Austria

Action 4.1.1: National Frameworks

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CCS	Carbon Capture Storage
EV	Electric Vehicle
GDP	Gross Domestic Product
OMV	Österreichische Mineralölverwaltung
PHEV	Plug-In Hybrid Electric Vehicle
RE	Renewable Energies
R&D	Research and Development
TU	Technical University

1. Summary

This document describes the national framework of Austria concerning energy storages.

Austria is characterized by the production of energy from hydro power. A large part of the total energy production is provided by hydro storage power plants. Nearly a fifth (19 %) of the total production of electricity is produced by hydro storage power plants. In Austria are 111 hydro storage power plants installed. The installed capacity therefor is 7,800 MW. In this case storage hydro power plants play by far the most important role in the field of energy storage in Austria. Especially the west of Austria, where the Alps are located, is characterized by storage hydro power plants. The next important "storage system" in Austria is the field of thermal storages with water. There are a huge number of units regarding storage systems for water for domestic use. There are also a big number of units regarding storage systems for heating-circuit water. Currently 270,000 units of solar panels with a thermal capacity of 3,334 MW are installed in Austria. Beside the storage of electricity (pump storage) and heat (thermal storages with water) biogas is another issue concerning storage in Austria. In Austria are currently 300 operating anaerobic digestion plants with a total capacity of approximately 80 MWel installed. The average capacity of all anaerobic digestion plants is at 250 kWel. For an average biogas plant approx. 100 m³ volume of biogas storage are to be assumed, which means that the overall biogas storage in Austria amounts to approx. 30,000 m³.The feed in of methane from biogas power plants to the gas grid is another important topic of different operators.
Other storage systems are available in the market, but play a minor role in Austria. That is the reason why private and public institutions concentrate on R&D projects to make other storage systems ready for the market. The Austrian government implemented therefore several institutions which handle the funding with different calls of proposals. The Climate and Energy Fund, which was founded in 2007 by the Austrian government, has a leading role in Austria. The main goal of the Climate and Energy Fund is the reduction of greenhouse gas emissions in Austria by setting targeted pulses and initiating funding for projects. The Climate and Energy Fund is therefore a key instrument of the Austrian government for the achievement of climate protection (20-20-20-targets, Energy Strategy, Kyoto Protocol), higher energy efficiency and the development of innovative renewable energies.

The legislation plays also an important role. In Austria exist several laws and regulations which deal with the topic of energy, but in Austria there is no law, which handles with the topic of energy storage in particular.

The market in Austria is characterized on the one hand by global players, which build the hydro power plants, and on the other hand by national players (private and public institutions, companies, R&D departments, regulators,…). A strong focus of these participants lies in the field of R&D. Austria has a leading role in the R&D activities. In 2012 institutions and firms, which concentrates on R&D activities spent € 8,610 Mio for different projects. Compared to 2011 the expenses for R&D increased about 4.2 %. The total expenditures for R&D run up to 2.8 % of the GDP. The average in the EU is at 2.0 %. Austria, together with Finland, Sweden, Denmark and Germany are those countries that have a higher R&D ratio as 2.7 %. In 2009 approximately 56,000 people have been employed in the sector of R&D. About two third (67.9 %) of them work in the industry sector and 26.7 % are employed in the higher education sector (e.g. universities, R&D institutes,…). Another 4.7 % fiddle with R&D activities at public institutions. About 19.1 % of the total expenditures for R&D activities refer to basic research. Another 35.4 % of the total expenditures are required for applied research projects. 47.1 per cent of expenditure is spent on experimental development. Several institutions focused on different R&D projects concerning storages.

The long term goal in Austria is to become energy self-sufficient until 2050 by using 100% renewable energy and an increasing energy efficiency. This ambitious goal will lead to a rising storage demand in the Austrian energy system. Within this context the storage demand for electricity and heat have to be emphasized. Depending on the conditions the storage demand for electricity rises up to 18-20 PJ/year and the energy storage demand for heat rises up to 20-26 PJ/year. In the near future further studies concerning storages shall be developed to reach the different energy goals which Austria has set.

2. Storage technology checklist

2.1 Market and local future options

2.1.1 Biogas digesters and storage tanks

Biogas storage tanks in combination with an enclosed pressure vessel, a digester and a combined heat and power unit form a complete biogas energy plant. Most available models feature a stiff steel or concrete ring and a flexible cover.

- Market availability / number of units in operation:
  In Austria are currently 300 operating anaerobic digestion plants with a total capacity of approximately 80 MWel installed. The average capacity of all anaerobic digestion plants is at 250 kWel. For an average biogas plant approx. 100 m³ volume of biogas storage are to be assumed, which means that the overall biogas storage in Austria amounts to approx. 30,000 m³.

- Local future options:
  Basically a further development of additional anaerobic digestion plants in Austria depends strongly on the feed in tariff situation. Similar to the situation in Germany, the biogas sector wants to become more independent from feed in tariffs therefore the production of bio-methane and the utilization of the natural gas grid for storage purposes are going to be more attractive. There are also efforts in creating so called virtual biogas plants (several biogas plants are working together) in order to produce peak load power. But this requires additional biogas storage capacity which is basically no problem and also cheaper than purifying biogas to bio-methane.

