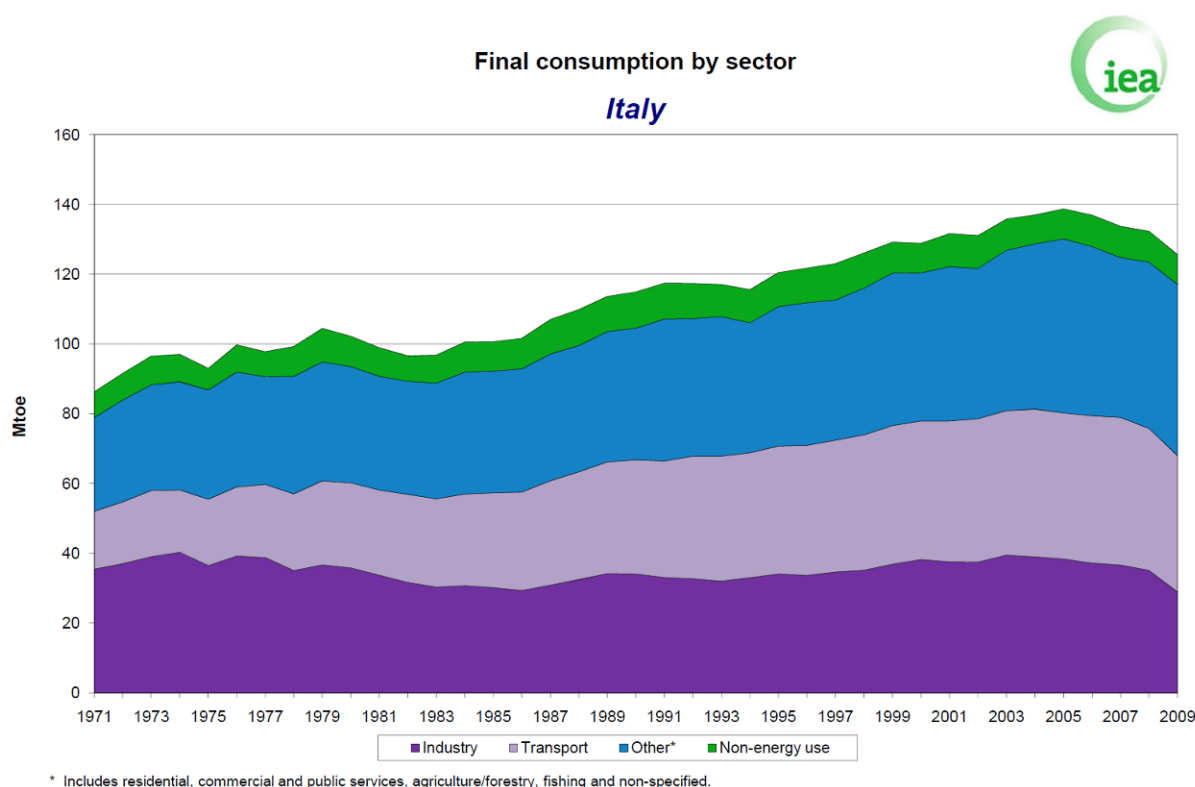


Figure 8 Final energy consumption (Mtoe/year) of Italy by sector (industry, transport, other, non-energy use) 1971-2009 (OECD/IEA 2011)

The consumption of the industry sector was declining from the 1970s, while all other sectors increased their demand. Oil covers the largest share of the total demand (44%), natural gas

contributes 29% and electricity 20%. Renewable sources are almost negligible (s. Figure 10). The total electricity consumption amounts at 317 TWh in 2009, corresponding to 5271 kWh per capita.

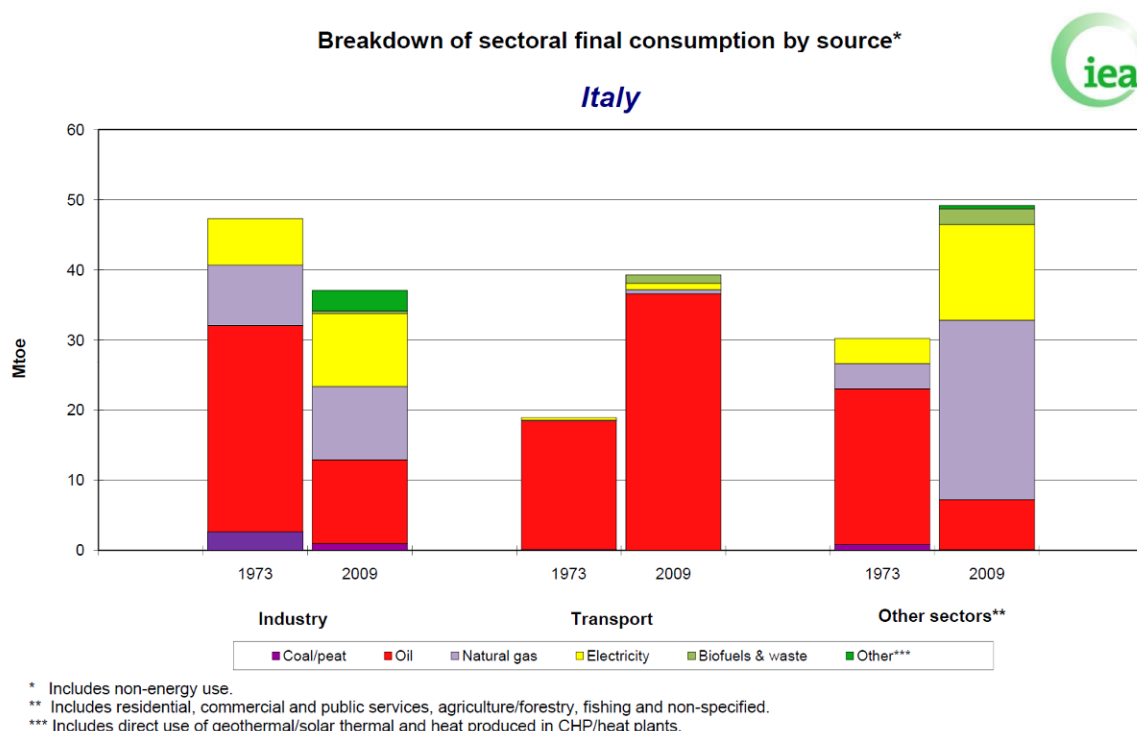


Figure 9 Final energy consumption (Mtoe/year) of Italy by sources (coal, oil, natural gas, electricity, biofuels & waste, others) 1973-2009 (OECD/IEA 2011)

In March 2013, the Italian national energy strategy was approved. Its four main goals are to improve competitiveness, achieve the environmental targets of the EU 2020 climate and energy package, improve supply security and reduce dependency on imports as well as developing the energy sector in order to foster sustainable economic growth. Improving energy efficiency on the consumer side is a priority of the energy strategy.

The Italian Administration views energy efficiency as a policy priority. In recent years, a number of amendments to energy efficiency policy have been put in place. As an example, energy efficiency certificates («white certificates»), a tradable instrument giving proof of the achievement of energy savings, are granted. Further, a tax rebate of 55% for energy efficiency refurbishment works in the building sector has been established. From 1990 to 2005 the residential sector demonstrated the greatest improvements in terms of energy-efficiency. Further improvements are expected in the coming years thanks to the increased use of thermal insulation in older buildings and more efficient air-conditioning systems as well as new regulations concerning the sale of domestic electric appliances.

2.3.5 Liechtenstein

The Principality of Liechtenstein with an area of 160 km² and 36'000 inhabitants lies entirely within the Alps.

The final energy consumption of Liechtenstein has peaked in 2006, reaching 0.12 Mtoe (corresponding to 5 PJ), as shown in Figure 10. Energy demand has slightly declined since to the level of 2002, corresponding to 0.11 Mtoe (4.7 PJ) in 2011. The energy demand per capita is

130 GJ. The main energy source is electricity with a share of 30% of total demand, followed by natural gas (23%), heating oil (13%), petrol (12%) and diesel (11%).

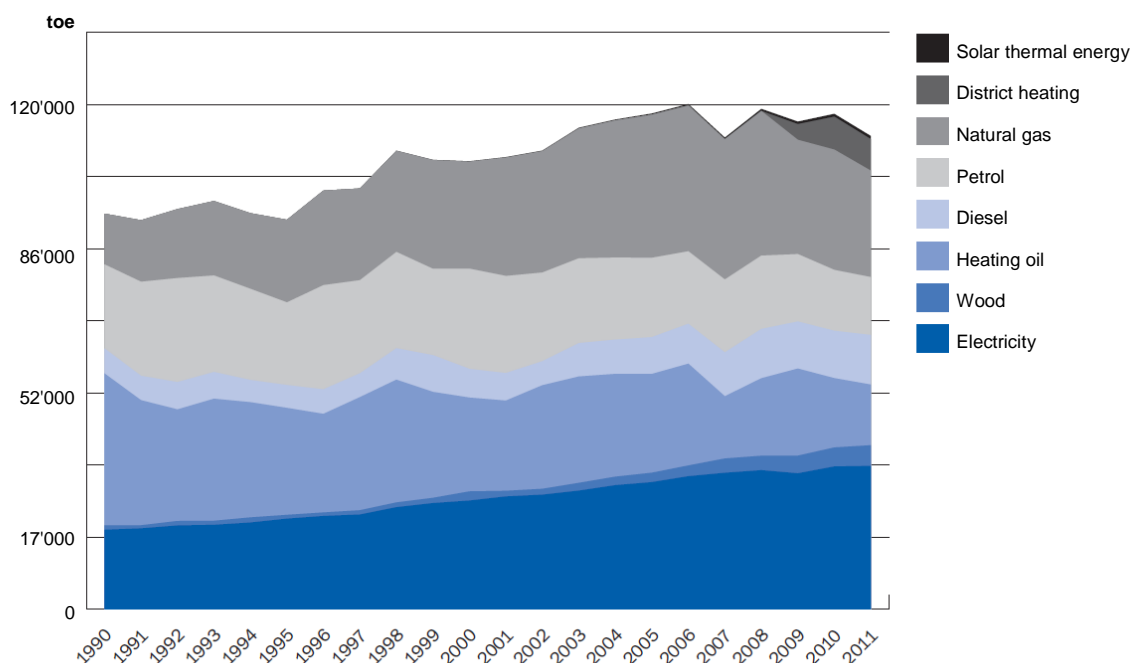


Figure 10 Final energy consumption (toe/year)¹³ of Liechtenstein by sources (solar thermal energy, district heating, natural gas, petrol, diesel, heating oil, wood, and electricity) 1990 – 2011

Liechtenstein has ratified the Kyoto Protocol in 2005, agreeing to reduce its GHG emissions by 8% in the period from 2008 to 2012 based on the 1990 level. The energy demand for buildings could be reduced significantly based on the 2008 law on energy-efficiency. The energy strategy of Liechtenstein is based on the 20:20:20 targets. It focuses on the implementation of measures in six different fields of action, that are buildings, energy efficiency and low-energy mobility, processes and appliances, energy production and supply, creation of awareness as well as research.

2.3.6 Slovenia

The population of Slovenia counts approximately 2 million inhabitants. The alpine region is located in the north-western part of the country, bordering Italy and Austria.

In Slovenia¹⁴, the final energy consumption was 4.96 Mtoe (208 PJ) in 2012, corresponding to roughly 100 GJ per capita. The electricity consumption amounted at 6160 kWh per capita. Since 1992 the country's energy demand has increased by an average of 2% per year, corresponding to a total growth of 40% until 2009. The main contributor to the increase of energy consumption was the transportation sector (mainly because of transit traffic), which increased by 110% in the same period. The main share of the total energy demand is covered by petroleum products, accounting to 49% of the overall consumption in 2012. Electricity is covering 22% of the demand, followed by

¹³ Original values in MWh; the values have been converted to toe (tonnes of oil equivalents) for better comparability with other figures in this report.

¹⁴ The following data was validated by members of the Slovenian delegation to the Energy Plattform.

RES and waste with 12% and natural gas with 11%, heat with 4% and solid fuels with 1% of the final consumption.

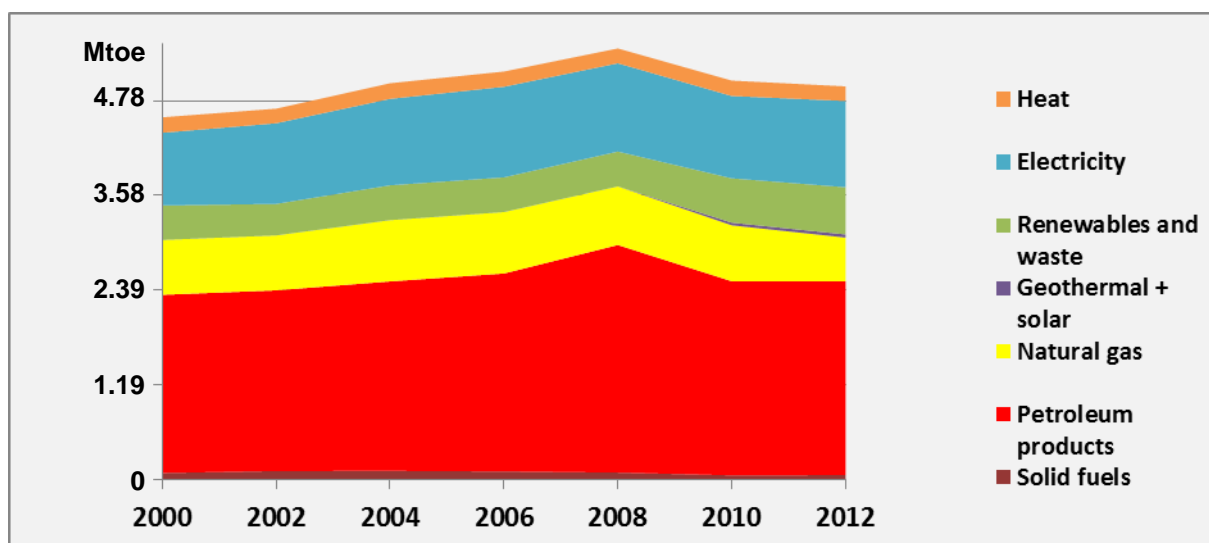


Figure 11 Final energy consumption (Mtoe/year)¹⁵ of Slovenia by sources (heat, electricity, renewables & waste, geothermal & solar, natural gas, petroleum products, solid fuels) 2000-2012 (source: Elektro-Slovenija, ELES)

Regarding the distribution of the final consumption per sector, the transport sector covers the largest share of 40%. Today, the industry requires 24% of the total consumption. The energy demand of households has been markedly declining since 2003 and amounted for 24% of the total consumption in 2012.

The Slovenian energy strategy defined the target of saving 2.5% (0.103 Mtoe; 4.3 PJ) of final energy consumption between 2008 and 2010, which could be achieved. For the period from 2008 to 2016 the target is set at a 9% reduction (0.365 Mtoe; 15.3 PJ) in total consumption. The strategy to attain this goal includes the accelerated renovation of public sector buildings, zero-energy buildings and ensuring the leading role of the public sector as a model of energy efficiency as well as direct financial incentives to reduce the energy consumption of households. The commercial sector is being targeted by measures promoting the development of energy efficient products, production processes and services. Further, a legal and technical basis for energy efficient spatial planning is being established. The new Energy Act (EZ-1), which entered into force in March 2014, provides a legal framework for a new long-term national energy strategy up to 2050 («Energy concept Slovenia»), which will define strategic policies in the energy sector for potential investors.

2.3.7 Switzerland

Switzerland has a population of 8 million of which 22% live within the alpine region.

The IEA review 2012 states that the final energy consumption in Switzerland was 21 Mtoe (corresponding to 880 PJ) in 2010, higher than ever before. The final consumption has increased by an average of 0.7% per year over the last decade (comparing with an IEA average annual

¹⁵ Original values in PJ; the values have been converted to toe (tonnes of oil equivalents) for better comparability with other figures in this report.

decrease in consumption of 0.2% in the same period). Switzerland is one of the few IEA member countries where population continues to grow and where the economy has performed relatively well in recent years.

In a sectorial view, energy usage in the residential, the industrial, the transport and the commercial sector have developed differently in the last 30 years, with the strongest increase in the transport sector (s. Figure 12). Still, the residential sector remains the largest energy consumer by far. GHG emissions are especially high in the building sector, where more than half of the energy used for heating is oil. In the Alps, a generally older building stock accentuates this issue.

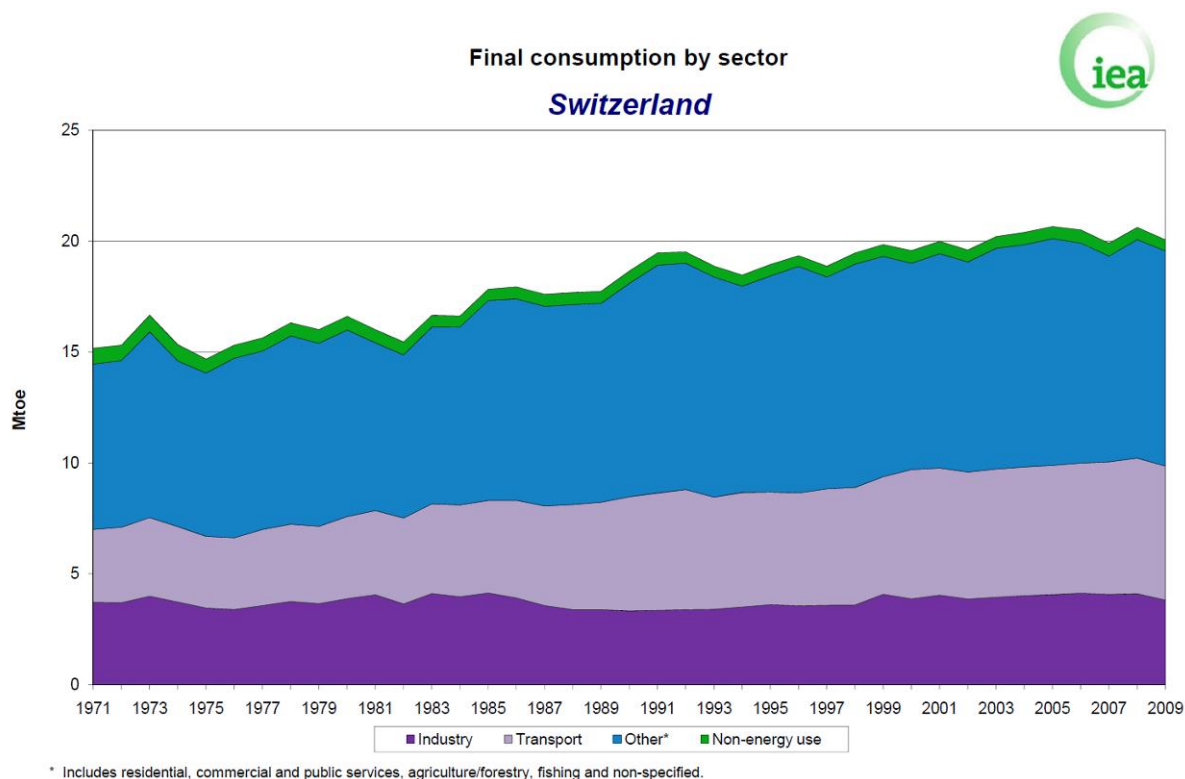


Figure 12 Final energy consumption (Mtoe/year) of Switzerland by sector (industry, transport, other, non-energy use) 1971-2009 (OECD/IEA 2011)

The highest share of the total demand was covered by oil with 54% in 2009, followed by electricity with 25% and natural gas with 12% (s. Figure 13). The electricity consumption in Switzerland amounted at 62 TWh in 2009 which corresponds to 7962 kWh per capita.

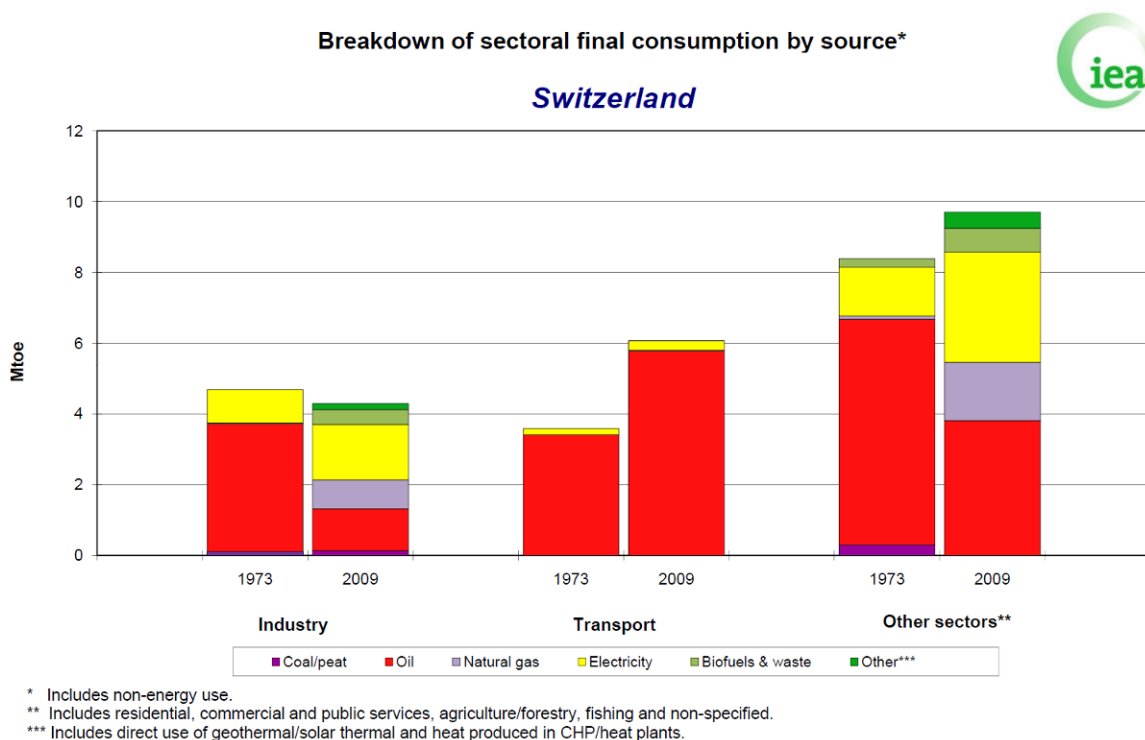


Figure 13 Final energy consumption (Mtoe/year) of Switzerland by sources (coal, oil, natural gas, electricity, biofuels & waste, others) 1973-2009 (OECD/IEA 2011)

The Swiss energy program, working closely together with cantons, municipalities and the private sector, focuses its activities on buildings, renewable energy, mobility, industry and services, electrical appliances, measures in cities and municipalities, training and education, as well as communication and awareness rising. The program fosters the following objectives: a general reduction of final energy consumption per capita by 35% until 2035 and by 50% until 2050 (baseline: 2000); reduction of CO₂ emissions and the consumption of fossil energy by at least 20% by 2020 (based on 1990 level); and increasing the proportion of renewable energy to overall energy consumption by at least 50% between 2010 and 2020.

The scope of the Energy strategy 2050 of the Federal government, which is currently under debate in the Parliament, is to develop strategies to provide electricity security without nuclear power in the future. The existing nuclear power plants currently in operation should be disconnected from the grid at the end of their lifetime without replacement by new nuclear plants.

2.3.8 Future development

The possible future development of the energy demand is discussed in this paragraph using a reference scenario and a scenario driven by new policies.

The **EU roadmap 2050** presents a possible future development of the EU energy demand in a **reference scenario (REF)** of unchanged policies. It is a projection of developments in the absence of new policies beyond those adopted by March 2010.

The final energy consumption is predicted to rise until 2030, after which demand is expected to stabilize. The biggest increase is expected for the electricity demand. Considerable fuel switching

is expected in final energy demand, especially in the residential and tertiary sectors where the use of fossil fuels decreases while there is a strong tendency towards electrification. The share of renewable energy sources should increase markedly.

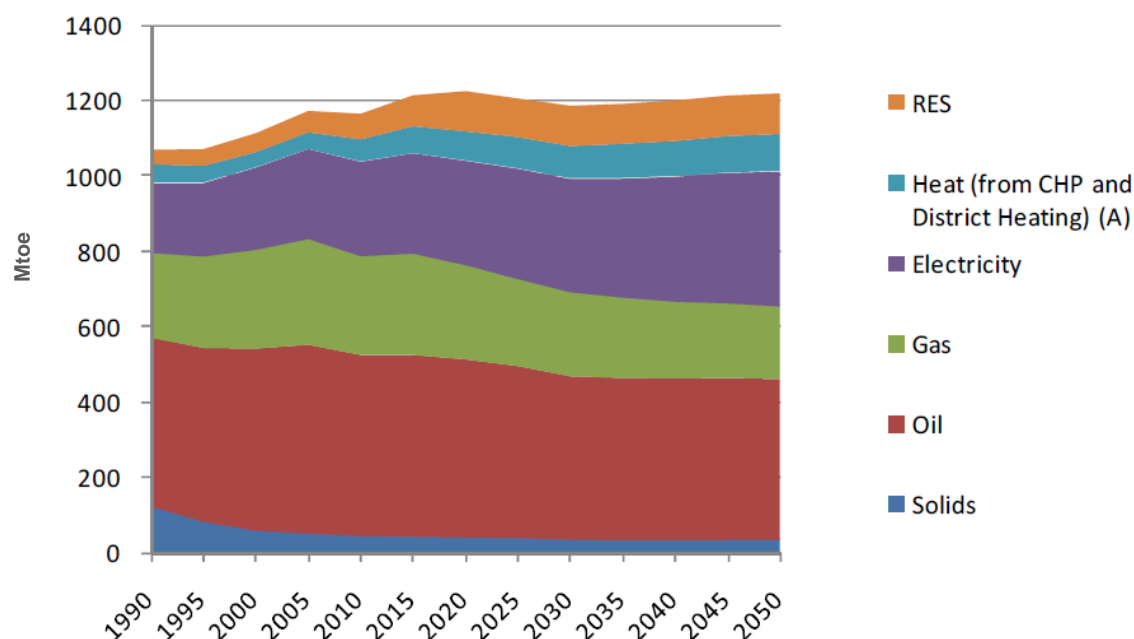


Figure 14 EU roadmap 2050 reference scenario: final energy consumption of the European Union (Mtoe/year) by fuel type (renewable energy sources (RES), heat, electricity, gas, oil, solids) 1990 – 2050 (European Commission 2011)

The share of sectors is assumed to remain broadly stable with transport remaining the biggest single consumer in 2050. In a context of growing demand for transportation, final energy demand by transport is projected to increase by 5% by 2030 to represent 32% of total final energy consumption. This development is driven mainly by aviation and road freight transport. At the same time, however, the energy use of passenger cars is expected to drop by 11% between 2005 and 2030 due to the implementation of the regulation setting CO₂-emission performance standards for new passenger cars.

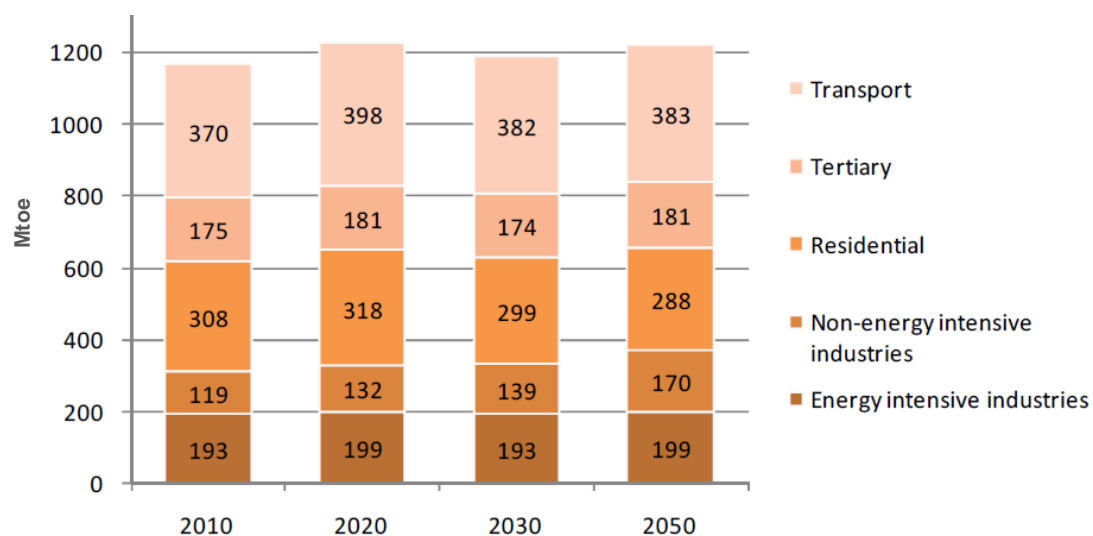


Figure 15 EU roadmap 2050 reference scenario: final energy consumption of the European Union (Mtoe/year) by sectors (transport, tertiary, residential, non-energy intensive industries, energy intensive industries) 2010 – 2050 (European Commission 2011)

In the EU roadmap 2050 the **Current Policy Initiatives (CPI) scenario** was modeled by taking into account the latest policies adopted and planned after March 2010. As a result of CPI, energy consumption is expected to be reduced significantly. The decline in final energy consumption is most pronounced in the medium term, for which most of the measures have been designed.

In the CPI scenario, further energy savings are brought about mainly by energy efficiency measures for households and services sector and efficiency improvements in energy transformation leading to further declines in final energy demand which remains 4-6% below the reference scenario (s. Figure 16).

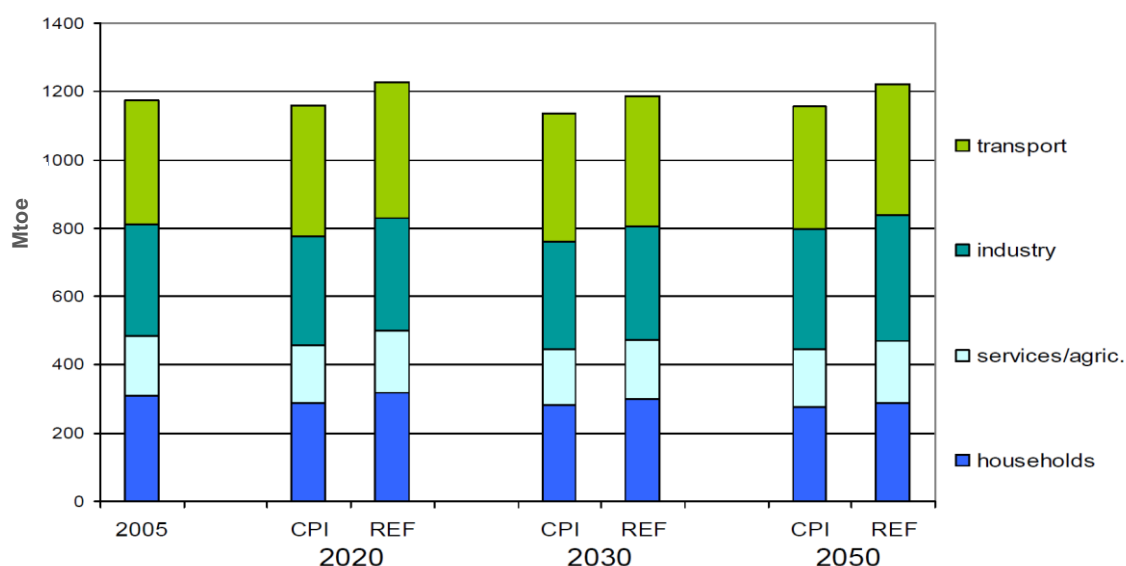


Figure 16 EU roadmap 2050 scenarios: final energy consumption of the European Union (Mtoe/year) by sector in Current Policy Initiatives (CPI) and Reference (REF) scenarios (European Commission 2011)

While final energy demand for oil, gas and coal would continuously decline up to 2050, demand for electricity, heat and renewables would increase. Most important in absolute terms is the increase in electricity demand, which rises 43% between 2005 and 2050. Nevertheless, electricity demand in the CPI scenario falls well below the electricity use in the reference case, reflecting measures in the Energy efficiency Plan and the revised Energy Taxation Directive. The demand for distributed heat is rising compared to current level but is 1-2% lower than in the reference scenario reflecting effects of measures, in particular more efficient heating systems in houses.

In the **Swiss Energy Strategy 2050**, currently under debate in Parliament, the Federal Council works with different scenarios in order to quantify future energy usage. In the «business as usual» scenario the total energy demand is predicted to be 17.8 Mtoe (744 PJ) in 2050. The scenario «new energy policy» foresees a significant decrease in total final energy consumption. According to the «new energy policy» scenario the demand is estimated to be substantially lower than in the «business as usual» scenario, that is to say 11.8 Mtoe (493 PJ) (s. Table 3).

scenario	final energy consumption [Mtoe/year]				final energy consumption per capita [GJ]			
	2000	2009	2035	2050	2000	2009	2035	2050
business as usual	18.7	19.4	18.6	17.8	109	104	93	84
new energy policy	18.7	19.4	13.8	11.8	109	104	68	55

Table 3 Swiss Energy Strategy 2050 scenarios: projected final energy demand of Switzerland under the «business as usual» scenario and the «new energy policy» scenario (BFE 2012)

In both scenarios total electricity demand is predicted to increase, in the «business as usual» scenario heavily and in the «new energy policy» scenario slightly. The difference is mainly due to an incentive tax applied in the «new energy policy» scenario, influencing both electricity demands of private households and of industries.

The future development of the energy demand of the single member countries of the Alpine Convention is estimated according to Table 4 below. The final energy demand is expected to decline below the level of 2010 for Austria, France, Germany and Switzerland by 2050, whereas for Italy and Slovenia it is estimated to grow slightly. However, for all countries the share of renewable energy sources of the energy demand is forecasted to grow substantially between 2010 and 2050. Accordingly, the carbon intensity of the energy demand is predicted to decrease.

Country		2010	2020	2030	2050
Austria¹					
Final energy demand	Mtoe	27.9	27.7	27.0	27.2
Share of RES in final energy demand	%	30	35	39	41
Carbon intensity of final energy demand	t of CO ₂ /toe	1.9	1.8	1.7	1.6
France¹					
Final energy demand	Mtoe	158.8	151.4	147.9	150.9
Share of RES in final energy demand	%	13	23	28	30
Carbon intensity of final energy demand	t of CO ₂ /toe	1.9	1.7	1.6	1.5
Germany¹					
Final energy demand	Mtoe	217.4	201.1	187.2	176.9
Share of RES in final energy demand	%	11	19	25	33
Carbon intensity of final energy demand	t of CO ₂ /toe	2.0	1.9	1.8	1.5
Italy¹					
Final energy demand	Mtoe	124.8	123.6	122.3	126.4
Share of RES in final energy demand	%	10	18	20	25
Carbon intensity of final energy demand	t of CO ₂ /toe	2.0	1.9	1.8	1.7
Liechtenstein²					
Final energy demand	Mtoe	0.118	0.120	n.a.*	n.a.*
Share of RES in final energy demand	%	8	20	n.a.*	n.a.*
Carbon intensity of final energy demand	t of CO ₂ /toe	2.0	1.5	n.a.*	n.a.*
Slovenia¹					
Final energy demand	Mtoe	5.0	5.4	5.6	5.7
Share of RES in final energy demand	%	19	26	28	30
Carbon intensity of final energy demand	t of CO ₂ /toe	1.8	1.7	1.6	1.6
Switzerland³					
Final energy demand	Mtoe	20.1	17.5	14.4	10.8
Share of RES in final demand	%	7	15	21	31
Carbon intensity of final energy demand	t of CO ₂ /toe	2.0	1.7	1.4	0.8

Table 4 Projected final energy demand in Mtoe/year, share of RES in final energy demand and carbon intensity of final energy demand of the Alpine Convention member countries for the year 2030
Sources: 1) EU Trends to 2050 Reference scenario 2013¹⁶; 2) Energy Strategy 2020 of Liechtenstein;

¹⁶ EU Reference scenario 2013: development of EU energy system under current trends and adopted policies, including current trends based on 2010 statistics and binding targets of EU legislation.

3) Swiss Energy strategy 2050, new energy policy scenario (see section on Literature for details);
*n.a.: data not available

It is important to point out, that the future energy consumption is very much dependent on the energy policies in force or planned for the coming years. As the political discussion on energy topics is rather active at the moment, all projections of energy consumption must be taken with some caution.

3 Energy production

The following chapter addresses aspects of energy production in the alpine region (chapter 3.1) and summarizes the findings and conclusions of the second workshop (chapter 3.2). Thereafter, chapter 3.3 delivers an overview of the current situation and planned developments concerning renewable energy production for each member country of the Alpine Convention participating in the process of the Energy Platform.

3.1 Aspects of energy production in the alpine region

3.1.1 Renewable energy in the alpine area

The alpine area provides a substantial potential for renewable energy production; especially regarding electricity generation from hydropower, wind and solar power, but also biomass and geothermal sources for heating applications. The different renewable energy technologies are briefly discussed in the following, placing special emphasis on their spatial requirements and possible conflicts with other land uses in the alpine area.

Renewable energy and land use

Promotion of renewable energy sources (RES) is a goal of the Alpine Convention Energy Protocol (art. 6) and of the energy strategies of all Alpine Convention member states (see chapter 2.3). As a consequence, a shift from centralized large-scale energy production towards decentralized, small-scale production is likely to take place. The increasing exploitation of RES has an impact on land resources and conflicts with other interests in the alpine area like tourism, nature conservation or species protection.

The use of natural resources such as biomass or water for energy production can directly influence other types of resource use (e.g. agriculture or production of drinking water) and the construction of plants for renewable energy generation often has an impact on the landscape. Moreover, the storage and transport of energy might affect landscapes as well, since additional infrastructure needs to be built. It is postulated that different types of regions/landscapes differ in their suitability for the production of renewable energy, as specified below.

- **Settlement areas:** Solar energy generation through photovoltaic panels and solar thermal collectors are especially suitable for populated areas, because already used surfaces like buildings or other types of constructions can be used for the installation. The use of biomass, especially wood, for district heating has to be near to the communities, since heat can only be transported over relatively short distances. Finally, the use of environmental heat is well established and accepted for heating purposes. Nevertheless, the production of RES in settlement areas is also prone to conflicts: Space for the construction of new infrastructure is often limited in populated areas. Also, infrastructure for energy production might be seen as visually disturbing or not fitting in the architecture of a community. Conflicts also appear

because of noise and strobe-like shading (e.g. wind turbines) or bad smell (e.g. biogas plants).

- **Agricultural land and forest:** The use of biomass for energy production as a waste product from forestry or agriculture increases the sustainability of these sectors. Moreover, additional value can be generated for farmers or forest owners. Energy production from RES that conflicts with agricultural production or forestry is questionable, for example the installation of PV panels on agricultural land. There is a need for national and regional discussion on whether agricultural land shall rather be used for food or energy production; in addition, the impact of non-building integrated PV panels on landscapes is considerable. However, in some cases a shared use of land resources is possible, such as the combination of wind turbines and pasture.
- **Touristic areas:** A differentiation between areas with a high intensity of tourism and remote areas that are visited for recreation and nature experiences needs to be made. Highly frequented touristic areas in the vicinity of cities/communities or within skiing areas might be less vulnerable than remote areas and therefore better suited for renewable energy generation. Production sites can sometimes even sustain the touristic attraction of a region (e.g. barrier lakes) and they can be more easily integrated into existing infrastructure (PV panels on hotel roofs, cabin lifts, between avalanche protection barriers). Especially skiing resorts offer opportunities for renewable power generation since the required infrastructure (e.g. high-voltage supply, access roads/transportation, water reservoirs) as well as technically skilled staff are already available, the only thing missing is the production unit. Further, the landscape has already been technically transformed. Another aspect to be considered is that the demand curve of skiing areas with midday peaks in winter often matches the supply curves of wind power and photovoltaic energy production.
- **Extensively used land and nature conservation areas:** The exploitation of RES often conflicts with protected habitats or nature and species protection areas. In such cases, the use of RES has to be balanced carefully against the ecological values. Conflicting interests of different parties (farmers, NGOs, tourists, energy supplier) are naturally given and a ban of energy production in such areas is part of the discussion.
- **Remote areas:** In remote areas, the potentials of RES are often large, e.g. due to high irradiance or strong winds. However, the installation of production sites in remote areas usually requires the construction of additional infrastructure (access roads, electricity grids). In high altitudes difficult, very variable climatic conditions are an additional factor that reduces the attractiveness of such areas for energy production. Generally, the mountainous landscapes are associated with a high landscape value (e.g. «unspoiled» nature). Further, it has to be considered that in remote areas ecosystems are often rather fragile, being inhabited by unique, locally adapted species.

Not only are different landscapes differently suitable for energy production, but also do different types of RES vary in their space requirements and their production output per space unit. Further, each type of RES needs specific spatial characteristics for optimized energy output and conflicts with specific land use/nature protection interests.

Hydropower has a long tradition in electricity production in alpine countries. Since the priority areas for barrier lakes and production sites are often already in operation, the remaining development potential is limited in many regions today. By expanding existing production sites, the output generated can often be increased significantly with a minimal number of additional conflicts. In operation, the costs of electricity from existing power plants are relatively low, the installation of new systems, however, is quite expensive, which argues for an increase of the efficiency while maintaining or improving the ecological aspects of the existing facilities (Alpine Convention 2011). In some cases it is possible to triple the electricity output through modernization and expansion of storage capacity while the ecological situation was improved at the same time (CIPRA 2009:5 in Alpine Convention 2011).