2.1.2 Power-to-Gas (methane in gas grid)

Large areas of Europe, countries and the region are linked by a massive gas grid for natural gas supply connecting also private households. This historical grid could be used for the storage and transportation of bio- or renewably produced methane.

- Market availability / number of units in operation:
  In Austria are currently seven operating upgrading plants for the production of bio-methane, which is fed into to the natural gas grid with a capacity of 1,100 Nm³ per hour (ca. 9.6 Mio. Nm³ per year), running. There are three further upgrading plants for the production of bio-methane with no feeding in to gas grid but for gas fueling stations. So in Austria there are three bio-methane gas filling stations and 176 natural gas filling stations. The company Stipits, located in Rechniz/Burgenland, is providing container as a mobile bio-methane storage system. A local biogas grid for the heat supply of private households is projected for the Güssing region.

- Local future options:
  Basically the gas grid as a potential storage for energy is very high. The gas grid is also a very low loss storage opportunity. Through pressure increase it would be possible to extend this storage capacity. But there is a general problem in Austria when it comes to use the gas grid as a possible storage. It is possible and permitted to feed in bio-methane from biogas plants into the gas grid but it is not permitted to feed in synthetic methane or hydrogen (from wind power – power to gas) in the gas grid, since there is no adequate legislation to handle this.
  At the moment biogas is mainly used as fuel for cogeneration units in order to produce heat and electricity (to use the heat is not possible everywhere). Future aims will lead to more upgrading units for the production of bio-methane in order to feed in to the gas grid or to supply gas filling stations.
  Local-independent utilization on the one side and the capability of storage on the other side are important advantages of bio-methane or virtual biogas. Except hydro storage power plants, biogas is the only efficient storable renewable energy. Because of the time-independent usage and the possibility to provide peak load power to balance the energy supply, biogas has the opportunity to close the gap between the renewable energy suppliers like photovoltaic and wind power. Since 2008 – by amendment of the Austrian feed in tariff law – there is already the opportunity for biogas plant operators to gain additional 2 cent per fed in kilowatt-hour for upgraded biogas. Quality requirements of this so called bio-methane for feeding in to the Austrian natural gas grid are regulated in the quality guide line ÖVGW G31 and G B220 (former G33)

  These innovative opportunities of using biogas are set as an important topic in the Austrian energy strategy paper (written by the State Ministry of Environment and State Ministry of Economics) and should be reflected in a sustainable Austrian bio-methane strategy.

So biogas respectively bio-methane plays an important role in a decentralized energy supply since it is regional and sustainable applicable. The goal is to cover 5% of the current natural gas demand with bio-methane, which means an extension of further 450 to 600 Mio. Nm^3 bio-methane. This will bring a little more independence to the future Austrian energy supply.

2.1.3 Power-to-Gas (hydrogen in gas grid)

Instead of methane it may to a limited extent be possible to store and transport hydrogen in the gas grid.

- Market availability / number of units in operation:
  Not available, since there is no legislation framework.

- Local future options:
  A requirement in respect of Power to Gas legislation was already announced by several stakeholders.

- Other:
  Individual project ideas to use wind power in combination with an anaerobic digestion plant to run a bio-methane treatment unit.

2.1.4 Power-to-Gas (hydrogen local)

This connotes local energy storage in gas form. This could be done at different scales - for example in vehicle fuel tanks, stationary fuel tanks or in large salt domes or mines.

- Market availability / number of units in operation:
  Currently there are three hydrogen filling station units operating in Austria. One of them is in public use (Vienna, operated by the OMV), the others operate for R&D purposes (TU Graz HyCentA) respectively for in-company transport purposes (Company Fronius HyLOG project). The company Fronius developed a project called “Energy Cell” for stationery and portable applications.

The system consists of a photovoltaic plan and an inverter with the “energy cell”. The energy cell can be used to convert excess energy into hydrogen for storage, converting it back into useful power when needed. The number of units in operation is not known.
Link

- Local future options:
  In general the interest in stationery or portable storage solutions in combination with hydrogen is increasing but strongly correlating with the price. The Austrian oil company OMV is operating a project (in cooperation with TU Wien) in respect of production of hydrogen out of biomass for refinery purposes. There is also a project to construct several hydrogen filling stations along the Brenner Route from South Tyrol to Bavaria with a projected hydrogen treatment plant in Bozen.

2.1.5 Chemical storage (zeolite etc.)

Chemical storage systems involve the storage and release of thermal energy through reversible chemical processes. For example, zeolites *are microporous aluminosilicate, adsorbent minerals that can be deployed to store thermal energy at high temperatures which can later be recovered when water is added to the mineral. When heat is applied to the zeolite, the process is reversed and the water is released.*

- Market availability / number of units in operation:
  Currently no marketable chemical storage systems are available in Austria. In respect of R&D, the EU project “COMTES” is dealing with chemical storage systems. The overall goal of the COMTES project is the technological development and demonstration of three compact thermal energy storage technologies, in three parallel development lines:
    - Line A, Solid sorption heat storage: thermal energy storage by adsorption of water vapor in a solid sorption material (zeolite)
    - Line B, Liquid sorption heat storage: heat storage by absorption of water vapor in a liquid (sodium hydroxide, NaOH)
    - Line C, Supercooling PCM heat storage: storage of heat in a supercooling phase change material (sodium acetate trihydrate, $NaCH_3COO3H_2O$).

  These Austrian R&D institutes are involved in the project: AEE INTEC Gleisdorf, TU Graz, ASIC Wels and AIT Vienna. The project duration is four years. Roughly, in the first two years the storage and auxiliary components are developed and tested, Then, from summer 2014 to summer 2015, the complete system of storage and all heat

sources and heat sinks will be tested and monitored in a real environment. At both component and system level, simulation software will be developed and used to calculate the performance. The monitoring results will be used to validate the simulation software. The simulations subsequently will be employed to determine the system performances in predefined situations, with given meteorological, building and user boundary conditions. At the end of the project, the participating industries will decide on further developing the proven systems.

- Local future options:
  The first prototypes are being expected for 2016 to be tested in field trials. Depending on the results the first marketable thermal storage units are being expected for 2018. Thermal storage technologies play a very important role in achieving the European targets for renewable energy and energy efficiency. The final impact of thermal storage is very high, as 49 % of all the primary energy consumption in Europe is for heating purposes. If a technology has impact in this sector, it will automatically have impact on the energy supply as a whole. Solar thermal technology is the largest potential supplier of renewable heat for the built environment, which has the largest heating demand of all energy consuming sectors. States of the art are solar thermal systems for combined hot water generation and space heating, which cover between 15% and 40% of the heat demand. These systems are available as small domestic systems or for larger, solar assisted district heating systems. This solar fraction can only be substantially increased, if new storage systems are developed that can efficiently store heat over the seasons. The disadvantage of water heat storage systems is that very high volumes for seasonal storage are needed. The solar thermal system has to be over sized to cover the relatively high heat losses, which altogether leads to high initial costs, impeding a fast market implementation. In case of limited space availability, especially in the building renovation sector, solutions for seasonal heat storage are desirable that are more compact than the water based systems.

2.1.6 Compressed air storage

At the moment only two compressed air energy storage plants operate in the world: One in Huntdorf (Germany) and the other one in McIntosh (USA). The Huntdorf plant is located on a 300,000 m^3 salt dome, in which compressed air is stored, originally to capture excess nuclear power production. For rapid responses to power shortages, the air is channelled to a conventional gas turbine, at a capacity of up to 290 MW. Smaller, even mobile compressed air batteries are currently in deployment as well.

- Market availability / number of units in operation:
  Not available, because the focus of R&D in storages is in other sectors.

- Local future options:
  Compressed air storage will not play an important role in the future.

2.1.7 Pump storage (regional in Alpine Space)

Regional water pump storage systems refer to using dams in nearby, higher altitude valleys, to store excess solar or wind power, or to manage and utilise hydropower harnessed from two lakes with different heights or artificial water storages, within the regional context of settlements. Water is pumped using excess or low-priced electricity - the potential gravity energy is maintained with little loss. The stored water is released to drive turbines, to dispatch power to meet peak demands.

- Market availability / number of units in operation:
  Austria is characterized by the production of energy with hydro power. About 19 % of the total electricity production refers to the storage hydro power plants. In the storage hydro power plants are the pump storage power plants included. The difference between these two “storages” is that the pump storage power plants have the possibility to pump the water back into the lake when a lot of electricity production from other sources is available. They can react really fast to relieve the grid. Storage hydro power plants on the other side has only the possibility – also pump storage power plants – to produce energy through turbines when energy is needed by letting water flow from the storage lake to the turbine. In Austria are 111 hydro storage power plants installed. The installed capacity therefor is 7,800 MW. In this case storage hydro power plants play an important role in the field of energy storage. Especially the west of Austria, where the Alps are located, is characterized by storage hydro power plants.

- Local future options:
  The past years showed that more pump storage power plants have been built by the energy suppliers. In the future; more pump storage power plants are planned, which will produce electricity in the next years. The energy regulator (e-control) predict that in 2016 about 8,200 MW of hydro storage power plants will be installed.

2.1.8 Pump storage (Scandinavia etc.)

These water pump storage systems are in principle similar to those above but are linked in a wider spatial context, such as using Norwegian storage capacity for Danish or Dutch wind power.

- Market availability / number of units in operation:
  Not available, because Austria has no geographical access to Scandinavia.

- Local future options:
  This possibility will be no possible solution concerning storages in the future.

2.1.9 Thermal energy storage systems – High temperature

These storage systems can be combined to every source of thermal heat. Storage materials can be solid or liquid for example concrete, stones, sand, water or combinations with salt. A high variation made it useful to split up the different types of thermal energy storage system. This one is for high temperature – also well know under the term HTTESS.

- Market availability / number of units in operation:
  Potentially there are some units in the industrial sector, but exact number of units is not assessable.

- Local future options:
  Interesting for the metal industry, but no economic efficiency yet (the energy costs level is still very low for the industry). Other applications of high temperature thermal storage system in respect of solar thermal power plants have no relevance in Austria.

2.1.10 Thermal energy storage systems – Low temperature

Known as low temperature or latent heat thermal energy storage system.

- Market availability / number of units in operation:
  There are no units in Austria in respect of phase change storage systems. Other low temperature storage systems are to be used in order to increase the temperature level of thermal material at component integration systems.

- Local future options:
  Only in respect of component integration

2.1.11 Thermal energy storage system - Water

Water is here the storage material.