Nowadays, energy from alpine hydropower has a high strategic importance for the European energy network because of its storage and regulating capacities. Thus, alpine hydropower energy guarantees the stability of nets and balances unstable and unpredictable electricity generation from wind and photovoltaic systems. The high added value of hydropower is accompanied by a great importance for rural development: water charges and taxes create revenues for the region and the municipalities (Alpine Convention 2011). However, the consequences of increasing hydropower generation have to be evaluated carefully in any case.

Suitable areas for **wind parks** are often located in the open land or on mountain ridges. Therefore, wind turbines are usually visible over large distances and are often seen as a disturbing element in the landscape. Because of the noise of rotor blades, installations must be placed at a certain distance from settlements. Also flying animals can be disturbed by the rotor blades. The spatial occupation of wind parks however is relatively low. In the alpine region, the wind speed shows considerable differences depending on the location, the surrounding mountainous relief, windward and leeward locations and also within the seasonal cycle (CIPRA 2002:5 in Alpine Convention 2011). Also, turbulence, snow and ice hamper the operation and maintenance of wind turbines in the alpine regions.

Since clear atmosphere and high irradiance possibly throughout the whole year is crucial for effective **solar power and heat generation**, locations at higher altitudes provide good conditions for solar energy. However, in some mountainous areas shadows from the mountains can be a disadvantage in comparison to the lowland. Solar thermal production is rather common for small-scale installations and therefore generally bound to existing buildings. PV panels for electricity production, however, could in principle be installed at any location with the right conditions. Nevertheless, the consumption of space for the installation is substantial. Estimations assume an annual electricity production of 90-170 kWh per m² of installed PV panels (depending on the technology)¹⁷. Particularly south-orientated hillside situations without mountain shadowing are suitable for the production of solar energy.

Biomass can be used for the production of electricity, heat or fuel. As long as the biomass resources stem from forestry or waste products (wood processing, agriculture, food waste), conflict potential seems to be rather low. District heating systems based on biomass use and private heating systems with wood chips/pellets are already common nowadays. They provide a good solution for alpine communities where wood is available locally. However, the amount of

¹⁷ Swissolar: <http://www.swissolar.ch/de/photovoltaik/technik/>

biomass accessible for energy production is limited. If biomass is used for energy production as a first priority, conflicts with other types of resource use are programmed, as for example the growth of energy crops competes with food production. Further, the growth of energy plants itself is very energy-intensive and consumes land resources. Concerning energy production from accessible waste products, transport distances and costs are an important issue.

Regarding the usage of **geothermal energy**, a differentiation has to be made between the direct use of geothermal heat by heat pumps (usually using probes and low-drilling) and the conversion of geothermal energy (usually hot aquifers and deep-drilling) into electricity in a power plant. Deep-drilling is more expensive and bares more risks, for example the risk of provoking earthquakes. Hence, the potential of this resource depends strongly on the geomorphological conditions and is limited to the areas where drilling is feasible. In settlement areas, especially the direct use of «surface-near» sources is suitable and already quite common. In some areas of the Alps warm water springs provide an additional source of geothermal energy.

Conflicts in the alpine area

In the alpine area, the potential for the production of renewable energy is still substantial. Environmental resources such as water, wind, solar irradiance, and biomass as well as spare land resources are abundant. Additionally, the positive impact on the regions' economies and the people could foster the use of the present natural resources. However, the use of natural resources for energy production in the Alps is linked to conflicts. This dilemma has already been acknowledged by the Alpine Convention (2011): *«[On the one hand] the regional added value, which is generated by the installation and the operation of renewable energy facilities, offers promising development options specifically for rural areas. The creation of jobs and the independency to imported energies are further major benefits. On the other hand, to develop renewable energies is a particular challenge in the Alps due to the vulnerability and topographic particularities of this region. It is obvious that a sensitive nature needs a sensitive care and thus a specific and adapted strategy based on local and regional conditions, which includes ecologic (potential impact on nature), topographic, economic (potential added value) and social situations»*.

For the alpine area, conflicts between energy production and other land use requirements are expected primarily with tourism, farming and nature/landscape protection. Further conflicts can arise in areas with strategic (e.g. military) infrastructures that may be disturbed by RES exploitation, namely by wind power. Concerning tourism, different types of touristic (land use) activities have to be differentiated. For some activities, which are dependent on infrastructure themselves, the combination of touristic use and renewable energy production might be perfectly possible and even increase attractiveness. Concerning other activities such as hiking or climbing, this is more difficult as tourists are looking for pristine landscapes and protected nature. Conflicts are expected to occur in connection with electricity production from hydropower, large-scale solar power or wind power. Heat production from renewables (in alpine areas mainly biomass, ambient heat and solar thermal) is assumed to be less controversial.

While analyzing possible conflicts between renewable energy production and other land use or nature protection interests, it might be helpful to illustrate the conclusions in a conflict potential matrix. However, not only conflicts should be assessed but also possible synergies, which exist for example between renewable energy installations and existing touristic infrastructure. It has to be stressed though that the result of such an analysis depends on the local characteristics and on

the characteristics of the specific energy generation project. In one region, for example, energy from biomass might conflict with agricultural production, while in another region synergies could be created.

The study commissioned by the Alpine Convention (2011) concludes that *«geographical and socioeconomic conditions vary significantly between the alpine regions. Therefore it is imperative for each alpine region to analyze carefully its strengths and weaknesses, opportunities and threats in the field of renewable energy production. The geomorphology of the Alps, the potential trade-offs with tourism and nature conservation and the economic prospects for individual regions should be carefully weighed up against each other»*. The following three main criteria have been identified to be influential in the decision of a community to extend local renewable energy production:

- technical possibilities,
- potential economic benefits and
- mentality of decision makers, stakeholders and population.

Therefore, it is crucial that any energy policy for the Alps takes into account these three factors.

3.1.2 Spatial planning of land use and protection

A possible approach to handle conflicts between land use and landscape protection has been proposed by the Swiss Academies of Arts and Science (2012). They suggest to classify spatial resources into priority areas for energy production, reserve areas and exclusion areas. Accordingly, energy production should take place mainly in the priority areas which are already used intensively, have a high energy production potential and relatively low conflict potential. In exclusion areas, e.g. habitat protection areas, the use of energetic resources should not be allowed. Energy production in reserve areas should only be accepted if no priority areas are available and if the production potential is rated higher than other landscape qualities.

In order to be able to categorize land resources, criteria allowing the assessment and comparison between use of resources and protective interests need to be defined. These criteria have to be well accepted by all involved parties, and the roles, e.g. between central government and regional authorities, need to be defined clearly as well. On such a basis, the authorities have the right fundamentals in order to develop their concepts adapted to local characteristics on how to deal with the land use versus protection conflicts. The coordination of regional planning with the development of renewable energy production would provide an important basis for better dealing with different interests.

The proposed approach suggests three main steps towards spatial planning of land use and protection regarding renewable energy production:

- (1) The potentials of renewable energy production have to be analyzed spatially.
- (2) Energy production and landscape protection have to be assessed and weighted against each other. Thus, the relevant criteria for an assessment need to be established.
- (3) Based on the assessment, spatial planning is able to manage land resources according to their priority for energy production or other uses. Planning – especially for electricity

production – should take place on a regional scale and integrate local stakeholders into the process.

Spatial analysis of renewable energy production potentials

The potentials of renewable energy production need to be analyzed by a geographically explicit assessment. Factors that are relevant in the analysis are, for example, soil cover, ecosystem types and habitats, protected objects or landscapes, steepness and inclination of the terrain, altitude, meteorological conditions, or existing infrastructure. Tools for such assessments have already been developed based on GIS (geographic information systems). One specific example amongst many others are wind-power-maps that show all potentially suitable sites for wind-power generation¹⁸. Similar examples include potential analyses for biomass use and photovoltaic production of electricity.

Establishing criteria for the assessment

Based on the previous step of spatial analysis, the most productive sites for renewable energies can be identified. In a next step, these areas need to be evaluated with respect to their conflict potential between energy production and landscape protection. For this assessment, accepted criteria and benchmarks have to be established in order to judge the benefits from energy production and landscape protection respectively and they have to be weighed up against each other. Guidelines for the assessment should on the one side help to define the priority areas for energy production and on the other side support the decision-making process of energy projects in favor of ecologically and socio-economically sustainable solutions.

A range of guidelines for the evaluation of renewable energies has been developed by different institutions throughout the alpine regions. The provided recommendations and the criteria/approaches for the assessment are presented in this chapter in a generalized way, extracting the main aspects that are valid for all types of RES.

The Alpine Convention has published common guidelines for the use of small hydropower in the alpine region (Alpine Convention, Platform water management in the Alps 2011). It is assumed that the suggested method can be well adopted for other types of renewable energy projects. The method is based on the assessment of the two factors «energy generation potential» and «ecologic value/value of the landscape». For both factors, criteria for the evaluation have been established. The two main factors (hydro-electrical potential / ecological and landscape value) of the assessment are weighed up against each other in the next step according to the following scheme:

¹⁸ As example, see wind power map for Switzerland: <http://www.wind-data.ch/windkarte/>

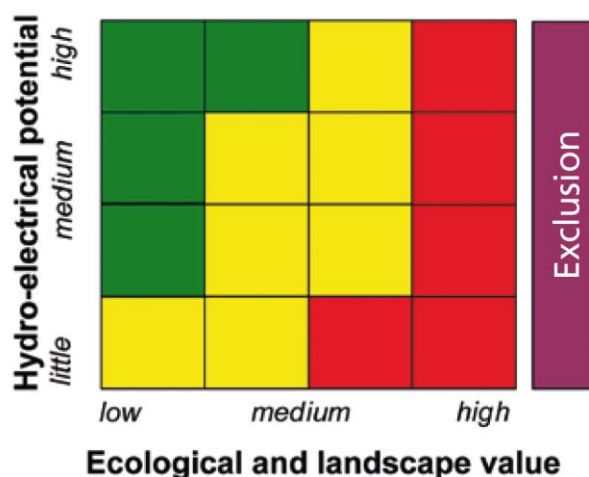


Figure 17 Assessment scheme for energy production / landscape and ecosystem protection conflicts (source: Alpine Convention, Platform water management in the Alps 2011)

The conclusions of the evaluation process described above need to be further specified according to local characteristics and project-related advantages and disadvantages. This includes on the one hand the evaluation of criteria regarding the production site (efficiency of production, costs of investments, possible synergetic effects). On the other hand, social and economic criteria such as effects on tourism and local economy, conflicts with other interests of resource-use or construction of additional infrastructure have to be discussed.

The authors of the cited study recommend that regional concepts should be based on common standards and general factors for the whole alpine area, but also integrate specific regional characteristics. In evaluation of the «best» production sites, the regional, strategic perspective should be combined with the local, project-specific assessment. The strategic development of a region is led by the responsible authorities. However, all interest groups should be integrated in a participatory approach in order to contribute to transparency and well-accepted solutions. Further, it should be discussed how to integrate the results of the evaluation process into national or regional planning instruments.

A regional concept for land use and protection

The Swiss Canton of Uri offers an example for regional spatial planning of land use and protection. With about 35'000 inhabitants and an area of roughly 1'000 km² it is a small mountainous canton affected by the typical conflict between energy production and other land use interests. A concept for land use and protection for renewable energies was developed over four years and adopted in 2013. The concept is based on national and cantonal jurisdiction, findings of previous research as well as the specific geographic conditions of the area. Although the generalization of these results can prove difficult, they can still be regarded as a good example and a place to learn how to develop a spatial planning for land use and protection for a mountainous area with its specific features.

The concept is part of the overall effort to establish a sustainable energy policy in Uri. By 2020 the energy consumption in the canton shall be reduced to 4000 Watt per person and year¹⁹.

¹⁹ The average Swiss primary energy demand is approximately 6'500 Watt

Combined with the Swiss national plan for energy transition the focus of the canton now lies on the use of RES.

To achieve these goals while minimizing the negative impact on other interests a concept for land use and protection for renewable energies was developed. This concept looks at the production of electricity through hydropower, solarpower and windpower, whereas the heat production – which is more a local topic – will be handled later on. These three RES were judged in terms of a) their potential for additional electricity generation, b) the amount of land necessary for the production and c) the economic consequences of such exploitation for the whole of the canton. In a next step specific areas were analyzed with regard to other interests such as nature and landscape protection, water conservation, fishery as well as tourism to finally distinguish the areas that are suited or not suited for energy production.

The largest energy potential was found for hydropower. Hydropower is already extensively used in Uri and plays an important role for the economy. Generally water power plants can also be installed with a reasonable effect on other interests, if done in the right places and in the right way. The gain from energy production through hydropower was balanced against other interests (nature and landscape protection, water conservation, fishery and tourism) to secure this last point. Broader areas, rather than single waters, were divided in categories: areas that are suitable for hydropower, areas for which increased, specific requirements have to be fulfilled and exclusion areas that shall not be used for the energy production.

In the concept it is concluded that the installation of PV panels in undeveloped areas requires the use of large areas while resulting in a modest energy production. The use of solar energy will therefore be restricted to developed areas. Relating to windpower, it proved difficult to estimate the energy potential with the existing data. Further, large parks with wind turbines may have severe negative effects on the landscape and potentially on tourism as well. After evaluating five potential sites for wind turbines it was concluded that windpower capacities should not be built in the canton unless decided so on the national or interregional level.

The final concept, adopted this summer, aims at increasing the planning security for future projects. Investors can rely on profound information which does not jeopardize area plans for the construction or the expansion of new hydropower plants by other interests. Further, the concept gives information on area specific measures that have to be taken into account to avoid conflicts. Thanks to the concept for land use and protection for renewable energies, new projects are expected to be realized in an efficient manner.

After the publication of a first draft the project faced some political challenges. The cantonal parliament expressed severe critique after not having been included into the process of development. Additionally, issues concerning property rights were discussed controversially, but could be solved at the end of the process.

The different levels of detail adopted in the concept are convincing. Hydropower was judged the most promising RES. Solar power in undeveloped areas was rejected already on a general level after estimating the low benefits and the high costs arising from extensive land use. Windpower appeared inappropriate with regard to the national evaluation of suitable locations. Therefore, a more detailed approach was followed to identify specific, suitable areas. Spatial planning for land use and protection should therefore start from a broader view and «zoom in» into a more detailed

view, where needed. Besides defining the role of interests such as nature and landscape, water conservation, and tourism, a concept specifically for land use and protection offers investors the possibility to focus on new projects with less uncertainty about possible conflicts with these other protected interests. It proved to be important to include all relevant actors into the development process and to consider all relevant aspects to ensure that such a concept will not face significant opposition.

3.1.3 Acceptance of renewable energies

A strategy for handling and possibly solving the conflicts between energy production and other forms of land use is the involvement of local population and interest groups in the decision-making processes. People have to be shown that a specific energy project generates value for the local community and that the negative effects are taken seriously, in order to increase the acceptance for renewable energy production in alpine areas. The involvement of all stakeholders might be facilitated if single projects are carried out within a broader concept, for example in so-called «Energy Regions».

Many energy regions in Europe were introduced in the last decade mainly to increase the production of renewable energies within a region by launching and supporting new initiatives and to reduce energy consumption by effective campaigns for end users. To achieve these goals, energy regions often aim at raising the acceptance for the production of renewable energies and at sensitizing the population to launch new initiatives for the production of renewable energies and the reduction of energy consumption.

Concerning the energy supply of mountainous communities, a decentralized supply system can already be observed and will become more prominent with the intensification of renewable energy production. Moreover, some communities or regions nowadays want to become «energy-autonomous» or «self-sufficient» communities.

Benefits and factors for the success of energy regions

The main reasons for creating an energy region are to increase the regional use of RES and to reduce energy consumption. In an Austrian study (Späth et al. 2007) possible benefits of energy regions were identified and analyzed. The authors especially highlight the infrastructural change. In the four Austrian energy regions considered the idea of sustainable energy consumption and production was translated into guidelines for public investment in infrastructure. By sensitizing the population and giving good-examples local authorities were able to foster private investments in RES. This caused a spread of investment possibilities as well as an increase in the population's awareness, which resulted in a positive continuative cycle.

According to the authors, important factors that are crucial for the successful development and operation of an energy region are:

- a critical size of the region so that sufficient financial means as well as know-how can be mobilized,
- a regional identity which increases the support of the local population and
- regional associations as well as a broad alliance of different political actors ensuring that the project will not be disapproved by a relevant part of the population.

Further, the economic benefits emerging from the use of RES to the region and its population enhance the acceptance for renewable energies. The local value creation is increased by a smaller outflow of money due to a higher self-sufficiency rate as well as potentially new jobs for the constructions and maintenance of the installations. The highest potential for value creations is given by the export of renewable energy and technology, know-how and services related to RES. For an increasing value creation some economic factors are decisive. Regional economic structures that are already somehow linked to questions of energy production and technology improve the economic chances of energy regions. High energy prices and low production costs as well as market access and especially grid access enable the region to sell energy and are therefore important factors as well. Finally, support from national government is often necessary to have sufficient financial means to invest in new initiatives (ARE 2012).

To sum up, the development of an energy region can enhance the population's acceptance of local renewable energy production. Societal factors, such as the identification of the population with the region, and the institutional design, e.g. the size of the region and the leading political actors, are crucial for the success that substantively depends as well on the economic conditions. Energy regions, however, do not replace overreaching energy policies as notions of «energy autonomy» at the level of regions could result in a non-coordinated development of energy production sites, multiplying the negative effects on landscapes and nature.

Energy cooperatives

An energy cooperative is a form of a corporate structure that enables private individuals and small local businesses to invest together into the regional production of renewable energy. They are often launched with assistance from local governments, local energy suppliers or regional banks. Often, financial support is required to launch a cooperative. For example, in Germany an estimated 34% of energy cooperatives receive public funds (DGRV 2013).

An example of an energy cooperative is «Vintl» in South Tyrol. A group of craftsmen decided in 2000 to found a cooperative in order to produce renewable and affordable energy for craftsmen businesses. As a result of the success of this initiative, the community of Vintl supported the cooperative which led to a massive expansion. Today, district heating which supplies 165 of Vintl's buildings is installed.

One driving force behind the emergence of energy cooperatives is the possibility for private persons to engage in the energy system transitions and to be part of the growing RES economy and community even with a small budget. In Germany about 125'000 private individuals have invested an estimated 426 million Euro into energy cooperatives and into RES (mainly PV and biomass) with a growing number in the last three years (DGRV 2013). By offering the chance for individuals with a small budget to benefit from the RES economy and at the same time to be part of a special community, energy cooperatives can increase the local acceptance of renewable energies of the population.

Economic benefits for local entities

The use of natural resources, e.g. water for hydropower, leads to an economic benefit for the companies exploiting the resource. The difference between the production costs (including the «normal» returns to investors and capital providers) and the revenues gained is called *resource*

rent. In some alpine countries, a part of this resource rent must be delivered in form of taxes or direct services provided to communities free of charge or at very low costs.

The acceptance of renewable energy production is very much dependent on the economic impact of such production to the local communities. Besides job-generation through the utility, the companies themselves or by stimulating the consumption of local goods and services generated by their employees as well as the partitioning of the resource rent between local, regional and national entities can play an important role for the acceptance of renewable energy production.

The system of water fees in operation since many years in Switzerland can serve as an example of such partitioning. Water fees are imposed per kW on the gross production capacity of hydropower installations and sum-up to 20-30% of the total production costs. The fees are often split between the canton and the local entities, generating up to 50% of overall revenues for some alpine municipalities. This leads to massive financial incentives to promote the use of local hydropower potentials. To counter-balance these incentives, compensations for not using hydropower potentials are under some circumstances paid to areas which could potentially use hydropower for energy production but chose not to do so in order to conserve unique landscapes.

3.2 Workshop on Energy Production

On October 24 and 25, 2013, the second workshop of the Energy Platform took place in Lucerne (Switzerland). Delegates and experts from all participating countries of the Energy Platform were present and shared their knowledge, experience and expectations concerning renewable energy production in the alpine regions. The workshop focused on the conflicts between renewable energies and landscape protection as well as on social acceptance of renewable energy production in alpine communities. The targets of the workshop have been defined as follows:

- To discuss assessment methods and success factors in dealing with interest conflicts concerning renewable energy resources in the alpine area.
- To exchange experiences and strategies regarding social acceptance of renewable energies in the Alps.
- To provide a fundament for the report on behalf of the XIII. Alpine Conference.

Two input sessions on «balancing landscape protection and energy production» and «strategies for enhancing public acceptance of renewable energies» were framed by an introducing keynote on climate change impacts in the Alps and a final panel discussion.

In her introductory speech Mrs. Prof. Lučka Kajfež Bogotaj presented the main findings of the fifth IPCC assessment report and the consequences for renewable energy production in the alpine area. In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years. Climate change might affect alpine areas, causing, for instance, the loss of glacial surfaces or the decrease in spring snow cover. Such changes in the climatic system could have an impact on the availability of natural resources and thus, indirectly, on renewable energy production. Hence, the future effects of climate change have to be considered when the potentials for renewable energy production in the Alps are assessed.

In the following sections the inputs and lessons learned of the workshop on energy production are summarized. The summary includes strategies and examples presented and discussed at the workshop (see Table 1). The sections are structured as follows:

- Conflicts of renewable energies, land use and protection (chapter 3.2.1)
 - Assessment methods to evaluate conflicts and solution approaches
 - Handling interest conflicts in the alpine region
 - Public acceptance of renewable energies in the alpine area
- Discussion and conclusions (chapter 3.2.2)

Country/Organization	Presentation title
Germany/German Federal Environment Agency	Renewable energies and landscape protection in Germany
Slovenia/HSE (Holding Slovenske elektrarne)	Sustainable energy: Problems and challenges in investments
Italy/Department for Environment, Autonomous region of South Tyrol	Renewable heat production in South Tyrol
University of Liechtenstein, Chair for Sustainable Spatial Development	Making «100% Renewable» acceptable – Lessons from the Lake Constance - Alpine Rhine Energy Region
Alpine Space Project, Recharge Green	The bearded vulture, untouched alpine landscapes and sustainable tourism
France/National research institute of science and technology for environment and agriculture, Grenoble	Energy and wood in the French Alps – Strategies for an uncertain resource
Switzerland/Office of the environment, Canton of Uri	Protection and Utilization Concept Renewable Energy Sources (SNEE) of Canton Uri
Austria/Alpen-Adria Universität Klagenfurt	Decentralized or centralized solutions for the Alps? Strategic reflections in the framework of the Austrian Energy Strategy
Swiss Academies of Arts and Sciences	Conflicts of renewable energies and land use – solution approaches from the example of Switzerland

Table 5 Overview of the presentations held at the Energy Platform Workshop 2

3.2.1 Conflicts of renewable energies, land use and protection

Assessment methods to evaluate conflicts and solution approaches

The discussions of the workshop made clear that there is broad consensus about the need to establish generally accepted criteria and evaluation methods for the assessment of conflicts between renewable energy production and landscape protection. The representatives of the alpine countries discussed basic principles of the assessment methodology for the evaluation process, as described in an exemplary way in chapter 3.1.2. The examples from the alpine countries presented during the workshop showed that there are similar approaches already being applied in practice. However, there are no common methodological standards established yet.

The Recharge Green project of the Alpine Space Program is currently researching the impacts and the interactions of renewable energy production in the Alps. In the project's assessment methodology, the concept of ecosystem services (e.g. hazard protection, recreational values, carbon sequestration, agricultural production) is applied in order to describe interactions of renewable energies with the alpine landscapes and different land use interests. The project

outcomes suggest to look not only at conflicts but to assess also potential positive interactions. Currently, the Recharge Green project is developing a decision support tool based on a GIS application. As an approach to involve local stakeholders in the decision making process, the «sample hectares concept» was presented, which might help to better understand the effects of renewable energy production and discuss them with the affected stakeholders.

The Swiss Academies of Arts and Sciences developed a comprehensive approach to solve conflicts between renewable energies and land use. Three main steps are suggested: Firstly, the priority of development should concentrate on sites with low conflict potential. Secondly, existing infrastructures should be used as production sites whenever possible. And thirdly, technologies with low conflict potential should be prioritized. Regarding criteria for the assessment, priority criteria and exclusion criteria are differentiated. Priority criteria include the suitability for energy production, the vicinity to customers and synergies with the local economy. Exclusion criteria are the protection status (depending on the degree of protection) and values of nature and landscape. The current intensity of land use as well as the reversibility of the project's intervention can be attributed to both categories of criteria. This allows a categorization of the landscape into priority areas, exclusion areas and reserve areas. As political measures the Swiss Academies of Arts and Sciences suggests to further integrate energy production into spatial planning; to support initiatives or labels by providing a clear definition of such labels; and to enhance research. As a proposal to the Energy Platform they suggested to develop a reference document for the alpine area which identifies potential conflicts and synergies in the Alps, proposes strategies for solutions and discusses measures and examples.

An important aspect discussed at the workshop valid for any evaluation method is the need to integrate economic aspects into the assessment process. Some exemplary questions that should be answered with this regard are the profitability of a project, the revenues created for the local community/economy or the costs of energy production. Concerning energy production from biomass, especially wood, the profitability of the whole wood processing chain appears to be an important aspect that requires consideration. Hence, the value creation chain should be taken into account in order to support the economic sustainability of resource use.

Handling interest conflicts in the alpine region

The different contributions have shown that there are still large, so far unused potentials for renewable energy generation in the different alpine regions. Various approaches on how to assess these potentials and how to handle interest conflicts have been discussed.

In the future electricity supply of Germany, wind power will play a key role. There is a high potential for onshore wind power generation, also in the southern, mountainous regions. Taking a closer look at the potential production sites, the German Federal Environment Agency identified that many are situated within the borders of protected landscapes, which often expand over large, continuous surfaces. As wind turbines are considered by German law as privileged projects outside of settlement areas, the planning authorities have to reserve substantial space for wind power generation. Generally, wind turbines are not allowed in nature conservation areas, national parks and the sensitive areas of biosphere reserves. In the transition zone of biosphere reserves, landscape protection areas and nature parks wind energy generation is possible, depending on the purpose of protection. In order to evaluate the tolerable production sites within such areas, a new approach called «zoning-concept» was applied. Using this zoning method, a small-scale

differentiation between tolerable zones and exclusion areas for wind power can be implemented. However, the concept only provides recommendations for the planning process; the final permission remains a case-by-case decision. Further, any intervention in nature and landscape must be compensated, either by direct compensatory measures or by a monetary compensation which will be invested in nature protection projects.

In Slovenia, large potentials for hydropower generation by run-of-river power stations are still available. Current projects addressing the usage of these resources are concentrating on the Sava River, which offers a production potential of 2'800 GWh/a. Many sections of the river flow are crossing Natura2000 sites. Hence, the effects of hydropower projects on the ecosystem need to be evaluated carefully. In the realization of the energy projects, compensation measures, such as the revitalization of the river basin or the construction of fish bypasses, are taken. An important argument supporting the projected power plants is the multifunctionality of the projects. Besides the priority goal of energy production, several additional targets are integrated into the hydropower projects. These include for example flood protection measures, improved ground water management or the development of local infrastructure.

The approach of the Swiss Canton of Uri, that developed a spatial concept for land use and protection for renewable energies in order to support regional spatial planning and deal with interest conflicts regarding energy production, has been presented in chapter 3.1.2. In the discussion at the workshop, it was stressed that the focus had been set on the use of few but selected rivers with high energy production potential, allowing the protection of sites with lower potential and the preservation of large-scale, continuous ecosystems. In the evaluation process of possible hydropower sites, the production potential and the ecological values were assessed. It resulted that weighing up trade-offs between these two alternatives was a crucial step of the process. A discussion of their advantages and disadvantages between involved experts and authorities is required in order to reach a consensus. The owners of land and water bodies of protected sites are compensated for their resignation of use. The terms of the concept have been secured by contracts between the canton and the land owners.

The project of the «Lake Constance - Alpine Rhine Energy Region» aims at demonstrating that the «100% Renewable» vision can be made true. It comprises the surrounding area of Lake Constance of 15'000 km². The main goals of the project are to show

- that 100% renewable autonomy can be achieved within 15-35 years,
- that the region can be managed as a carbon sink,
- that costs are below 200 Euro per inhabitant and year
- and to create significant regional income and jobs.

The projects approach is to work with the specific spatial characteristics of the region and to produce spatially explicit results. In the model, city and landscape prototypes are defined. For these categories, the present and future energy demand is assessed on the one hand. On the other hand, the efficiency potentials as well as the renewable energy production potential are identified. Based on this information, the autonomy potential, greenhouse gas emissions and cost performance can be evaluated for different scenarios. The results showed that, depending on the

scenario, local thermal energy production can be increased substantially and that concerning electricity, autonomy might be reached by 2050.

Public acceptance of renewable energies in the alpine area

In the discussion on how to support the acceptance of renewable energies by the affected communities, two main aspects became evident. First, it is necessary to involve the population in the decision making process and provide people with the opportunity to become personally active. Second, positive effects of energy projects on the local economy are crucial and revenues need to be shared with the communities.

Regarding the first aspect, the necessity of a cultural change to make the energy transition possible has been proposed by several speakers; especially in South Tyrol, a cultural change is strongly promoted already today. It was suggested that a change in communication is also necessary; hence, telling people what they can do to support sustainable energy supply instead of telling them what not to do.

Local communities can be involved in renewable energy projects by the creation of energy cooperatives (see chapter 3.1.3) or similar forms of public participation. Successful examples of this approach have been presented by Austria, France and Liechtenstein. On the one hand, energy cooperatives lead to the active involvement of people in the projects; on the other hand, people can profit financially from the revenues of energy production.

Another example of a strategy to share economic benefits with local communities is the system of water fees (s. chapter 3.1.3). In the discussion it was mentioned that many communities in the alpine region profit substantially from water fee revenues. These financial benefits help preventing the emigration of the mountainous population. Hence the question must arise whether similar approaches are to be implemented for other types of renewable energy production as well. The participants of the workshop agreed that it is necessary to change the general perception of renewable energy production from «cost factor» to «income source».

On a regional level, communities can create a chain of regional value added. This includes the production of technical components, the planning and installation of production sites, servicing as well as strategic operation of plants.

In many regions, the concept of «energy autonomy» or «100% renewable» is proposed in order to become independent and strengthen local economy. However, the notion of autonomy was critically discussed at the workshop, indicating that these declarations are rather useful as political catchwords and are not holding true when energetic balances are studied in detail (especially when discussing energy imports in products). Some participants stressed that «real» self-sufficiency in the alpine area would only be possible in case of a significant reduction of energy and general consumption.

3.2.2 Discussion and conclusions

Concluding on the statements and discussions at the second workshop, the need of having common guidelines and relevant criteria to better deal with conflicts of renewable energies and landscapes and to enhance social acceptance of renewable energy production in the Alps became clear. There was consensus on the basic methodological approaches. However, the

approaches need to be elaborated more in-depth and the implementation in the specific alpine context has to be defined.

The use of existing infrastructures as well as landscapes and technologies with low conflict potential as a first priority could be defined as a principal for renewable energy production. Based on an alpine-wide approach, the trade-offs between use and protection could be evaluated both on the large-scale as well as from the local perspective. Thereby, the concept of ecosystem services might be useful and both hard and soft criteria should be applied in the evaluation, since pondering benefits and disadvantages from the views of different stakeholders will always be necessary. Further, some participants deemed it useful to assess the energy generation potentials throughout the whole alpine area in order to facilitate the coordination of production between different regions and allow the use of synergies.

From an economic perspective, it will be crucial that the alpine regions manage to position themselves with their characteristic strengths on the energy market. The renewable energy production potential and especially the large regulative capacities of hydropower plants will become even more valuable in the European energy market of the future. Therefore, the Alps should make sure that these goods can be sold at the highest possible price and that a substantial part of revenues remain in the region itself.

Finally, the participants agreed that thinking should not be limited by regional or national borders when solutions for the sustainable use of renewable resources in the Alps are developed. Hence, the establishment of common «energy visions» for the whole alpine area on the issues discussed is suggested as a task for the community of the alpine countries. Such a process could also foster the exchange of knowledge and experiences between the various regions and give useful impulses to the rest of Europe as well.

3.3 Current situation and planned development of renewable energy production at the national level of the alpine countries

As an important basis for the reflections in the previous chapters and to promote the discussion during the workshop, in the following the current situation and planned development of renewable energy production is described for each member country of the alpine convention participating in the Energy Platform (Austria, France, Germany, Italy, Liechtenstein, Slovenia, and Switzerland). The information presented below is taken mainly from the IEA country-reports on energy policies, Eurostat statistics and other publicly available sources (see also chapter on Literature).

3.3.1 General view

To provide a first general view, the following tables and figures summarizes the most important facts concerning primary energy production²⁰, primary renewable energy production²¹ and final

²⁰ Any kind of extraction of energy products from natural sources to a usable form. Primary production takes place when the natural sources are exploited.

²¹ Primary production of biomass, hydropower, geothermal energy, wind and solar energy are included.

energy consumption²² for all alpine countries. More detailed information is provided afterwards, in the chapters on each country.

Country	Total production of primary energy [TWh/a]	Total final energy consumption [TWh/a]	Primary production of RES [TWh/a]	RES production as % of total primary production	RES production as % of total final consumption
Austria	134	318	97	73%	31%
France	1'569	1'722	208	13%	12%
Germany	1'447	2'408	364	25%	15%
Italy ²³	371	1'422	155	42%	11%
Liechtenstein	0.13	1.31	0.13	100%	10%
Slovenia	44	58	11	24%	18%
Switzerland	146	255	58	40%	23%

Table 6 Total renewable energy production in TWh/a per country in comparison to primary energy production and final energy consumption. Data basis: 2011 (Switzerland 2010). Data sources: Eurostat, Energiestatistik 2011 Liechtenstein.

For some countries more recent statistics might be available from other sources. To ensure comparability the same data source was used for all countries, wherever this was possible. In the following country-specific chapters data might therefore slightly differ from the numbers presented in the table above.

The following figures show the shares of different renewable energy sources (RES) on total renewable energy production per country and the share of renewable electricity production per country. Both figures reveal the heterogeneity of the different countries concerning the current situation of renewable energy production.

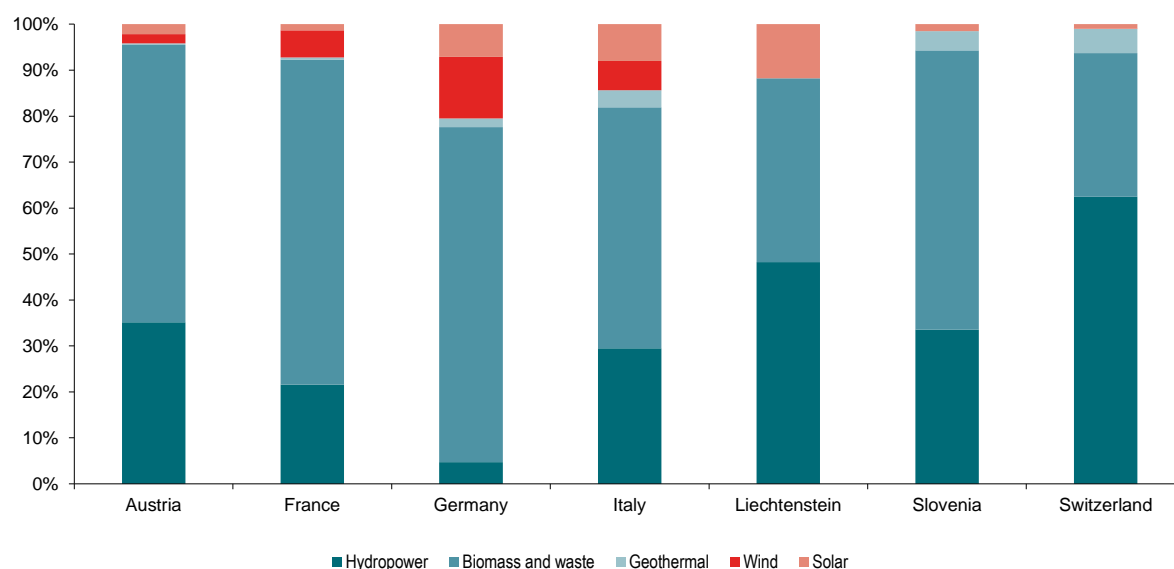


Figure 18 Shares of hydropower, biomass and renewable waste, geothermal, wind and solar on total renewable energy production per country. Data basis: 2011 (Switzerland 2010). Data sources: eurostat and Energiestatistik 2011 Liechtenstein

²² Final energy consumption includes all energy delivered to the final consumer's door.

²³ The data from eurostat on geothermal energy was validated and amended by using Italian statistics (Rapporto Statistico 2012, Settore Elettrico, GSE) .

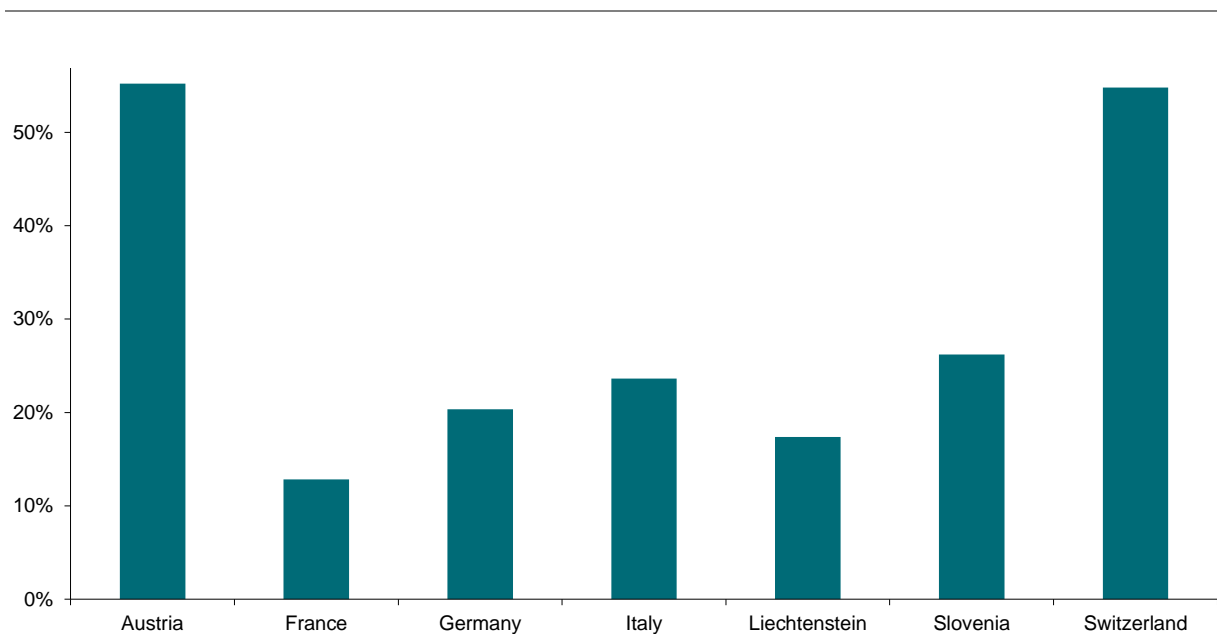


Figure 19 Electricity production from renewable energy sources (RES) as percentage of the gross national electricity consumption. Data basis: 2011 (Switzerland 2010). Data sources: eurostat and Energiestatistik 2011 Liechtenstein

3.3.2 Austria

In Austria, renewable energy production was 8 Mtoe (97 TWh) in 2011, 73% of the primary energy production and 31% of final energy consumption respectively. The largest share of renewable energy sources (RES) is biomass and wastes, followed by hydropower. Concerning electricity production from RES, 55% of the gross national electricity consumption is covered by renewable production. Hydropower is the main source for renewable electricity generation.

The Austrian government plans to more than double the contribution of renewables to the energy supply by 2020. The specific targets according to the government's program for 2007-2010 include the following:

- Increase of renewables in total energy supply to 45% by 2020.
- Increase of the share of domestic electricity production from renewables to 85% by 2020, compared to electricity production of 1997.
- Switch of at least 400'000 households to renewable energy carriers by 2020.
- Increase of alternative fuels in the transport sector to 20% by 2020.
- Development of a master plan for the optimal use of hydropower.

3.3.3 France

In 2011, renewable energy production in France was 18 Mtoe (208 TWh), corresponding to 13% of the primary production and 12% of the final consumption. The largest contribution to renewable energy generation stems from biomass and waste (71%), followed by hydropower (22%). Solid biomass²⁴ is the most important source for renewable energy in France and it is mainly consumed

²⁴ Dry or dried plant material

for heating by private households. France ranked second in the production of biofuels in the European Union in 2007. Electricity production from RES covers 13% of the national electricity consumption. Hydropower accounts for the main share of renewable electricity production.

France accounts for the second-largest wind power potential in Europe. Hydropower is not expected to increase significantly in the future because of environmental restrictions for the remaining potential production sites.

According to France's renewable energy action plan, the target for renewable energy production is to cover 23% of the final consumption by 2020. The French government is planning to invest heavily in solid biomass, wind power and biofuels. These objectives are specified as follows:

- Heat from RES: 19.7 Mtoe (230 TWh) in 2020
- Electricity from RES: 12.9 Mtoe (150 TWh) in 2020
- Biofuels: 4 Mtoe (47 TWh)

In order to reach these targets, the French government is encouraging the regions to set up their own climate and energy plans and targets based on the regional technological and geographical potential. These programs define zones for wind energy deployment and express the need for additional investments in electricity distribution grids in each region. The mechanisms defined by the renewable energy action plan include feed-in tariffs for RES electricity plants, tender schemes for renewable energy plants, income tax credits schemes for households and tax exemptions for biofuels.

3.3.4 Germany

The energy production from renewable sources was 31 Mtoe (364 TWh) in 2011, corresponding to a share of 25% of total primary energy production. The highest contribution (73%) stems from biomass and waste, followed by wind, solar, hydropower and geothermal energy. Electricity production from RES covers 20% of the national electricity consumption.