- Market availability / number of units in operation:
  There are a huge number of units regarding storage systems for water for domestic use. There are also a big number of units regarding storage systems for heating-circuit water. Currently 270,000 units of solar panels with a thermal capacity of 3.334 MW are installed in Austria. The total annual output of all solar panels is 1.920GWh. (90% in private one family houses, 7% in multi-family houses and hotels, etc. and 2% for applications regarding with district heating grids and in the industrial sector. There are no water based thermal storage systems in respect of aquifer in Austria.

- Local future options:
  There is a big potential for thermal storage systems in combination with district heating systems. More and more operators of small district heating grids are installing thermal storage units on the final consumer side to reduce peak loads.

2.1.12 Thermal energy storage system - Salt

In this case salt or combinations with salt are the storage material.

- Market availability / number of units in operation:
  No relevance in Austria

- Local future options:
  Only in some rare R&D projects

2.1.13 Thermal energy storage system – Materials like concrete, stones or sand

Lithic materials like stones and sand or concrete are used here for the storage. This is an important aspect in concrete core cooling – concepts.

- Market availability / number of units in operation:
  Number of units not assessable.

- Local future options:
  Is not given.

2.1.14 Flywheels (small-sized)

Flywheels are rotating mechanical devices to store kinetic energy. It releases the energy by applying torque to a mechanical load. Contemporary flywheels consist of a carbon-fiber composite rotor suspended by magnetic bearings. Rotors spin at 20,000 to over 50,000 rpm in a vacuum shell to reduce friction.

- Market availability / number of units in operation:
  The University of Vienna has a R&D project in which they develop a flywheel for common energy storage. It should be possible with these flywheels to store energy for a couple of hours.

- Local future options:
  The University of Vienna is going to provide more information about the flywheels in the near future.

2.1.15 Flywheels (large-sized)

Large sized flywheels operate on the same principle, but store more energy in a higher mass und physical size.

- Market availability / number of units in operation:
  The University of Vienna has an R&D project in which they develop a flywheel for common energy storage. It should be possible with these flywheels to store energy for more hours.

- Local future options:
  The University of Vienna is going to provide more information about the flywheels in the near future.

2.1.16 Mobile batteries (electric vehicles)

Vehicle-to-grid (V2G) systems store and dispatch electrical energy stored in networked vehicle batteries, which together act as one collective battery fleet for peak shaving and supplementary resource- still largely conceptual.

- Market availability / number of units in operation:
  Austria started in 2009 the first model region for electromobility in Vorarlberg with the project VLOTTE. Today are in total eight model regions for electromobility established. Austria has in total 1,130 EVs and PHEVs on the road (Source: Statistik Austria, 25.04.2012). The goal of the model regions have been the implementation of e-cars into the market and the construction of charging infrastructure. The topic “Vehicle-to-grid (V2G)” have not been a big issue by the model regions. There are just a few R&D projects, which deal with this topic. (see chapter 8. R&D)

- Local future options:
  Austria's government plans to have 250,000 EVs and PHEVs on the road till 2020. An average EV has a battery capacity of 20 kWh. By multiplying the amount of cars with the theoretical battery capacity the theoretically storage capacity could be 5 GWh. This figure shows only the theoretically maximum and will not be storage capacity where operators of mobile storages can rely on.

- Other: please also see chapter 7 market conditions

2.1.17 Stationary batteries

Examples of stationary batteries include lead acid batteries, lithium ion batteries, redox-flow batteries or hybrid-flow batteries.

- Market availability / number of units in operation:
  In Austria a few projects with stationary batteries have been started. The exact number of these projects couldn't be figured out. There are also some R&D projects which deal with the integration of stationary batteries to a home system (in combination with PV) or with the integration of stationary batteries to the energy system. (see chapter 8)

- Local future options:
  In Austria the demand for decentralized storage with stationary batteries increases. The reason for that is a not a technical necessity like in other countries which have already problems with the grid, it is the wish for an independent energy production with the own energy system (e.g. PV) in combination with a stationary battery.

2.2 Technology comparison

Table: Technology - EXAMPLEFehler! Textmarke nicht definiert.	Market availability	Storage period	Storage volume	Response Time	Local Option
Biogas digestion and storage	+++	days	+	medium	+++
Power-to-Gas (methane in gas grid)	o	weeks	+++	quick	o
Power-to-Gas (hydrogen in gas grid)	o	weeks	+	quick	--
Power-to-Gas (hydrogen local)	--	days	-	quick	+
chemical storage (zeolite etc.)	+	days	o	slow	+
compressed air storage	+	weeks	o	medium	---
pump storage (regional in AS)	+++	months	+++	quick	+++
pump storage (Scandinavia etc.)	+	weeks	++	quick	---
Thermal energy storage system – high temperature	+	hours	+	medium	+
Thermal energy storage system – low temperature	o	week	++	medium	o
Thermal energy storage system – water	+++	days	+++	quick	+++
Thermal energy storage	o	weeks	++	medium	o

system – salt					
Thermal energy storage system – lithic material	o	hours	o	Very slow	o
fly wheels (small-sized)	++	minutes	--	very quick	++
fly wheels (large-sized)	--	weeks	o	very quick	o
mobile batteries (electric vehicles)	--	hours	-	very quick	+++
stationary batteries	o	days	-	very quick	+++