The government projects that the contribution from renewables will increase substantially by 2030. Biofuels and waste are expected to provide the greatest contribution. For wind and solar power a significant growth rate is predicted while hydro and geothermal-power are expected to grow more slowly. The long term goals are to provide 60% of the energy consumption from RES by 2050. In electricity generation, the share of renewable sources shall reach at least 35% by 2020 and 80% by 2050. The largest increase in renewable electricity production is expected to come from wind power.

3.3.5 Italy

In Italy, RES production was 13.6 Mtoe (158 TWh) in 2012, accounting for 46% of the country's primary energy production. The largest share of about 50% of renewable energies is produced from biomass and waste, followed by hydropower (26%) and solar energy (12%). Electricity production from RES, mainly from hydropower, solar and wind energy, covered 28% of the electricity production in 2012. The installed capacities for wind and solar power generation have been developed strongly in the recent past. The production from wind power grew from 9.1 TWh in 2010 to 13.4 TWh in 2012. The growth of solar power production is even more impressive, developing from 1.9 TWh in 2010 to 10.8 TWh in 2011 and reaching 18.9 TWh in 2012.

Italy has adopted the following main incentive mechanisms in order to promote renewable energy production:

- Priority access to the grid system is granted to electricity from RES and CHP²⁵ plants.
- An obligation for large electricity generators and importers to feed a given proportion of RES into the power system.
- Tradable green certificates are used to fulfill the RES obligation.
- Production from small plants benefits for 15 years from fixed feed-in tariffs or premium tariffs.

Some regional and local entities have introduced measures to support heating from renewable sources. They include incentives for solar thermal heating and compulsory installation of solar panels in new or renovated buildings.

3.3.6 Liechtenstein

Liechtenstein's energy supply is based mainly on imports. About 10% of the energy consumption can be covered from local production, which is almost entirely renewable (except electricity production from natural gas). The most important resources are hydropower (48%) and biomass²⁶ (40%); solar energy covers 12% of renewable energy production in 2011. Regarding electricity production, 90% is produced by hydropower, 9% is produced by photovoltaic. Renewable heat production is based mainly on wood with 85% and on solar thermal energy with 15%.

The energy strategy of Liechtenstein defines the target of covering 20% of the energy consumption by renewable energy production until 2020. The potentials of renewable resources such as solar and wind energy, wood and biogas and geothermal energy should be increasingly used. Especially in the building sector measures will be taken in order to extend the use of RES, e.g. heating with wood or solar thermal energy.

3.3.7 Slovenia

Renewable energy production in Slovenia relies mainly on biomass (61%) and hydropower (34%). The total production of renewable energy was 1.0 Mtoe (11.5 TWh) in 2012, corresponding to 28% of indigenous energy production and 20% of final energy consumption.

33% of the electricity consumed in 2012 was produced from renewable sources. Hydropower generates about 27% of the total electricity production (in 2012). Sharp increases in renewable electricity generation were recorded lately in photovoltaics and biogas. Hydropower still accounts for around 90% of the total electricity generated from renewable energy sources, followed by biomass with 6% and photovoltaics with 4%.

Slovenia has prioritized the development of renewable energies, in particular biomass, geothermal and heat from waste. Hydropower capacities shall be enlarged extensively: seven new plants are planned to be built by the year 2018 and additionally eight new plants by 2030. Further, there are four major wind farms expected to be commissioned by 2015.

²⁵ Combined Heat and Power

²⁶ Biogas and wood

The new Slovenian Energy Strategy will focus on renewable energy sources, energy efficiency and GHG emissions with the objective of meeting the European climate and energy targets for 2020 and 2030 on a national level, with a further outlook to 2050.

In order to promote renewable energy sources, the following support mechanisms (among others) are implemented in Slovenia:

- Feed-in tariffs for renewable electricity generation.
- Investment subsidies and low-interest loans for projects for renewable energy generation.
- The Eco Fund provides grants for investments in the use of RES in one-family and multi-family houses by residents, environmental investments and projects by legal entities.

3.3.8 Switzerland

In Switzerland, RES contribute 40% to the primary energy production corresponding to 5 Mtoe (58 TWh) produced from renewables in 2010. The main shares are contributed by hydropower (62%) and biomass / waste (31%). Because of the country's large share of hydropower, more than half of the electricity consumed is produced renewably. Biomass and waste contributes a small share to the electricity production; the shares of wind and solar power are very small. Concerning heat production, about 15% of the total thermal energy consumption is produced from renewable sources. Fuel wood contributes roughly half of the renewable heat production. The additional shares stem mainly from municipal and industrial waste incinerations as well as from heat pumps.

According to the federal government's energy strategy, to be discussed in parliament soon, the share of RES in the electricity production should be increased significantly, taking into account the planned phase out from nuclear power generation in the near future. The goal of the energy strategy 2050 is to increase renewable electricity production (*without* hydropower) to 14.5 TWh per year by 2035, and to 24.2 TWh per year by 2050 respectively. Electricity production from hydropower should reach 37.4 TWh per year in 2035 and 38.6 TWh per year in 2050.

One of the most significant measures to promote renewable energy are feed-in tariffs, applying to all renewable electricity production technologies. More measures for promoting renewable energy and efficient electricity usage are currently being discussed in the parliament. According to inter-cantonal recommendations²⁷, at least 20% of the total heating energy in new buildings should come from renewable sources.

²⁷ MuKE: Mustervorschriften der Kantone im Energiebereich

4 Energy systems

With regards to the development of the energy system in the alpine regions, the opportunities and challenges will be discussed in the following chapters, both from a transnational perspective (chapter 4.1 and 4.2) as well as from a more regional point of view (chapter 4.3). The inputs and findings of the third workshop are presented in chapter 4.4, and chapter 4.5 provides an overview of the current state for each member country of the Alpine Convention participating in the process of the Energy Platform.

4.1 The transnational perspective on energy systems in the Alps

From a transnational perspective many of the challenges regarding the energy system in the alpine countries are similar and interconnected and need an international approach in order to be solved. In the current transformation process of the European energy landscape towards a higher sustainability – as is the goal of all member countries of the Alpine Convention – two aspects of the European energy system are in the focus of the debate. Firstly, the development of the electricity grid in order to meet the requirements of a more renewable European energy landscape and secondly, the energy storage capacity, especially of pumped storage, which could play an important role in balancing the electricity system. These two aspects are certainly most relevant for the alpine countries and will therefore be further discussed in the following chapters.

4.1.1 The electricity grid

In order to meet the EU «20-20-20» goals²⁸ and eventually the future EU 2030 framework for climate and energy policies²⁹, many European countries are strongly pushing renewable energy production, especially electricity production from wind and solar power. Since these renewable sources are dependent on seasonal and daily weather conditions, the production patterns will become increasingly irregular compared to today's power production. In addition, production will often take place in greater distance from consumption, e.g. in the case of offshore wind parks. At the same time, the importance of decentralized feed-in of electricity, e.g. from rooftop photovoltaic panels. These developments lead to new challenges for the European electricity grid as electricity flows will be more variable both in time and direction. Moreover, in many countries the grid has reached the age at which reconstructions are necessary, irrespective of additional requirements.

To sum up, the European electricity grid needs to be further developed and transformed in order to provide the services needed for the future energy system. The alpine countries have to play an important role in this process, since the main transmission lines in the North-South direction (and vice-versa) run across the Alps.

²⁸ A 20% reduction in EU greenhouse gas emissions from 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20%; a 20% improvement in the EU's energy efficiency.

²⁹ The European Commission proposes the European Parliament to adopt the 2030 framework for climate and energy policies, mainly containing a 40% CO₂ reduction and a 27% renewable energies target (without an energy efficiency target).

4.1.2 The future European electricity grid

The future European electricity grid is being discussed on the transnational level in the EU «e-Highway2050» project with a time horizon of 30 years. Funded by the European Commission, the project aims at putting forward a Modular Development Plan, based on a long-term planning methodology which is able to assess the coming restructuring and expansion operations of the European power transmission system. The studies pave the way for an integrated European electricity market as well as for a pan-European grid that is capable of hosting large quantities of electricity from renewable energy sources and transporting it over long distances. The consortium of the project includes transmission system operators (TSO), research institutions, universities, utility companies and NGOs from all over Europe. It is one aim of the project to provide TSO with an appropriate regulatory framework in which they can handle future challenges and which will ensure the efficient use of existing transmission infrastructures and the implementation of new, efficient infrastructures (German Energy Agency 2013).

Already today, the Ten-Year Network Development Plan elaborated by ENTSO-E (European Network of Transmission System Operators for Electricity) offers an instrument for a pan-European network planning within a time horizon of 10 years. In addition, however, a methodology for the long-term period up to 2050 also requires that new technological solutions are taken into account, which is one of the main objectives of the e-Highway2050 project³⁰.

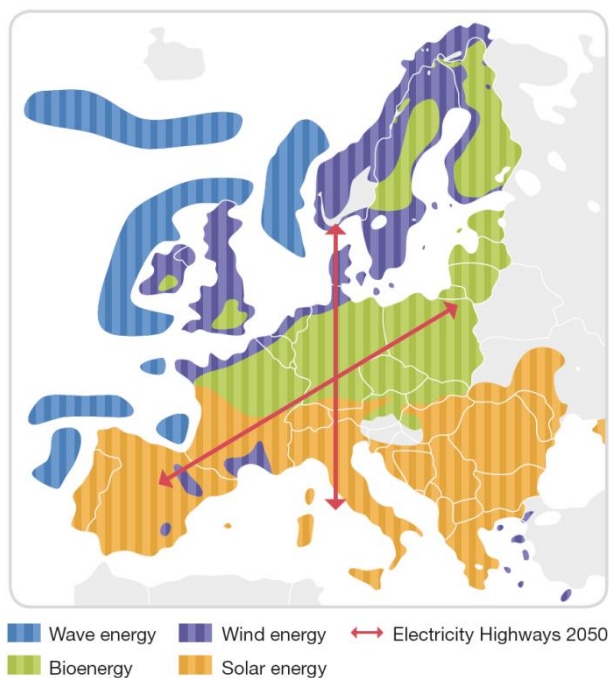


Figure 20 Illustration of the European electricity highways 2050 in view of (future) renewable energy production. Although this figure only shows a scenario of the future development, it becomes clear that the Alps are located in the heart of the «European grid» (Source: German Energy Agency).

Figure 20 provides an illustration of a possible 2050 European electricity landscape. However, this rough sketch of future North-South and East-West electricity «highways» shows only one scenario

³⁰ For more information on the objectives of the e-highway project see: <http://www.e-highway2050.eu/objectives>

of distributing renewable energy in Europe. Other alternatives of balancing production and consumption in the energy system will have to be discussed, for instance approaches to managing energy system more on a regional level. Even though this figure only shows one scenario of the future development, it becomes clear that the Alps are located in the heart of the «European grid». Hence, the question arises what the impacts of the changes of the European energy network on the alpine regions are and how alpine countries, regions and their citizens can represent their interests in this development process.

4.1.3 Development of the grid

In the past decades, the grid infrastructure in central Europe has been developed to provide electricity supply from mainly large-scale, centralized power production plants. In the future, the energy system will have to further integrate production from small-scale decentralized energy generation as well as from large-scale centralized renewable production in geographically suitable locations.

The energy policy of the European Union sets the goal of a European single energy market. Hence, it is assumed that the transnational energy flows will further increase. However, the existing capacities for cross-border energy transmissions are limited. Already today, there are several bottlenecks in the transmission system between European countries, which are expected to become even more prominent in the future. The European high-voltage network will have to be adjusted to these new circumstances as a common project of the European countries.

It can be assumed that grid development will be based to some extent on DC (direct current) power lines instead of AC (alternating current) lines, as this technology provides higher efficiency for power transmissions over longer distances. However, the electric current needs to be transformed from AC to DC and back, which requires expensive infrastructure and leads to conversion losses. Therefore, DC power lines are only suitable for large distance power transmissions of several hundred kilometers. In the context of the development of a powerful European high-voltage grid, the term «super grid» is often applied. In contrast, on the lower voltage level so-called «smart grids» - based on information and communication technology - are more suitable to coordinate supply and demand in the future (see chapter 4.3).

Europe aims at increasing the percentage of energy generated from renewable sources to 30-35% of all electricity consumed by 2020. It has also set the target of reducing emissions by 80-95% by 2050. A prerequisite for these ambitious goals is that renewable energies can be fully integrated into the electricity grid. The Renewables-Grid-Initiative (RGI)³¹ promotes the integration of 100% renewably generated electricity into the European grid and the build-up of a sufficient grid infrastructure in Europe for both decentralized and large-scale renewable energy sources. RGI members originate from a variety of European countries, as it consists of TSOs from Belgium (Elia), UK (National Grid), France (RTE), Germany (50Hertz and TenneT), Netherlands (TenneT), Switzerland (Swissgrid), Norway (Statnett) and Italy (Terna), as well as several NGOs. The Renewables-Grid-Initiative was launched in July 2009.

³¹ For more information see: <http://renewables-grid.eu/about.html>

In October 2013, the EU commission published a list of roughly 250 «projects of common interest» as key infrastructure projects in the energy sector³². The majority of the projects involve electricity and gas transmission lines, but also electricity storages, underground gas storages and LNG terminals. Two of the projects are smart grid projects. A lot of the projected transmission lines and pumped storage plants are located in the Alps. The «projects of common interest» should benefit from a number of privileges, such as accelerated planning and permit granting procedures, less administrative costs and increased transparency and improved public participation. From the point of view of the alpine regions, the question arises as to how the interests defined in the Alpine Convention and its protocols can be represented on the European level, also for privileged «projects of common interest».

4.1.4 Handling impacts and challenges of grid development in the Alps

The Alps are in the center of the current and the future European grid. Therefore, important questions arise, such as: What will be the impact of new power lines on the alpine landscapes and ecosystems? What kinds of benefits can alpine regions take from the grid development? How can new power lines be built in a socially acceptable way? How can the participation of the population in the planning process be guaranteed?

An often cited approach of minimizing the landscape impact of high-voltage power lines is underground cabling. However, the installation of underground power lines is very expensive and not without ecological impacts. Furthermore, it is a question of technical feasibility, especially in an alpine setting with generally shallow soils. Hence, underground cabling cannot solve all problems and the question of finding the «right» routes for transmission lines will remain essential.

In the evaluation of new power line projects (whether high-voltage long distance or low-voltage regional transmission), several aspects need to be considered. These include mainly spatial planning, environmental protection, project costs, technical aspects and the power supply itself. The Swiss Federal Office of Energy has developed an assessment scheme for power transmission lines, which shall be shortly presented (BFE 2013d). The assessment method allows for an evaluation of the best option if there are several project alternatives for a power line between two points of interest. It can be applied both to aerial and underground lines.

In this assessment methodology, four main fields of interest are considered (see Table 7). For each field of interest there is a set of criteria, which are evaluated for each project alternative. This approach provides an aggregated result of the assessment for every alternative, making the options comparable. In Switzerland, this evaluation scheme has become standard procedure in the planning approval process.

³² For more information see: http://europa.eu/rapid/press-release_MEMO-13-880_en.htm

Spatial development	Technical aspects	Environmental protection	Economic aspects
resource protection	grid operation	protection from immissions	real costs
protection of settlement area	security and responsibility	landscape protection	cost efficiency
integrating goals of spatial development	lifecycle	forest and biotopes	
		groundwater and soil	

Table 7 Assessment of power line projects: fields of interest and categories of criteria. (Source: BFE 2013d)

Acceptance of grid development projects

Grid development projects are often facing long time spans from the start of the planning process to the construction and operation. Especially for cross-border transmission lines, the authorization processes and the negotiations between countries might require several years. A crucial factor for every project is the acceptance by the population of the affected regions. If there is opposition from local communities or even from individual land owners, projects might be delayed significantly or even totally blocked.

On the European level, the Renewables-Grid-Initiative (see chapter 4.1.3) works on how to deal with public concerns and how to minimize environmental impacts within grid development projects. The «European Grid Declaration on Electricity Network Development and Nature Conservation in Europe» was signed in November 2011 by Europe's largest transmission system operators and environmental NGOs. The declaration clearly states that a renewables grid for Europe can and must be built in line with nature conservation objectives. Signatories commit to a set of principles on how to achieve this. The Renewables-Grid-Initiative also works on a second part of the Declaration which focuses on participation and transparency. It includes principles on how «people's concerns» should be incorporated and respected in grid expansion projects. This part of the Declaration will strengthen the coalition of stakeholders supporting grid expansion towards integrating renewables.

The Renewables-Grid-Initiative develops principles on how to increase local acceptance for new grid infrastructure and renewable generation sites through local stakeholder dialogue and tailored pilot projects. The controversial issue of (financial) compensation will also be addressed in view of different approaches across European countries. On the project website, «best practices» are shared regarding several topics of integrating social and environmental responsibility in grid development. As an illustrative example, conclusions found concerning «stakeholder engagement» and «environmental impacts» are depicted in the following table. It must be stressed, however, that not all countries are using the SEA method mentioned below (e.g. Switzerland is developing an alternative sustainability assessment concept, taking into account social and economic impact criteria, besides ecological ones).

Stakeholder engagement	Environmental impacts
Challenges: <ul style="list-style-type: none"> – A lack of resources can impede the engagement of both authorities and NGOs. – Engaging the overall public at a very early stage can be challenging since interest can be low if people don't feel affected. However, interest normally increases after major decisions have been taken. At this point, comments are harder to take into account for the planning activities. – The support of politicians can be unstable and dependent on the public opinion. Uncertainty normally increases before elections. 	Challenges <ul style="list-style-type: none"> – The capacity of environmental authorities plays an important role for environmental assessments. If they are overstretched, high-level assessments cannot be guaranteed. – The interpretation of requirements related to a Strategic Environmental Assessment (SEA) differs substantially from country to country. – Re-shifting the overall planning approach and front-loading major planning steps to the pre-application phase can limit the positive effect of Environmental Impact Assessments (EIAs) if they are carried out after major spatial decisions. – High quality environmental data is scarce in some countries.
Lessons Learned <ul style="list-style-type: none"> – To ensure that important concerns are sufficiently discussed in time it is important to proactively approach the public before major decisions are taken. – Through early consultation with the public and concerned organizations important local information can be obtained. – Formally agreeing with politicians on the rules of engagement and common objectives, e.g. via written Memoranda of Understanding can ease long-term relationships. 	Lessons Learned <ul style="list-style-type: none"> – The SEA can have positive impacts on the planning of grid expansions. While time has to be spent on thorough assessments, SEAs can be a time-saving investment for later stages. – It can have a positive impact on the assessments if transmission systems operators exchange their views to better understand how to run a successful SEA. – Local NGO involvement in SEAs and EIAs can yield valuable information about the specifics of areas under consideration. – The exchange of data used for projects can enhance both assessments and working relations with authorities. – Spatial planning techniques and sensitivity maps can help to minimize environmental impacts. – Going beyond the analytical requests of SEAs and EIAs and implementing additional measures can be highly beneficial for the environment and stakeholder relations.

Table 8 Challenges and lessons learned in dealing with stakeholder engagement and environmental impacts regarding grid development projects; SEA: Strategic Environmental Assessments, EIA: Environmental Impact Assessment (table cited from the Renewables-Grid-Initiative webpage).

The question arises as to how the alpine countries could use those lessons learned both to enhance local acceptance for new grid infrastructure and to minimize environmental impact.

4.2 Pumped Storage Hydropower

Today, various technical options for energy storage are known, with different storage potential and status of large-scale implementation (e.g. large-scale batteries, flywheels, compressed air storage, hydrogen storage or power to gas). Pumped storage hydropower has so far been one of the most powerful storage technologies for electric energy because of its large storage volumes and higher energy efficiency compared to other technologies (roughly 70% to 80%, which means that 20-30% of the energy is lost).

Since pumped storage hydropower is very alpine-specific and its future development of importance to the alpine area, the work of the Energy Platform in the context of energy systems has put a great focus on this technology. However, it should be kept in mind that the demand for further developing pumped storage capacities in the Alps strongly depends on the development of other storage technologies in the European energy system and on the degree of integration of the

sub-grids in a possible future European «supergrid». Therefore, the question must be answered which storage technologies should be implemented in which geographical region in order to optimize the transnational energy system whilst minimizing environmental impacts.

Hydropower is the most important renewable power source in the alpine countries and there is still potential for a future increase in production (depending on the region). Bearing in mind the need for balancing capacities, it seems obvious that pumped storage plants will become increasingly important in the future. This assumption could give the alpine regions a more important role in the development of the energy landscape of the 21st century. Due to its significant potential of pumped storage, the Alps are sometimes even called «the battery of Europe». Nevertheless, it must be critically reflected whether the potential of pumped storage can meet these requirements and whether the increase in storage capacities will foster a sustainable development of the alpine regions. Besides the electricity market framework (see explanations below), three further aspects are especially relevant in this context: First, the impact of pumped storage hydropower on aquatic ecosystems, mainly the effects of hydropeaking on the ecology of downstream rivers. Second, the fact that by storing electricity – even with the relatively efficient hydropower storage technology – roughly a quarter of the energy produced is lost and third, the impact of pumped storage infrastructure on local tourism.