Table 1: Technological storage examples

Explanation

Please complete the above matrix in, following these scales:
Market availability, storage volume, local option: +++ (best), ++, +, o (neutral), -, --, --- (worst)
Storage period: minutes, hours, days, weeks, months
Response time: very quick, quick, medium, slow, very slow

3. Renewable energy status: sources, supplies, network, market

The 2010 **National Renewable Energy Action Plan for Austria** presents measures to achieve an increase to 34 percent, by 2020, of renewables as a share of gross energy consumption (in line with EU Directive 2009/28/EC). Compared to a reference scenario based on the data on energy consumption available up to 2009, final energy consumption is to be cut by 13 percent by 2020 in order to achieve the target. Sectors will contribute different shares to this goal. The largest contribution is expected from transport (–22 percent), followed by heating and cooling (–12 percent) and electricity (–5 percent). The directive's implementation is a dynamic process, to a large extent controlled by the envisaged energy strategy of the Austrian Federal Government.

Austria ranks high in renewable energy consumption, mainly due to its high share in **hydropower and biomass**. It was among the four EU countries with the highest share of energy from renewable sources in gross final energy consumption in 2005 and amongst the Member States committing to the most ambitious national targets for 2020 (in Austria: 34%) under the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Since 2005 the share of renewable energy in Austria had grown continuously, reaching nearly 29% in 2008. The main driver for the growing contribution of renewable energy is the enhanced use of biomass due to strong incentives such as targets set by regulations, a long-term focus on research and development policies as well as subsidies.

Wood biomass for heating purposes has always played an important role in the Austrian energy supply. In the beginning of the 1980s, strict air pollution legislation was introduced, forcing companies to improve the performance of wood boilers with regard to energy efficiency and emissions. Strong competition started which resulted in significant improvements and high-performance biomass combustion technologies. Hence, biomass boilers made in Austria nowadays represent one of the best available biomass combustion technologies worldwide. As regards consumers, grants for wood boilers stimulated demand. In 2009, more than 70,000 pellet boilers were installed with a power capacity of 1,356 MW. Over 1,000 biomass district heating stations have been constructed in rural areas since the 1980s, often with subsidies providing the decisive incentive.

Green electricity legislation was introduced in 2002 pursuant to the EU Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources, regulating eligibility of support and feed-in tariffs. In 2009, electricity produced from biomass under the green electricity scheme accounted to more than 2,500 GWh corresponding to around 5% of total electricity production.

In 2004, Austria's government adopted an ordinance on **biofuels** exceeding the targets of EU Directive 2003/30/EC (2% share in 2005, 5.75% in 2010) resulting in a 7% share of biofuels in 2009.

The objective of the (recently elaborated) energy strategy is the development of an energy system providing energy services to private consumers and businesses in the future while complying with EU climate and energy requirements (34% renewables, 16% reduction of GHG in the non-ETS sector). Achieving stabilization of final energy consumption (considered to be indispensable) is a major challenge for Austria.

According to recent national research papers, main challenges in the energy sector are achieving a higher rate of thermal refurbishment of existing buildings, a new approach to transport and mobility services and a higher rate of cogeneration and renewables in the production sector as well as future decision-making on energy supply and transformation technologies and increased public research funds for clean energies.

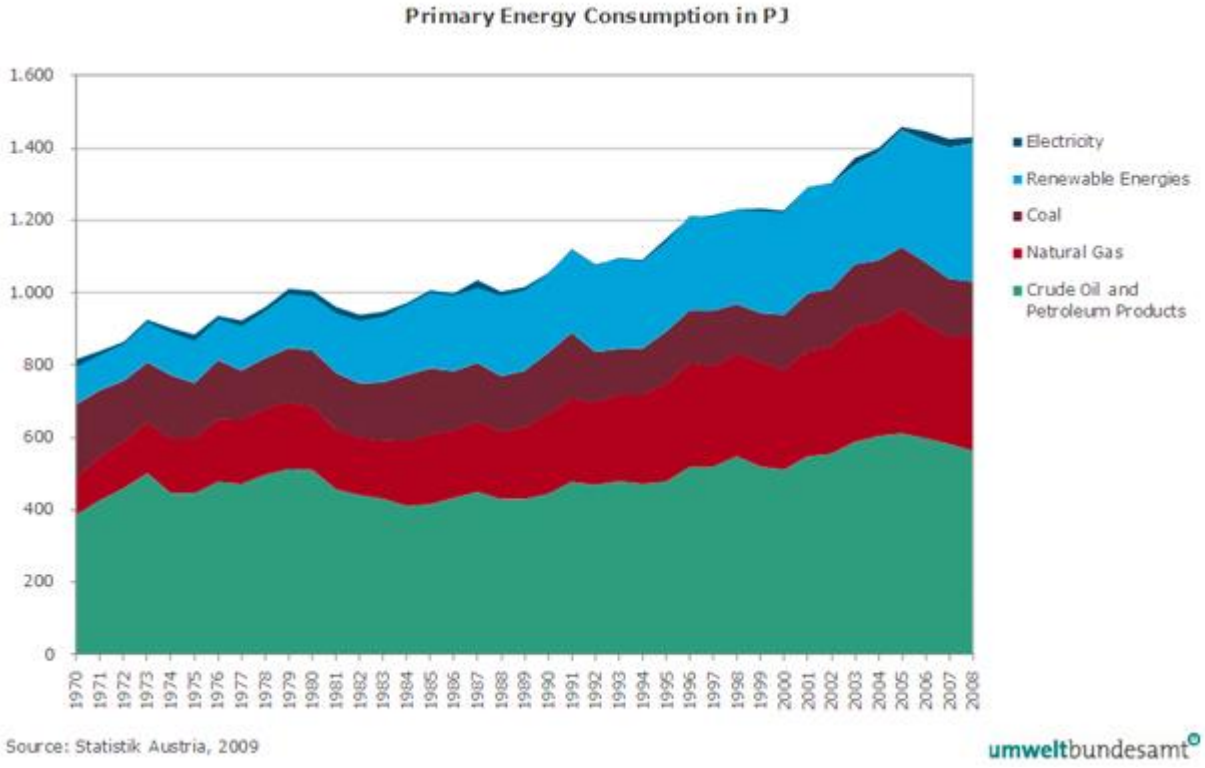

Figure 1: Primary Energy Consumption in PJ

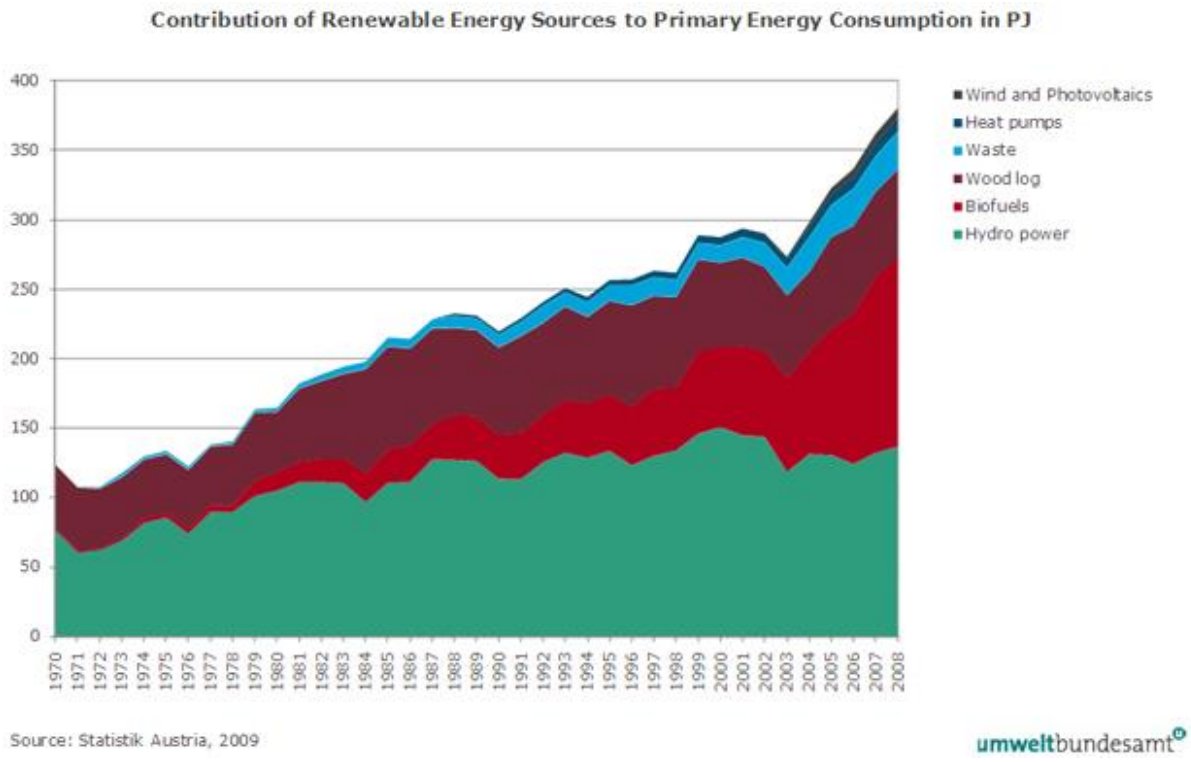

Figure 2: Contribution of Renewable Energy Sources to Primary Energy Consumption in PJ