4.2.1 The economics of pumped storage hydropower in the Alps

In general, the current conditions on the European energy market are not very favorable for hydropower. Electricity prices have been falling from an average of 70 €/MWh to around 40 €/MWh in the past five years (BFE 2013a). Moreover, coal and CO₂ emission certificate prices are extremely low, making it hard for hydropower to be competitive. Additionally, wind and solar power have benefited from subsidies and other advantages (e.g. privileged feed-in) in the past years. Given these circumstances, many projects for hydropower in Europe do not appear to be attractive today and have consequently been postponed. Asked about the reasons for postponing projects, hydropower operators named the economic situation as the main reason, followed by ecological and social concerns as well as restrictions regarding the concessions (BFE 2013a).

Specifically concerning pumped storage hydropower projects, the situation is even more complex. In the past decades, pumped storage hydropower plants have been able to count on quite stable frame conditions. During daytime peaks of consumption, the stored potential was converted into electric energy which could be sold at high prices. During the night, when energy from base load production of nuclear or coal power plants was available at low prices, the water was pumped back upwards into the storage basins. Nowadays, however, the mechanisms of the energy markets have changed and they will undergo even more significant changes in the future with the phasing out of nuclear power in some European countries and the additional feed-in of renewable energies. It is assumed that the patterns of production and storage from pumped hydropower are going to shift from the previous daytime/nighttime and weekday/weekend patterns to patterns with higher variability³³. For instance, if there is overproduction from solar power during midday, water will be pumped at this time of day. According to the operators the increase in flexibility and the

³³ The potentially also important shift towards more production during the summer months (mainly caused by additional photovoltaic energy production) is less important for the operations of pumped storage power plants, however, it could affect the production pattern of storage hydropower plants.

overall higher operating grade demanded by the variation in renewable energy production will clearly result in higher operating and maintenance costs for pumped hydropower plants (see VSE 2012b).

The development of existing and new pumped storage plants needs very large and long-term investments. The technical requirements are increasing (e.g. earthquake protection) and the renewal of existing concessions is an important cost factor. Since there are many uncertainties regarding the development of the energy market, it must be assumed that decisions about investment and construction will remain postponed. A study focusing on pumped storage hydropower plants in Switzerland reaches similar conclusions: From a medium-term perspective (2020), project risks for investors are relatively high; after 2020, however, it can be assumed that the profitability of pumped storage plants is going to improve significantly (BFE 2013b). This forecast is backed-up by other scientific analysis, e.g. from Germany (Enervis 2013). The long-term profitability of pumped storage will in any case be strongly affected by the development of other storage technologies, such as decentralized electricity storage.

4.2.2 Cooperation between alpine countries

As described above, the current market situation is not very favorable for long-term investments in pumped storage plants. On the other hand, the need for storage capacities will probably grow in the future. In view of these challenges, Germany, Austria and Switzerland have signed a common declaration and emphasized their intentions to support the development of pumped storage hydropower through a coordinated strategy. One major aspect of this declaration is to consider time pressure. The signing parties agree that the ambitious goals of the alpine countries to transform their energy systems can only be reached if the development of storage capacities starts in time (including project planning, approval procedures and construction, a considerable time horizon must be assumed).

4.2.3 Benefits and challenges for the alpine countries from pumped storage hydropower

Large investments in pumped storage plants will create important impulses for the economies and labor markets in the alpine countries. Hence, external investments might help to push the economic growth of certain alpine regions by generating new income.

Nevertheless, there is more to it than just the economic perspective. From the point of view of sustainable development, the question about the limits of development of (pumped) hydropower in the Alps needs to be answered. According to the NGO CIPRA, only 10% of the alpine river flows are in a sound ecological state. Therefore, the organization claims that the development of hydropower cannot take place at the costs of the environment (CIPRA 2011). Another issue concerns the expected increase of so-called «hydropeaking» when it comes to integrating very variable and small-scale energy production from renewable sources into the grid. River discharge can be affected strongly from these production facilities, with possible negative impacts on the habitat quality of aquatic species. Furthermore, the recently observed boom of small-scale hydropower plants is accused of large environmental impacts, especially based on the fact that the share on total production from small-scale plants is rather low.

It is very important that the concerned alpine communities can play an important role in the decision process and that the economic benefits of using hydropower and building new

infrastructure in the Alps are shared between the investors and the affected local population. Tools for such sustainable benefit-sharing are already in place in many alpine countries (e.g. by the instrument of water fees) and should increasingly be applied in the future. However, because monetary compensation cannot offset ecological and social impacts, the question of benefit- and burden-sharing has to be discussed in a more general way, going beyond financial compensation mechanisms.

Reflecting on the presented findings, the development of pumped storage hydropower seems to be in a critical phase. For alpine communities such projects can create significant benefits but also generate major losses in ecosystem diversity and touristic value of a region, together with the long-term dependence on external investors (electricity providers). Since the demand for storage technology is considerable, the right tools and concepts to support (pumped) storage hydropower and at the same time to foster the sustainable and long-term development of alpine communities must be found. Nevertheless, it has to be stressed that pumped storage hydropower will be just one part of a solution towards balancing the energy system. The claim for the Alps being the «battery of Europe» needs to be questioned. This is especially true regarding the negative ecological and social aspects of the development of pumped storage hydropower in the Alps and the challenges of developing the transnational transmission lines required to transport the electricity to and from the storage facilities in the Alps.

It might therefore be in the very interest of the alpine states and regions and their population to define a strong common position, taking into account economic, social and environmental sustainability, and speak up for «fair and sustainable» conditions for alpine (pumped) hydropower in the new European energy landscape.

4.3 Trends towards a regionalization of the alpine energy system

In contrast to the trends described in the previous chapters, where challenges regarding the future energy system need to be dealt with on an increasingly transnational level, a trend towards «regionalization» of the energy system can be observed in parallel. This trend describes the current development with rather small-scale renewable energy production from local sources as well as the development of strategies for improving the energy systems at the local level. Two aspects of regionalization and their relevance for alpine regions are discussed in the following chapters. One is the technology of district heating, providing communities with heat produced to a large extent from renewable sources and independent from imports. The other is the development of strategies in order to better balance the energy system regionally.

4.3.1 District heating systems in alpine communities

The technology of district heating provides one possible solution for communities to supply their heat demand on a regional level. District heating is quite well established already today and is applied in all alpine countries (to a different extent). Different power sources can be used for district heating; waste heat from incineration plants, other industrial processes providing waste heat or biomass as an energy source for heat production/co-generation. Also other renewable sources, such as solar or geothermal energy can serve as heat sources. In the alpine regions,

waste heat (incineration plants/industries) is usually only available in bigger cities/communities, whereas potential for biomass (wood) can also be found in more remote and/or touristic areas.

The feasibility of district heating for alpine communities strongly depends on the local frame conditions; e.g. whether there are sources of waste heat available or whether regional biomass production is able to deliver the resources for woodchip-fired district heating. If wood is used as a resource, the sustainability of the local forest management has to be ensured. However, not only the availability of heat sources is a crucial factor but also the structure of the settlements in the alpine area. Since the construction of heat pipelines and the installation of the heating systems are quite expensive investments, district heating is only economically attractive if there are enough buildings that can be connected to the grid within a certain perimeter. Hence, district heating is not a suitable solution for regions with scattered settlements. In addition, with more and more buildings being insulated, the number of buildings necessary for a district heating system tends to increase.

Moreover, for a district heating system the «key customers» (e.g. hotels, indoor swimming pools, hospitals, industries, or administrative buildings) are essential to ensure profitability. Large scale district heating networks are rather suited for alpine communities of a sufficient size and population (e.g. tourism hotspots) and for the industrial and economic centers. However, in some cases, small-scale heating networks over short distances can also be a viable solution for a smaller number of buildings. Another important factor is the question whether there is a continuous heat demand throughout the year. Energy supply companies are dependent on having a certain continuous base demand for heat. Especially summer demand, e.g. from hotels with spa or other sports facilities, can therefore improve financial viability.

A further advantage of district heating systems in the touristic regions of the Alps is that there is in some cases the possibility of combining heating and cooling applications, for example with sports facilities or hotels. Combined heating and cooling systems can reach higher energy efficiency compared to «conventional» district heating as they allow combining diverse heat sources and sinks in intelligent ways. The construction of district heating systems is often subsidized if heat is produced from renewable sources (including heat from waste) leading to the mitigation of greenhouse gas emissions. Local cooperatives might additionally play an important role in giving the right incentives or creating suitable frame conditions for a district heating project.

One additional benefit of district heating for alpine communities is that the revenues remain to a greater extent within the region, especially if wood from local forests is used as a power source or if a municipal energy supplier is operating the district heating system, which is often the case. In contrast, if heating systems are based on fuel or gas, resources have to be imported and the revenues are largely generated outside the alpine area. Another aspect is that district heating systems support alpine regions in becoming more efficient in using their own energetic resources. Furthermore, district heating might lead to a shortening of supply chains and therefore generating a higher sustainability of energy transportation.

District heating has become increasingly popular and there are various examples of projects from the alpine area. For instance, a district heating system fueled by wood chips in Dobbiaco and San

Candido in South Tyrol³⁴, the district heating grid of Saanen-Gstaad in the Swiss Canton of Bern supplying this touristic alpine region³⁵, or a district heating system in the community of Sonthofen in the Allgäu which is participating in the European energy award program³⁶, to name but a few. However, it should be stressed that district heating will be just one part of a more sustainable energy system, since the potential is technically and economically limited.

4.3.2 Balancing the energy system on the regional level

Demand and supply of electricity from renewable energy sources are steadily increasing, raising the requirements placed on electricity grids (see chapter 4.1.1). Looking at energy systems on a regional level, there are also challenges of balancing supply and demand. With more decentralized, very variable and small-scale energy production from renewable sources, the feed-in of energy to the transmission grid is a challenge. In the alpine area, distances to the national grid are usually large and the connection to the network complicated and costly. Therefore, it is a thought for discussion whether the energy system should rather be regulated to a higher degree on the regional level in order to avoid the need for establishment of the energy transport infrastructure. If a balance of the energy system could be achieved regionally, there might be less need for the development of transmission capacities, at least on a subnational level. Therefore, it must be discussed whether there might be other solutions on the regional level rather than the national level for matching energy supply and demand in the Alps. This includes the idea of a stronger cooperation of communities within an alpine region, even if they belong to neighboring countries.

One example of a technology that supports the regional balance of energy supply and demand is solar-thermal district heating. This technology allows for a combination of heat and electricity production with intermediate power storages, delivering heat produced from solar collectors to the customers. Hence, the system provides a possible regional solution to deal with peak production from renewable sources mismatching the actual power demand.

³⁴ See: <http://alpstar-project.eu/cna-form/district-heating-plant-of-dobbiaco-san-candido/>

³⁵ See: <http://www.holzenergie.ch/holzenergie/projektbeispiele/energie-contracting/fernwaermeversorgung-saanen-gstaad-im-einklang-mit-der-natur.html>

³⁶ See: <http://seap-alps.eu/hp1002/Sonthofen-is-the-first-pilot-city-in-the-Allgaeu.htm>

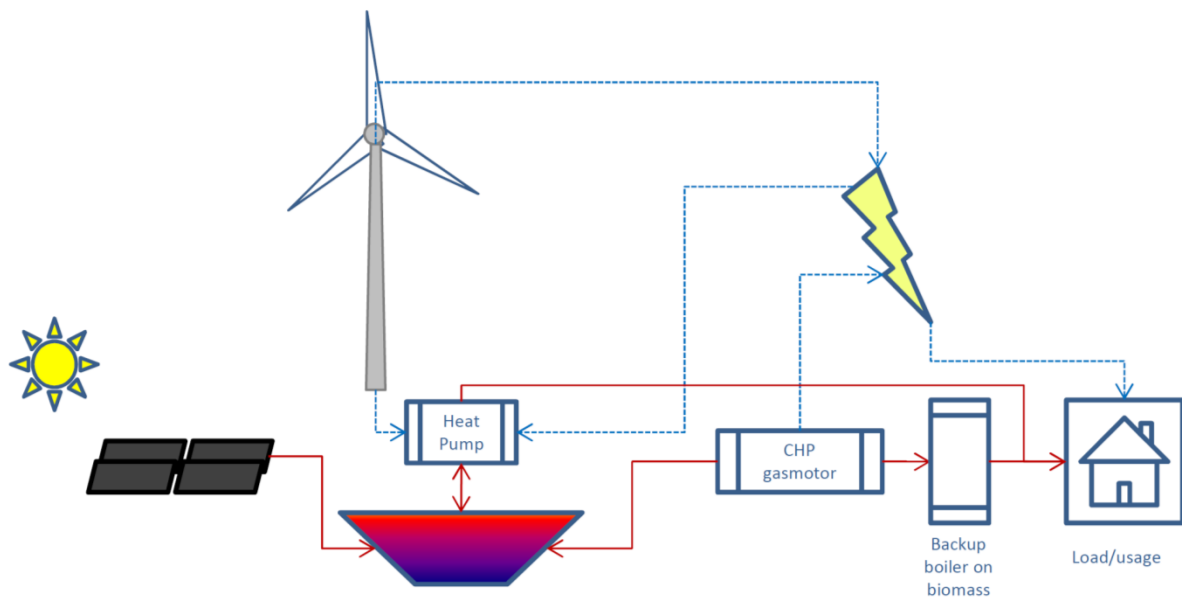


Figure 21 Illustration of the interconnection of solar thermal district heating and the power grid (Source: PlanEnergi)

However, this technology has considerable spatial impacts both because of the solar collectors as well as the heat storage basin. This might be an important challenge, especially the alpine area.

To cope with the increasing fluctuations in electricity production, transmission systems have to become smarter. A better balance needs to be established between production and consumption and grids need to become more automated. So called «smart grids» offer one possible solution to these challenges, both on the (trans-) national as well as on the regional level. They are based on a symbiosis of modern information and communication technologies, making the grid more efficient, reliable and easier to control.

The term «smart grid» is often used to subsume other «smart» technologies, such as «smart metering» (providing direct feedback to the customer and eventually giving the possibility to control electric appliances from a distance) or «smart feed-in» (sensors and intelligent systems as the basis for turning electricity production and storage systems on and off). The following figure illustrates the vision of a smart grid and the use of such «smart» technologies.

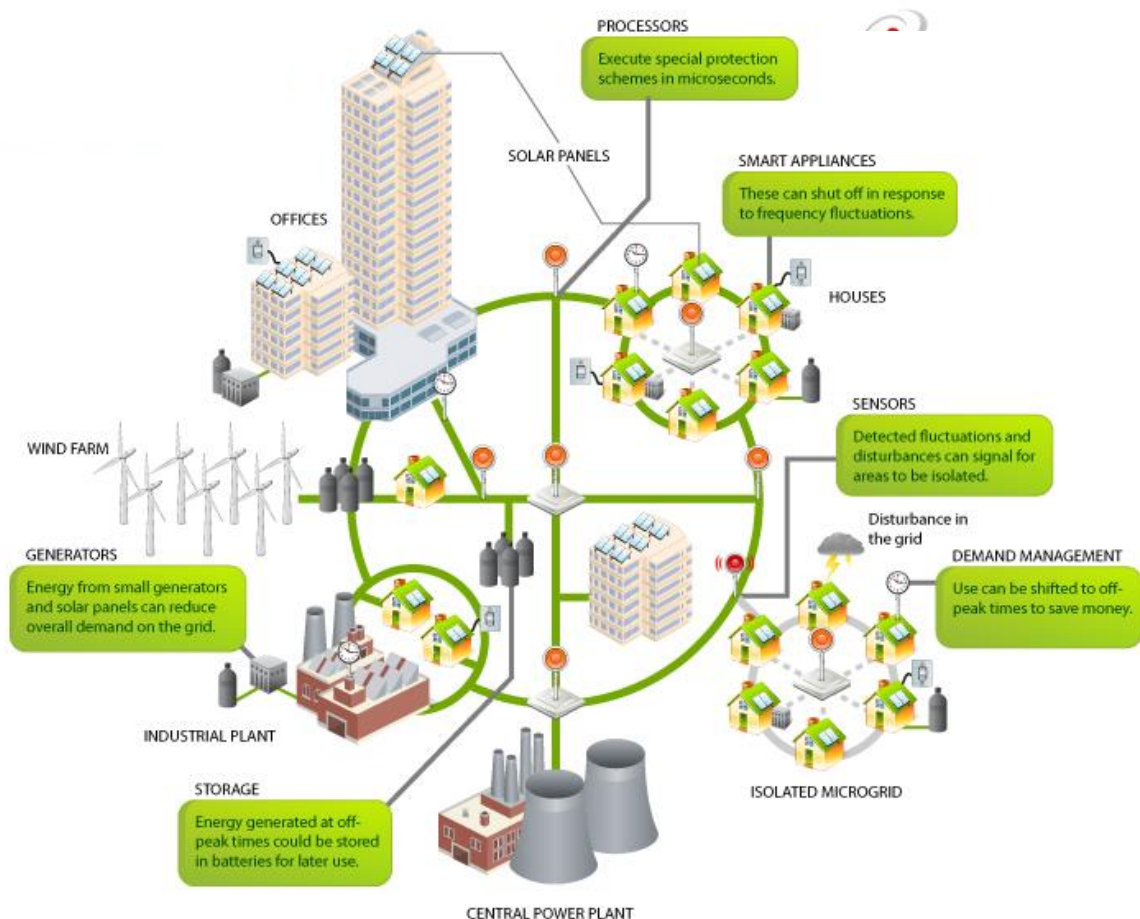


Figure 22 Visualization of modules and interconnections in a smart grid (Source: iTeres Group)

4.3.3 Examples from the alpine regions

Smart technologies could provide a solution towards an improved energy system management also on the regional level. In the following paragraphs, some examples of projects from the alpine regions are given.

The «Nice Grid» Project

A good example from the alpine regions where the smart grid concept is being implemented and tested is the «Nice Grid» project³⁷. Nice Grid is the first smart solar-energy district demonstration project to be conducted in France. This ambitious project, which brings together a broad range of stakeholders, is located in the municipality of Carros, in the department of Alpes-Maritimes, near the French Riviera. The project is running over a four year period with a total budget of 30 million Euros. The objective is to develop a smart electricity grid that integrates a high proportion of solar panels, energy storage batteries and intelligent power meters installed in the homes of volunteer participants. By giving energy users the opportunity to manage their power consumption and budget, Nice Grid intends to turn passive consumers into active «producer-consumers».

The project is conducted in the town itself and in its industrial zone. The already substantial solar power resources in the region will be supplemented by additional photovoltaic arrays and lithium-

³⁷ For more information see the project website: <http://www.nicegrid.fr/>

ion batteries installed in the homes of volunteer customers, on the distribution network, and at the primary substation. Furthermore, Nice Grid deploys an energy management system active on several levels: 1) forecasts of the next day's electricity demand levels and solar power generation capacity, 2) early detection and analysis of the power grid's stresses, 3) involvement of customers participating in the pilot project, 4) remote control of some equipment (e.g. hot water boiler, heating and air conditioning systems), together with an optimized management of decentralized storage (batteries).

Even though Carros' location on the periphery of France's transmission grid is a structural handicap for its electricity supply, the town has abundant sources of renewable energy and especially solar power. These characteristics and the fact that Carros also lies at the heart of Eco-Valley, a French «project of national interest», make it the ideal site for this pilot project. These characteristics might be similar in other regions of the Alps as well. (Source: Nice Grid)

The «AlpStore» project

A different project testing the feasibility of smart grids for the alpine area is the «AlpStore» project³⁸ of the Alpine Space program, focusing on smart energy management and sustainable mobility solutions. The project's claim is that using storage systems will become a key in ensuring stable energy supply in all alpine regions and that electric vehicles will be an integral element of the future energy system. Their batteries can be charged with excessive power from intermittent energy sources and electricity can be fed into the grid to meet peak loads.

With reliable energy provision, regions stay attractive as living habitats, working spaces and recreational sites. The goal of AlpStore is to develop a «smart storage and mobility concept» and to offer solutions to increase regional renewable energy supply and outbalance volatility with appropriate buffering means. Electric vehicles can provide short time balancing; however, mobile storages must be combined with stationary storages (battery, gas, hydrogen).