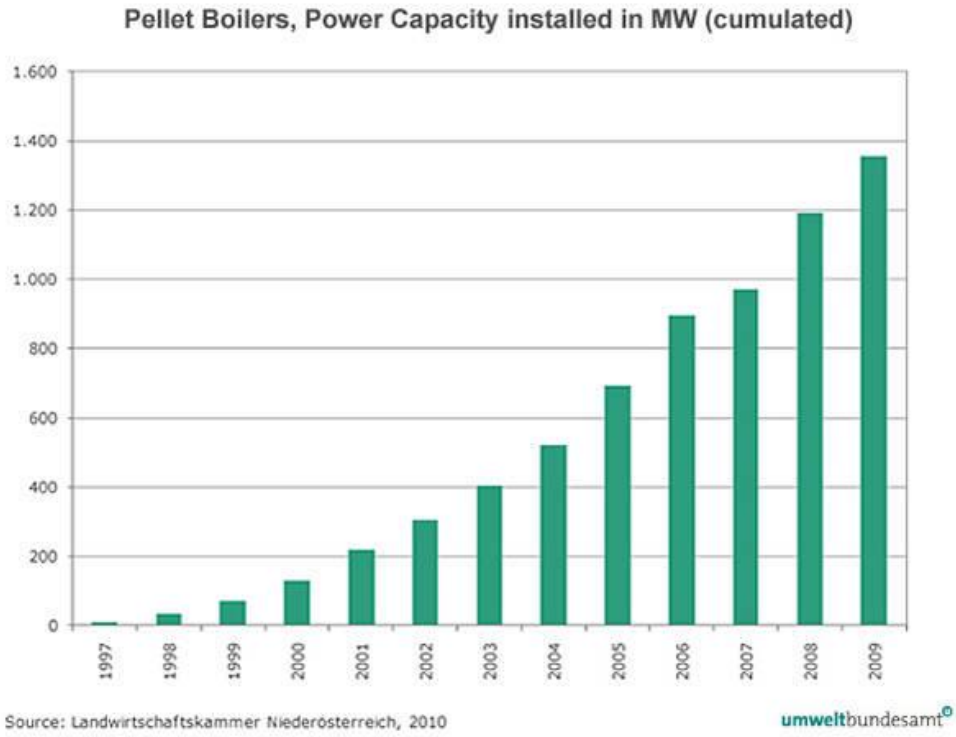

Figure 3: Pellet Boilers, Power Capacity installed in MW (cumulated)

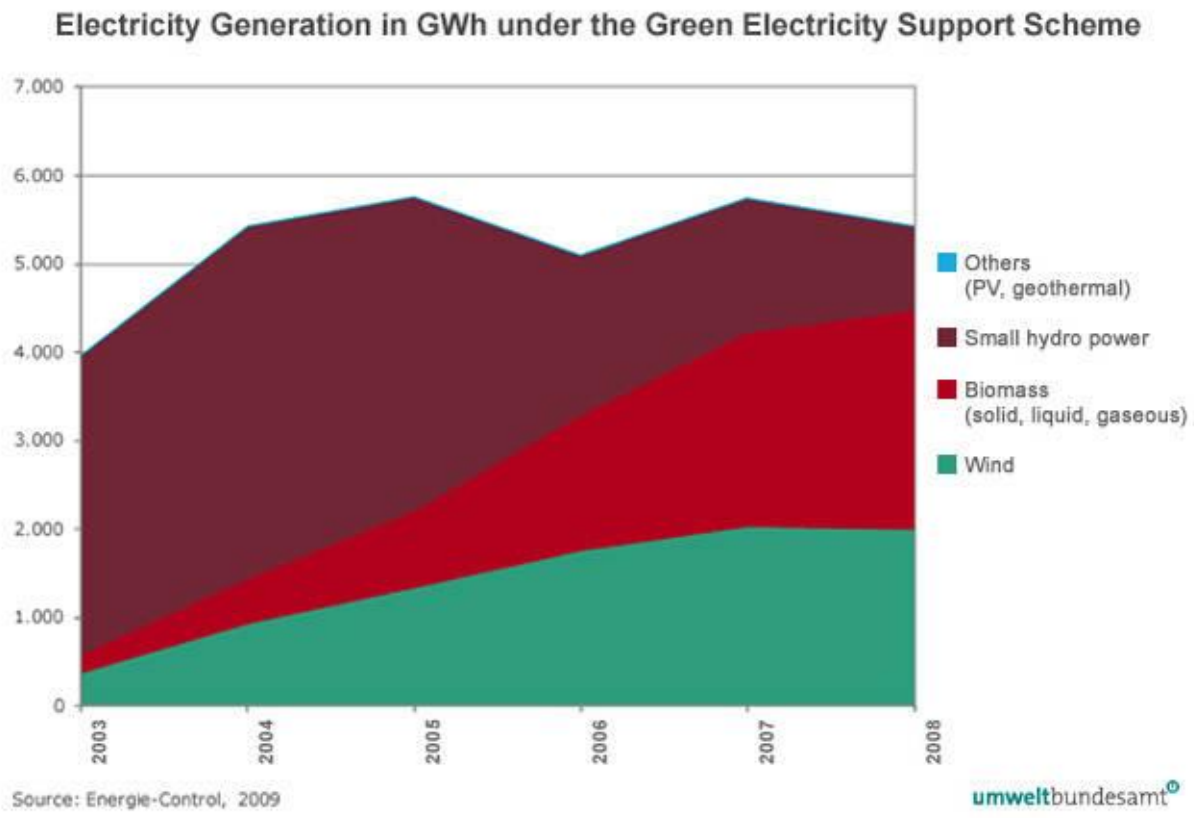

Figure 4: Electricity Generation in GWh under the Green Electricity Support Scheme

Facts and Figures for 2010 Link

The Austrian gross national consumption of energy for the year 2010 is 404.906GWh or 1.458 PJ (this is an increase of 6.7% compared to 2009). The **share of renewable energy** (by EU 2009/28/EG) has been **30.8%.** The biggest share of renewables has energy out of hydropower with 39.5%, followed by solid biomass with 32.4% and renewable energy in the district heating sector with 8.5% and biofuels with 6.1%. The rest of 100% is produced by other renewable energy sources like wind power, photovoltaic, solar thermal, biogas, etc.