Requirements of scattered habitats are emphasized as well as the requirements of combined business and living habitats in metropolitan areas. The project argues that with intelligent storages, both business and living habitats can become self-contained energetic cells. AlpStore's goal is also to show how electric mobility can bring new business opportunities to the alpine regions. Today, there is a lot of uncertainty concerning the viability of small, medium and large scale storages. With explorative and piloting actions AlpStore will assess which mixture of technologies will best fit the needs of alpine communities and prepare for the implementation of combined storage and mobility concepts in regional and municipal planning. (Source: AlpStore)

Smart grids in the Alps

At first sight, there is no strong alpine-specific component in the development of smart grid technologies. However, there are some interesting aspects that might make smart grids very relevant for the alpine area. It seems probable that we will observe a strong development of decentralized, renewable energy production in the alpine regions that needs to be integrated into the grid. In addition, there are some specific elements in the energy systems of the Alps that could possibly benefit from the implementation of smart technologies. For example, in skiing areas with infrastructure for artificial snowing, the water storage basins of the snowmaking

³⁸ For more information see the project website: <http://www.alpstore.info/Home.html>

systems could serve as year-round short-term pumped storage facilities. Even though, in some cases the water-use demand by other sectors (e.g. tourism and agriculture) has priority making “local pumped-storage” solutions difficult. In some touristic alpine villages, electric mobility has already been in use for many years; some of these villages are, besides electric vehicles, car-free, for example Zermatt in Switzerland. Hence, it might be possible to combine the already existing infrastructure for electric mobility with additional elements to create a smart grid infrastructure and to enhance the reliability and efficiency of the energy system.

4.4 Workshop on Energy Systems

The third workshop of the Energy Platform on the topic of energy systems took place on February 13, 2014, in Zurich (Switzerland). Delegations and experts from the participating countries of the Energy Platform shared their experiences and expectations with regard to the development of energy systems in the alpine regions (see table below). In the first part of the program, the trend towards regionalization of the energy production and its implications for (alpine) energy systems were discussed. The second part focused on energy systems from a European perspective, especially concerning the development of new pumped storage plants and transmission lines and its implications for alpine regions.

Mr. Christian Schaffner, the executive director of the Energy Science Center of the Swiss Federal Institute of Technology, set the scene on «new energy systems» for energy transition in his introductory speech. He proposed to deal with the complexity of energy systems by looking at the entire power system in its international context. One should aim at finding «technology-neutral» solution approaches. Since there are quite a lot of insecurities concerning energy transition from today's point of view, constant monitoring and an adaptable planning process are necessary. The findings of current research should be integrated into this process. As a case study from the alpine area he presented the «Zernez Energia 2020» project, an example for the transformation of an alpine community into a sustainable regional energy system. The inhabitants of the alpine community participate in shaping their energy system by voting on the communal electricity provider. The resulting financial benefits from a provider change support the assessment of the energy system of Zernez and the implementation of possible improvements.

The following sections summarize the inputs and lessons learned of the workshop on energy systems. They are structured as follows:

- Regional aspects of energy systems (chapter 4.4.1)
- Transnational perspective on energy systems (chapter 4.4.2)
- Conclusions and lessons learned (chapter 4.4.3)

Country/Organization	Presentation title
France / Compagnie Nationale du Rhône	E-Mobility for decentralized electricity storage
Liechtenstein / University of Liechtenstein	Balancing demand and offer with new storage systems
Denmark / PlanEnergi	Integrating solar energy into district heat systems
Slovenia / ELES (part 1)	Blizzard on the 1st of February 2014 in Slovenia: first conclusions
Austria / TIWAG	Integrating new renewable energies into the electricity grid
Switzerland / Federal Office for Energy	Pumped storage power plants for irregular solar and wind power?
Italy / ENEA	Adapting the grid system to the requirements of the energy transition
Slovenia / ELES (part 2)	Planned transmission lines in Slovenia, suggested recommendations and public participation

Table 9 Overview of the presentations held at the Energy Platform Workshop 3

4.4.1 Regional aspects of energy systems

Experiences

The second largest electricity producer in France, the «Compagnie Nationale du Rhône» (CNR), provides the French grid with 100% renewable energy. In the past, production has mainly been based on hydropower. With the strong growth of wind farms and photovoltaic production, the company was facing new challenges for the electric grid. For a traditional hydroelectric producer like CNR the obvious solution for storage capacities was first seen in pumped storage hydropower. Additionally, electric mobility was chosen as an approach towards a smarter grid on the regional level, since electric vehicles are able to provide some storage capacities as well. Therefore, CNR developed a management concept for smart charging of the future electric fleet based on information technology. This system allows for synchronizing the charging patterns of electric vehicles with the volatile production of renewable energies by direct interactions between the car and the power company. The project is in the pilot phase today and its real impact on the balance of the energy system will only become clear in the years to come.

The AlpStore research project (see also chapter 4.3.3) aims at developing solutions to connect stationary and mobile renewable energy sources to the grid and to manage production and consumption in an alpine context. AlpStore investigates short term and long term storage solutions and develops demand side and generation side management in the alpine context. It has been shown that a need for storages in the energy system starts to be relevant when the percentage of renewable electricity reaches 40 %. Below this percentage, the balance can be reached by going towards flexibility in the production and consumption patterns. Since storage technologies have typically large spatial requirements, several options of combining different energy carriers with storage technologies are currently being analyzed (e.g. integrated storages in buildings or combined storage / mobility solutions).

Focusing on the integration of heat production in the energy system, the experiences with solar thermal district heating were presented. This technology is already well established and successful in Denmark, since the preconditions seem to be quite favorable. Ground-mounted solar collectors show a good price-performance ratio and natural gas is subject to high taxes in

Denmark. Therefore, solar thermal heating is very competitive³⁹. Since the district heat providers are generally small and user-owned companies, they are well accepted by the communities and local authorities. Because the share of renewable electricity production increases, the mismatch of production versus load increases also in Denmark. Connecting the electricity grid via heat pumps and CHP-plants with the solar thermal heating systems and its large heat storages therefore provides a viable approach to tackle this issue.

Implications for the alpine region

In the discussion based on the presented experiences, the implications for alpine regions and their regional energy systems were critically reflected.

Regarding the **environmental impacts**, the spatial requirements are a key factor for local energy systems. Hence, it seems questionable whether the good experiences from Denmark with solar thermal heating are equally suitable for the alpine regions. This technology requires large surfaces for solar collectors and water pit storages (also questionable in terms of soil protection, because of the potential destruction of fertile soils). Moreover, the question arises whether agricultural land should be used for energy production. On the other hand, it was pointed out that the energy output per space unit from solar collectors is 40 times higher than the one from biomass (if biomass used for energy production). Several options of how to adapt the technologies to the alpine context were discussed, for example the possibility to install solar collectors on existing infrastructure or to use caverns as storages.

The **social acceptance** of technological solutions seems to depend on political and social guidelines and targets, for instance regarding the acceptable level of emissions or the security of energy supply. Raising the awareness of the population for energetic problems should be a political priority.

The question which **technology** is best suited to improve regional energy systems usually depends on the cost-benefit ratio. It is assumed that in general, technological solutions to reach the political targets are available, but it is a question of economics, social acceptance and environmental impacts whether a certain technology will be applied. In the debate whether central or decentralized energy production is the «right» approach for alpine areas, it was stated that different technological options shouldn't be played off against each other. It is suggested that the best solution in the interest of alpine communities will consist of a mix of technologies, adapted to the specific regional contexts.

Economically speaking, the currently rather unfavorable conditions on the energy market (low electricity prices) are an obstacle for the establishment of regionalized grid solutions. Many of the measures taken to improve the energy system on the regional level also have an effect on the (trans-)national system. Hence, the question arises as to how the financial benefits and burdens should be shared in a fair and sustainable way.

In general, it can be concluded that the heterogeneity of the alpine regions requires locally adapted solutions. Therefore, public participation is an important factor in order to find regional strategies for dealing with the challenges of future energy systems. Involving local communities

³⁹ The average energetic output of the collector is 450 kWh/m², with an efficiency of around 40%. Heat production prices result at roughly 45 Euro/MWh.

and the civil society in the decision making process or making them part of the development of regional energy projects can help increasing chances that social and environmental concerns are respected. Furthermore, it can be observed that the current (political) debate is focusing strongly on electricity production and on households as consumers. However, other components in the energy system, for instance mobility, shouldn't be neglected.

4.4.2 Transnational perspective on energy systems

Experiences

In the experience of TIWAG (Tiroler Wasserkraft), one of the most important Austrian storage providers, the European policy framework for energy, sustainability and ecology is highly complex. Therefore, the goals of the various players should be harmonized. It was observed that the increase in energy dependency might cause geostrategic weakness. Regarding the increase in installed renewable capacities, the production shares of RES are not growing equally as much. For the future development of the energy system, efficiency, stability and security are the key targets. These require the development of additional short-, medium- and long-term storages. Compared to other storage technologies, pumped storage hydropower is able to meet diverse requirements that ensure system stability, efficiency and security of supply. However, from an economic point of view, decentralized storage technologies profit from subsidies whereas pumped storage hydropower does not receive financial support in all countries. This fact creates the risk of market distortions.

In the case of Switzerland, the requirements for additional storage capacities and their economic performance were analyzed (see also chapter 4.2.1). The study presented by the Swiss Federal Office of Energy concluded that in the short to medium term (up to 2020) no additional storage requirement exists in the examined scenarios and supply options, because there is a relatively small increase in volatile production technologies during that period. However, until 2050 a sharp increase in decentralized and volatile production technologies is expected, which will give rise to local excess feeds into distribution networks. Therefore, the need for storage capacity or other measures (e.g. cutting-off of renewable power plants in peak times, demand side management) to avoid network overloads has to be anticipated, especially with regard to rural networks. Hence, the use of new types of energy storage in Switzerland only appears to be necessary in the long term, i.e. in the period after 2035. Based on a projection of past cost trends for various storage technologies to the future, it is assumed that pumped storage power plants are the most efficient and cost-effective available large-scale technology. They are important for integrating new renewable energy forms into the power system. However, the regulatory framework has a major influence on the viability of pumped storage power plants and other flexibility options represent alternatives to pumped storage hydropower.

Recent changes in the Italian electricity sector have led to an increase in «distributed electricity generation units» in the distribution network. This development bears some risks and challenges, since the distribution systems were generally designed for one-way power flow from the substation to the customer. Distributed generation bears various risks, such as higher energy production than the local load, power flow inversion, capacity problems in critical areas or overvoltage in the nodes of the distribution lines. The problem is that distributed generation units are usually not adjusted to the network in terms of quality of supply and system stability. A

possible solution to improve system stability could be provided by smart technologies. According to the Italian authority for electricity and gas, seven smart-grid pilot projects were selected in order to push the development of smart grids in Italy.

Slovenia was hit by a severe blizzard on the 1st of February 2014 that damaged large parts of the power grid and left many communities without electricity and fresh water supply. This showed that severe weather conditions can cause heavy disturbances in the electricity grid. Hence, new transmission projects are necessary and should be designed for heavier weather conditions, e.g. by installing the distribution network underground. The exchange of knowledge and information about best practices concerning the development of energy infrastructure should be fostered. The development of new and the substitution of existing transmission lines should take place with as low as reasonably possible impacts on the environment. If technically feasible and at acceptable costs, underground cabling of the distribution network should be the preferred solution. Moreover, for the planned activities in the future, public participation must be strengthened, e.g. by meetings with stakeholders, such as representatives of local communities, civil initiatives and NGOs.

Implications for the alpine region

The need to find a balance between use and protection of alpine resources and landscapes was already discussed at the previous workshop. Hence, these aspects should be kept in mind when discussing the development potential of the transnational energy system in the alpine regions. For the prosperity of the alpine regions both the protection of the alpine landscapes as well as the regional economic development have to be respected.

In Europe there is a growing demand for power storages, and the Alps can provide a share of this demand by further developing storage capacities, such as pumped storage hydropower. However, the question as to how the benefits of these services should be shared has not been answered yet. The share of benefits and burdens (both economic and environmental) from the development of pumped storage hydropower needs to be discussed between the alpine countries and the rest of Europe. Additionally to economic and environmental issues, however, the social dimension has to be taken into account as well.

When discussing the need for additional storage capacities and the development of power lines, another aspect should be kept in mind. The European countries have set very ambitious goals to improve energy efficiency and reduce their energy consumption. In order to achieve higher sustainability, the technical improvements of the power network are only one part of the solution. For the other part, it will be crucial that the consumption of electricity can be effectively managed.

In order to support the development of the infrastructure, security for investments needs to be established. Since investments in energy systems have a long time horizon, stable frame conditions are a prerequisite. Furthermore, different frame conditions and regulations between regions or countries might result in a distortion of the energy markets. Therefore, knowledge-sharing between the alpine regions and a harmonized approach of the authorities are essential factors.

The alpine area is strongly interconnected with the European energy system. Therefore, a common position amongst the alpine states and regions regarding the development of grid infrastructure and hydropower (storage) power plants would facilitate advocating for the interests of the Alps and its citizens.

4.4.3 Conclusions and lessons learned

The need for balance of demand and production and the management of the electricity grid was a key point in the discussions of the third workshop. These are major challenges both from the regional as well as the transnational perspective. Approaches discussed to better deal with these challenges include a smarter regulation of consumption and production, a better geographical distribution and enhanced regional energy system planning. Only if such mechanisms are not sufficient to ensure a strong and reliable energy system, big-scale storage technologies such as pumped storage should be further analyzed in the alpine regions.

As there are always losses in the process of energy storage and negative economic, environmental and social impacts may result from the construction of additional energy infrastructure, improved management of production and demand must be a priority for the alpine regions.

In this process it seems crucial to deal with uncertainties of future developments. The investments in energy infrastructure have a long time horizon; decisions taken today are setting the preconditions for the coming decades. It can be assumed that the challenges discussed are not primarily a question of technological solutions. Various technologies are available, but the implementation of these technologies might face various obstacles regarding social, environmental and economic interests. Such concerns will need to be taken very seriously.

For alpine communities large energy infrastructures can create significant benefits but also generate major losses in ecosystem diversity and the touristic value of a region. It might be in the very interest of the alpine regions and their population to define a strong common position, taking into account economic, social and environmental sustainability, and speak up for «fair and sustainable» conditions for alpine (pumped) hydropower and transnational transmission lines in the new European energy landscape.

Since the alpine area is a very heterogeneous space, social acceptance and public participation are essential for finding suitable solutions. In order to create acceptance, however, the citizens must understand the underlying problems, especially the dangers faced by the climate change and the need for a more renewable energy landscape. The importance of social acceptance is shown by the suggested bottom-up approaches that allow for integrating the local characteristics of alpine regions. There are various synergies between the Alps' and Europe's energy system. It has been proposed that the alpine regions should find a common position and define their role in the European transformation process of the energy system.

The workshop clearly showed the necessity of broadening the view on storage and transmission technologies, especially as far as pumped storage is concerned: Pumped storage needs to be complemented by other storage technologies (see chapter 4.2) and the potentials of demand-side management together with energy-efficiency need to be further analyzed in order to define the need of developing new large storage and transmission infrastructures in the Alps in a sustainable way, bearing in mind the European dimension of these infrastructures (pumped-storage as «alpine-specific asset»).

4.5 Energy systems in the alpine countries

After an overview on pumped storage capacities in the alpine countries, a short overview on the situation of the energy system(s) shall be given, per country. In contrast to the topics presented in the chapters 2 and 3, there is less common data available regarding the topic of energy systems.

4.5.1 Pumped storage hydropower capacities in the alpine countries

Table 10 provides an overview of the existing capacities and production of pumped storage hydropower plants in most of the Alpine Convention member countries for the year 2010.

Country	Installed net capacity (MW)	Net production per year (GWh)
Austria*	3'020 ⁴⁰	3'163
France*	6'985	4'753
Germany*	5'811	6'799
Italy*	3'957	3'290
Slovenia*	180	184
Switzerland**	1'383	1'593

Table 10 Net capacity in Megawatt (MW) and net production in gigawatt hours (GWh) of pumped storage hydropower stations per country in 2010. (Data sources: *eurostat, **BFE, Statistik der Wasserkraftanlagen)
For some countries more recent statistics might be available from other sources. To ensure comparability the same data source was used for all countries, wherever this was possible. In the following country-specific chapters data might therefore slightly differ from the numbers presented in the table above.

Eurelectric (Union of the Electricity Industry) has published a report on existing and projected pumped storage capacities of its member countries (Eurelectric 2011). The alpine countries have the highest installed capacities of pumped storage hydropower of all Eurelectric member countries⁴¹, together with Spain and the UK.

Even though in Europe most of the best locations for hydropower plants have already been developed, only about half of its technically feasible potential⁴² has been developed in Eurelectric member states and only about one third in the non-member states. As has been shown in chapter 4.2, besides the technically feasible potential the general framework conditions are decisive for the future development of pumped storage capacities (in the Alps, and probably elsewhere).

Development potential of pumped storage hydropower

The Joint Research Centre (JRC) of the European Commission has published a study that estimates the development potential for pumped storage capacity in Europe (European Commission 2013). The results show that the theoretical potential in Europe is significant. The

⁴⁰ The value is missing in the latest data actualization (29-04-2014). The value reported is from an older data actualization (26-06-2013).

⁴¹ Members of Eurelectric are documented following: <http://www.eurelectric.org/about-us/our-members/>

⁴² The technically feasible hydropower potential per year is defined as the total hydropower generation potential of all sites that could be developed within the limits of the current technology; regardless of economic or other considerations such as regulatory constraints or environmental preferences.

theoretical potential is reduced to a realizable potential through the application of constraints such as discarding potential sites close to population centers, protected natural areas or transport infrastructure, and also the electricity market (prices).

In cases where a pumped storage plant can be built based on linking two existing reservoirs, the theoretical potential in Europe is 54 TWh⁴³ (11.4 TWh in the EU, the large difference mostly because of Turkey). When restrictions on the use of land are applied, the theoretical potential is reduced to a realizable potential of 29 TWh in Europe of which 4 TWh in the EU.

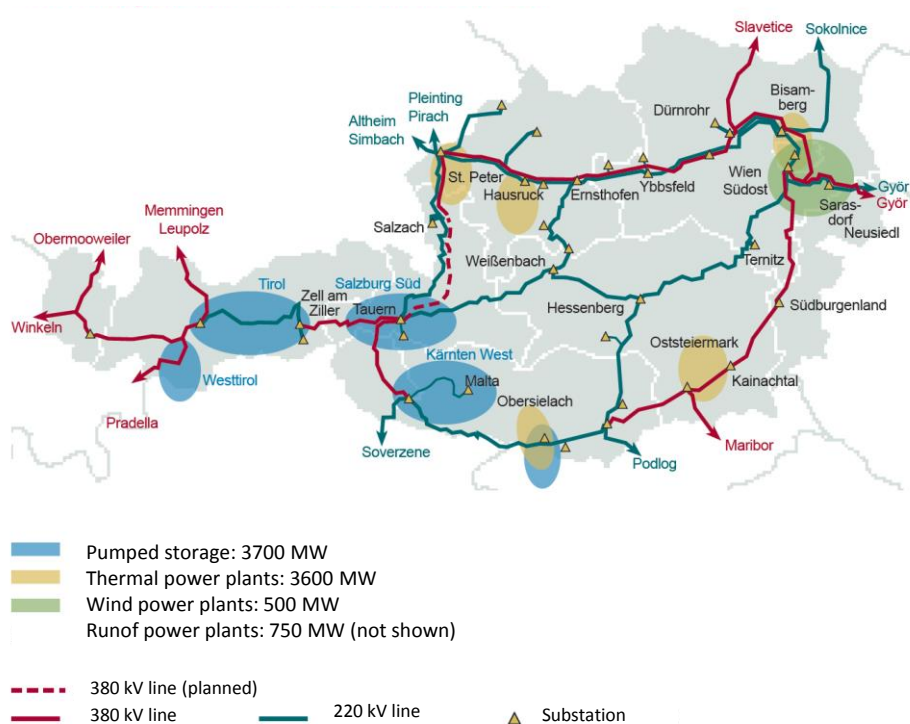
4.5.2 Austria

Hydropower and pumped storage hydropower stations

The total electricity production in Austria in 2011 was 67 TWh. The most important source of electricity is hydropower with roughly 60% of the total production. Today, there are 691 runoff river stations and 111 hydropower storage plants with a total capacity of 13'000 MW and an annual production of 40 TWh of electricity. The production capacity of pumped storage plants in Austria was about 3'400 MW in 2011, generating a net production of 3'500 GWh (European Commission 2013).

Development of capacities

The Austrian electricity economy is planning on investing roughly eight million Euros in the development of the country's power plants. Currently, power plant projects with a total capacity of 10'500 MW are under construction or in planning. Thereof, 5'500 MW are run-off river and pumped storage hydropower plants, 3'000 MW gas power plants and 2'000 MW wind, biomass or photovoltaic facilities.



⁴³ This potential strongly depends on the frame conditions for the calculations. It is assumed that the difference in elevation between two reservoirs is sufficient and that there is a maximum distance of 20 km between the reservoirs. The potential is drastically reduced if the maximal distance between the reservoirs is lower.

District heating systems

District heating is currently one of the strongest growing branches of the energy sector in Austria. The total production in 2011 was 22 TWh; the largest share of heat generation for district heating stems from combined heat and power plants (CHP). The Austrian district heating network spreads on roughly 4'400 km today and suppliers are planning on developing 57 to 88 km of heat pipelines every year. Today, 21 % of all private apartments are supplied by district heating.

4.5.3 France

Hydropower and pumped storage hydropower stations

In 2011, the production capacity from pumped storage hydropower was roughly 7'000 MW in France and production from pumped storage plants was about 5'000 GWh.

Grid development

In the past few years, large investments in renewable energies have been made in France and its neighboring countries, leading to a shortage of grid capacities, especially for border-crossing transmissions. For border-crossing power transmission between France and Italy, there's a need for development of the grid, especially because of the growing production from wind power. For power transmission between France and Switzerland, new transmission lines are planned in the region of Lake Geneva. It is estimated that the development of the Swiss pumped storage plants will have a strong influence on the North-South and East-West connection lines. Within France, the main challenge is seen in the integration of the growing production from renewables since these are produced to a large extent in regions with rather weak grid infrastructure (VSE 2012a).

4.5.4 Germany

Hydropower and pumped storage hydropower stations

The capacity of German hydropower plants is 7'150 MW; thereof, 6'050 MW apply to pumped storage plants. In 2011, net production from pumped storage plants was about 6'700 GWh. In Bavaria there are 4'100 hydropower plants with a total capacity of 2.9 GW in operation today (including pumped storage plants).

Currently, a new large-scale pumped storage plant is planned in Bavaria, with estimated costs of approximately 600 million Euros and a capacity of 700 MW. Construction is planned to start in 2018, with a construction time of about five years. Hence, start of operation is set for the year 2023⁴⁴.

The electricity grid

In the past, power plants have been constructed according to the demand. Because of the phasing out of nuclear energy in Germany and the strong development of wind and solar power, the need for grid development has become more imminent. The distances of electricity

⁴⁴ For more information see: <http://www.energieallianz-bayern.de/cms/Energiespeicher/Energiespeicher-Jochberg/Energiespeicher-Jochberg.html>

transmission are growing strongly, mainly because of the large wind parks on the country's north coast.

Recently, the North-South and East-West transmission lines have been under growing pressure. As a consequence, the German transmission system operators had to take regulating measures more often (e.g. switching off wind parks), for instance at times of strong winds (VSE 2012a).

In order to secure grid stability and security of supply, the modernization and development of the grid are essential. Since 2011, the four system operators of the German grid (50Hertz, Amprion, TenneT and TransnetBW) have been working on a grid development concept together. The grid development plan should define all actions for the coming ten years that are necessary to optimize and enlarge the grid.

4.5.5 Italy

Hydropower and pumped storage hydropower stations

The generation capacity of pumped storage plants in Italy was about 7'500 MW in 2011 (European Commission 2013). The production from pumped storage plants, however, was subject to a strong decline in the past decade (see Figure 24). One of the main reasons for this significant cutback is the fact that the strong growth of stochastically produced electricity from wind and solar mainly takes place in the center and south as well as on the islands of Italy, whereas pumped storage plants are located in the north of the country. The transmission grid however doesn't provide the capacity to outbalance between production and storage sites. Further, unfavorable conditions on the electricity market as well as a general decline of electricity consumption due to the economic crisis provoked the decrease of pumped storage production⁴⁵.

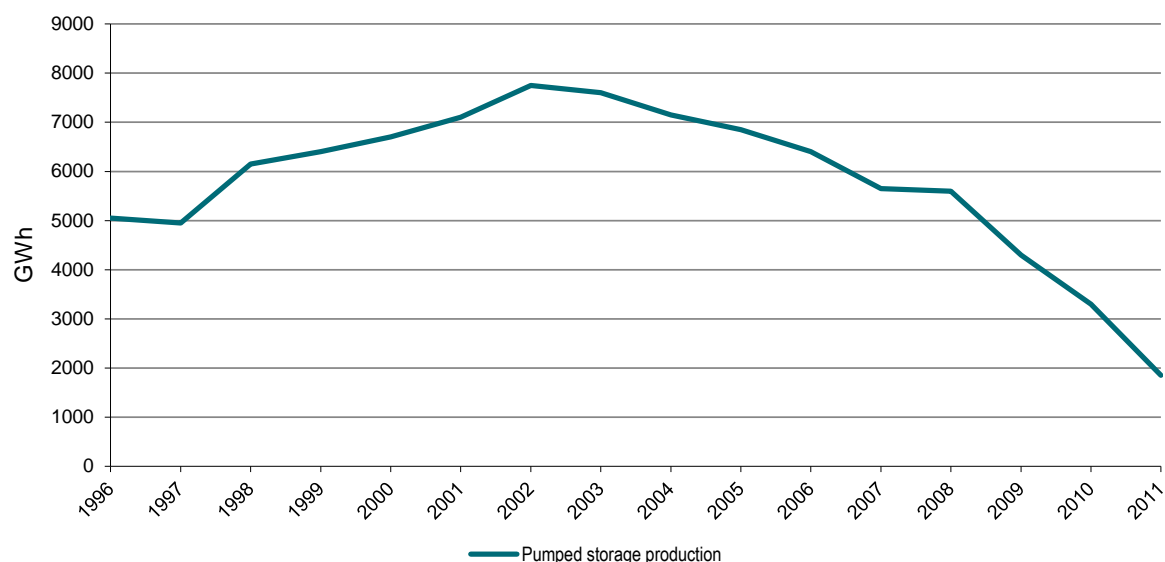


Figure 24 Electricity production from pumped storage plants in Italy, 1996 – 2011 (source: www.rinnovabili.it)

Grid development

⁴⁵ <http://www.rinnovabili.it/energia/idroelettrico/imbrigliare-lenergia-verde/>

There is a need for grid development in Italy with regards to the border-crossing transmission lines. Especially the connection to France is at the limit of its capacities. According to the European transmission system operators (ENTSO-E), the development of transmission capacities of the North-South connection is highly recommended, especially because of the strong development of wind power in Italy and Germany. Connections should also be improved in the direction of South-Eastern Europe, since it is assumed that conventional power production will grow in this region in the coming years and will be exported to Italy and Western Europe. As a consequence, new DC power lines are planned to connect Montenegro, Albania, Croatia and Greece with Italy. Within the borders of Italy, grid development is planned in the South in order to transmit renewable energies from the South to the North (VSE 2012a).

4.5.6 Liechtenstein

Hydropower and pumped storage hydropower stations

11 hydropower plants in the Principality of Liechtenstein are producing approximately 18% of the country's electricity demand, corresponding to about 72'000 GWh. Currently, a new pumped storage plant is in planning by transforming the existing Samina hydropower plant into a pumped storage plant. Construction work has already started and the start of operation is planned for the beginning of 2015. The development of this power plant will make it possible to optimize energy production according to the country's demand. Furthermore, the efficiency of the plant will be improved and ecological measures can be integrated into the project.

The power grid

The power grid of Liechtenstein is strongly interconnected with the grids in Austria and Switzerland. Because of the country's small size it is clear that the energy system and the future development of the power grid are strongly dependent on the actions of its neighboring countries.

4.5.7 Slovenia

Hydropower and pumped storage hydropower stations

In 2012, the electricity production from hydropower plants in Slovenia was 4'020 GWh or 27% of the total electricity production. The installed capacity of hydropower plants amounts at 1'254 MW (including pumped storage and small hydropower plants). Currently, there is one pumped storage plant (HPP Avče) with a generation capacity of 180 MW, which produced 251 GWh of electricity in 2012.

New hydropower capacities will be installed in Slovenia in the near future. The HSE and GEN group, the largest electricity producers on the Slovenian market, is planning to build new hydropower plants on the Sava River. Five new run-off river hydropower plants will be installed on the lower reaches of the Sava River. These new facilities, which shall be built by 2018, will more than double the power generated on the Sava. Their total output shall account for 21% of the Slovenian hydropower production, and it is anticipated that they shall meet 6% of the nation's energy needs. In addition, new hydropower plants are planned at the middle current of the Sava River, which shall increase the production of renewable electricity by roughly 1'000 GWh. With the implementation of this project, a chain of ten electrical power plants is expected to be built on the

Middle Sava River. The construction of these 10 hydropower plants is expected to be completed by 2030. There is significant unexploited hydropower potential (around 1'600 GWh per year) on the rivers Soča and Mura.

The electricity grid and development of the grid

The Slovenian energy agency reports that the well-functioning market coupling between Slovenia and Italy, which started in 2011, as well as the increasing cross-border transmission capacity on the Austrian-Slovenian border in 2012 led to more active electricity trading in 2012. Surpluses of electricity led to constantly high power flows in the direction of Italy (Energy Agency of the Republic of Slovenia 2013). Every two years, the Slovenian transmission and distribution system operators prepare development plans for a ten year period. These plans consider the strategic national energy policies and are harmonized with each other. The latest development plans of the system operators were prepared for the period 2013-2022. The expected investments in the electricity infrastructure for the transmission and distribution networks amounts at 2'400 million Euros (Energy Agency of the Republic of Slovenia 2013). The Slovenian network development plan also includes international lines to Italy (2 x 400 kV Okroglo-Udine) and to Hungary (2 x 400 kV Cirkovce-Pince) as well as a gradual renewal of transmission lines by increasing the operating voltage from 220 kV to 400 kV (Energy Agency of the Republic of Slovenia 2013).

District heating systems

In 2012, the service of heat distribution was carried out by 79 license holders. The heat distribution networks are set up in 55 of the 212 Slovenian municipalities, with a total length of 733 km, which is displayed in Figure 25.

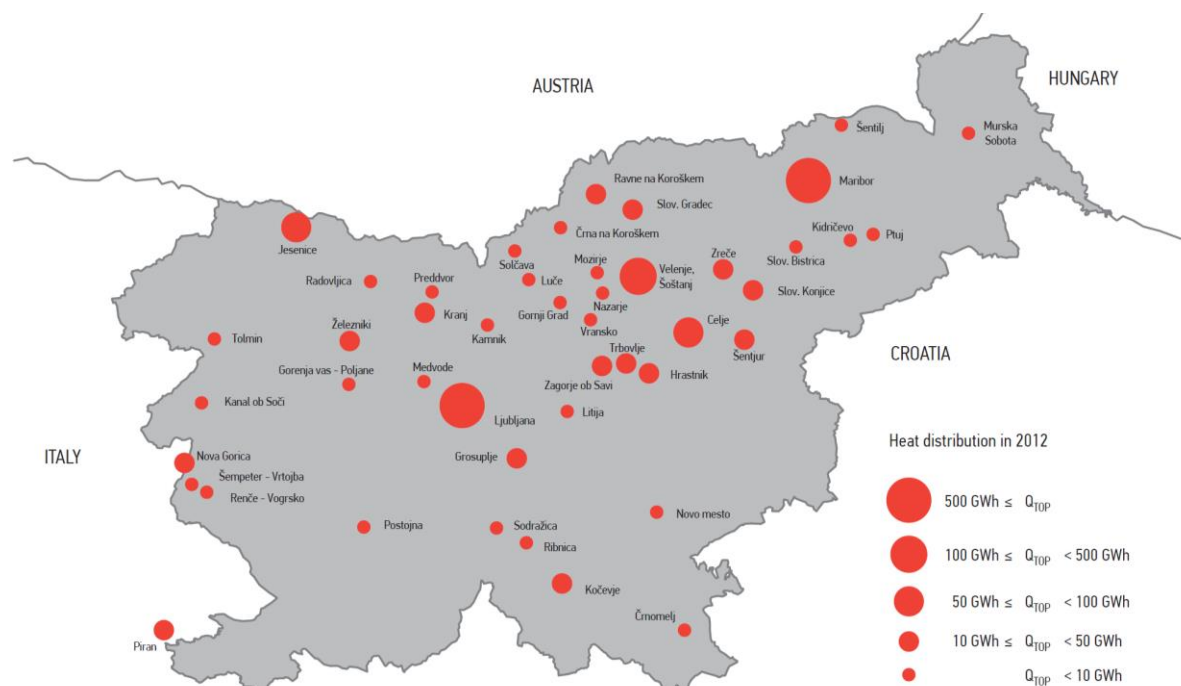


Figure 25 District heating networks in Slovenia in 2012 (Source: Energy Agency of the Republic of Slovenia)

Heat production for district heating (including supply to industry) was roughly 2'500 GWh in 2012. Almost half of the heat produced (40%) is used for the supply of 124'000 households, while the

remaining heat is supplied to industrial and other non-household customers. The primary resources for district heating are coal (58%) and natural gas (29%). Wood biomass and other primary renewable sources cover 13% of the resources.

4.5.8 Switzerland

Hydropower and pumped storage hydropower stations

Thanks to its topography and high levels of annual rainfall, Switzerland has ideal conditions for the utilization of hydropower. Today, there are 556 hydropower plants in Switzerland, producing an average of around 36 TWh per year, 47% of which is produced in run-off-river power plants and 53% in storage power plants (of which approximately 8% in pumped storage power plants). Two-thirds of hydroelectricity is generated in the mountain cantons of Uri, Grisons, Ticino and Valais, while Aargau and Bern also generate significant quantities. Roughly 11% of Switzerland's hydropower generation comes from facilities situated on bodies of water along its borders.

The electricity generation capacity of existing pumped storage plants was 1'800 MW in 2011. The net production of those plants was 1'700 GWh in that same year.

Today, the existing capacities of pumped storage hydropower plants are 1'800 MW. By 2020, the capacities should be expanded to 5'600 MW. Projects already under construction will provide 2'100 MW, and additional capacities of 1'600 MW will be supplied by projects currently in planning. However, under the current framework conditions, their realization remains unsure.

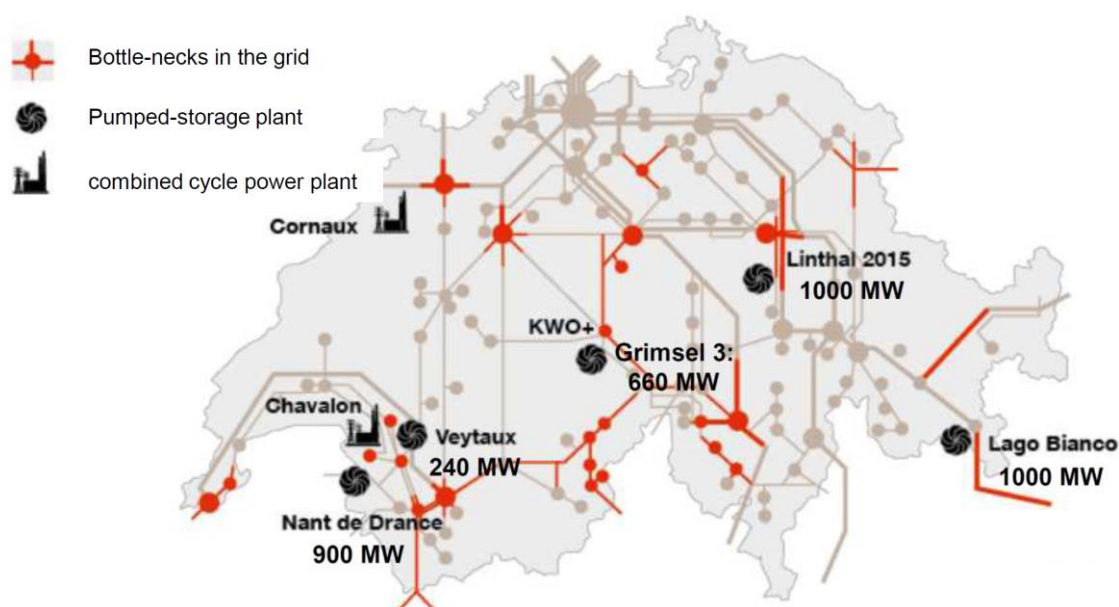


Figure 26 Pumped storage hydropower plants under construction / in planning with expected capacities in megawatt (MW) for the year 2020 (Source: Swissgrid).

The electricity grid and development of the grid

For more than 50 years, Switzerland has been a major electricity hub in Europe. Today, there is a need in Switzerland for modernization and development of the grid. As part of the Energy Strategy 2050 of the Federal Government, an Electricity Grid Strategy has been developed. The strategy

addresses two main goals for the development of the Swiss grid: on the one hand, the speeding-up of procedures with shorter deadlines for planning and permissions as well as faster appeal proceedings and limited access to the Federal Supreme Court under certain circumstances. On the other hand, a Smart Grid Roadmap should be developed, supporting the transformation of the grid.

Swissgrid, the national grid company and owner of the transmission system, is responsible for renewing and expanding the transmission system. Overall, the grid will be modernized along a length of 1'000 km. In addition, 300 km of new lines will be built. In the last ten years, only around 150 km of lines were built. Several projects must be urgently realized regardless of potential consumption and production scenarios. Investments of four to six billion Swiss francs will be required in the coming 20 to 30 years. The nine prioritized renewal and expansion programs are displayed in Figure 27.

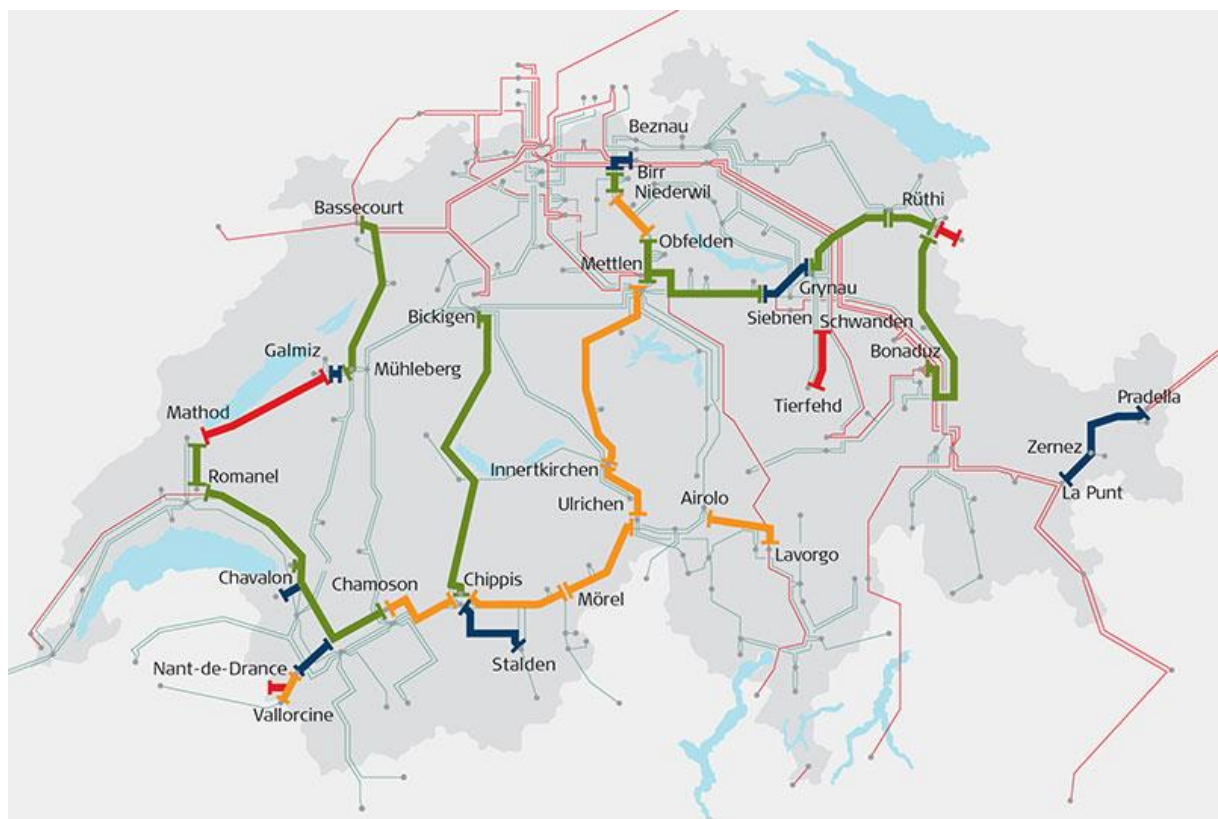


Figure 27 Prioritized renewal and expansion programs for the Swiss grid [categories: raising operating voltage (green, 50 %), conversions and additions to existing power line routes (orange, 14 %), replacement of existing power lines (blue, 27 %), new construction without existing power line routes (red, 9 %)] (Source: Swissgrid)

The main planning and coordination instrument for the expansion and development of the high-voltage transmission lines is the «Transmission Lines sectoral plan». It is developed by the Swiss Federal Office of Energy in cooperation with the Swiss Federal Office for Spatial Development. Its purpose is to evaluate corridor variations for transmission line projects and to identify conflicts and find solutions, determining the most suitable corridor for planned transmission line construction projects. A «transmission lines evaluation model», published by the Swiss Federal Office of Energy (2013f), helps to take into account social, economic, technical and ecological criteria in the impact assessment of planned corridors.

District heating systems

District heating is an increasingly popular technology in Switzerland. In 2012, the feed-in amounted to 18'370 TJ heat and 5'910 TJ electricity per year. District heating plants are fueled mainly by municipal waste (~82% from 31 incineration plants), natural gas (~10%), wood (~3%) and waste heat from nuclear power plants (~2%). Renewable-energy-based district heating projects are eligible for financial subsidies if it is proven that they substitute fossil fuels.

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