By using renewable energy it was possible to avoid greenhouse gases of 15.98 Mio. tons (CO_2 equivalent) in Austria in the year 2010 (by including the big hydropower energy 30.27Mio tons).
The total sales volume of all investments related with the operation of renewable energy was 5,229 billion Euros in the year 2010 (increase of 5.1% compared to 2009). 37,649 employees worked in the relevant sectors of production and service (increase of 1.9% compared to 2009).

Facts and Figures in different sectors

Austria has a leading role in Europe by using renewable energy sources. As mentioned before the share of renewable energies compared to the gross national consumption is at **30.8 %**. The proportion for renewable energies for the production of power and district heat is at **65.3 %** and **38.3 %**. Compared to other European countries, Austria has an leading role in this field.

Proportion renewable energy in Austria	
Proportion renewable energy	30,8%
Proportion renewable power	65,3%
Proportion renewable district-heat	38,3%
Proportion renewable transport	6,3%
Proportion renewable rest	27,5%

CO_2 –avoidance by renewable energy	
without large hydro power	15.98 Mio. Tons of CO2

Renewable power	
Hydro power	39.237 GWh
Biomass	4.554 GWh
Wind power	2.035 GWh
Photovoltaics	89 GWh
Geothermics	1,4 GWh
Total	45.916 GWh

Renewable heat	
Biomass	35.510 GWh
Distrct heating	8.451 GWh
Solarthermics	1.904 GWh
“Umgebungswärme”	1381 GWh
Geothermics	89 GWh
Total	47.335 GWh

Renewable fuels	
Biodiesel	5.062 GWh
Bioethanol	824 GWh
Other fluid biogenic energy carrier	177 GWh
Total	6.064 GWh
TOTAL RENEWABLE ENERGY	**99.315 GWh**

Importance renewable energy for national economics	
Volume	5,229 Mrd €
Employment	37.649 FTE

Table 2: Statistic Renewable Energy in Austria 2010

Source: Datenquellen: Statistik Austria 2011, Berechnungen EEG 2011

Smart Grids

Austria has the goal to establish **Smart Grids** in several regions. The National Technology Platform Smart Grids Austria is an association of overweight stakeholders in the field of electrical power supply. It aims is to bring together joint forces for future intelligent power networks, to support a more energy and cost-efficient system operation. Some R&D project concerning Smart Grids have been developed (Salzburg, Großes Walsertal,etc.). Smart Grids play an important role in the energy strategy of Austria in the future.

4. Institutional framework

The following list describes the main public and private institutions which are charged or mandated with energy storage development, management and standard-setting together with their main activities.

- **E-control**
  The Energy Control Austria (E-control) is responsible for the regulation of the electricity and the gas industry market. It has been founded in 2001 and is an institution of public law which is under the observation of the Federal Ministry of Economics and Labor.

- **Energy Supplier**
  Some energy suppliers in Austria have a strong focus on energy storage. Especially in the Alps (in the west of Austria) are many pump-hydro power plants in use, which produce peak energy for the electricity market.

- **ÖBB (public transport operator)**
  The ÖBB is the public transport operator in Austria. They have own hydro power plants, also storage power plants, in which they produce energy for the transportation sector.

- **"Österreichs Energie" (VEÖ)**
  "Österreichs Energie" represents the political, administrational and public interests of the Austrian electricity industry. On this base "Österreichs Energie" ensures that the electricity economy has the best conditions for their task and can manage the future challenges optimally.

- **Klima- und Energiefonds (Climate and Energy Fund)**
  The climate and energy fund is an institution of the Austrian government. It was founded in 2007 and has the goal to reduce greenhouse gas emissions in Austria by setting targeted pulses and initiating funding for projects.

- **Kommunalkredit Public Consulting**
  Kommunalkredit Public Consulting has set itself the goal of making a sustainable contribution to environmental, economic and social developments through the management of support programmes and targeted consulting activities.

- **The Austrian Research Promotion Agency (FFG)**
  The Austrian Research Promotion Agency (FFG) is the national funding agency for industrial research and development in Austria. As a "one-stop shop" offering a diversified and targeted program portfolio, the FFG gives Austrian businesses and research facilities quick and uncomplicated access to research funding. The FFG is wholly owned by the Republic of Austria, represented by the Federal Ministry for Transport, Innovation and Technology (bmvit) and the Federal Ministry of Economy, Family and Youth (BMWFJ). As a provider of funding services, the FFG also works for other national and international institutions.

- **Universities**
  The universities have a strong focus on R&D. They often deal with different topics of concerning energy efficiency, renewable energy sources, energy storages, etc. A list of topics concerning energy storages can be found in the chapter “8. R&D”.

- **Austrian Institute of Technology (AIT)**
  The AIT Austrian Institute of Technology, Austria's largest non-university research institute is among the European research institutes a specialist in the key infrastructure issues of the future.

- **Austrian Energy Agency**
  The Austrian Energy Agency is the national center of excellence for energy. New technologies, renewable energy, and energy efficiency are the focal points of our scientific activities. The objectives of our work for the public and the private sector are the sustainable production and use of energy and energy supply security.

- **AEE Intec**
  AEE – Institute for Sustainable Technologies (AEE INTEC) was founded in 1988 as an independent research association and is now one of the leading institutes for applied research in the fields of solar thermal energy, low-energy and zero energy buildings as well as in energy efficiency in industry. Besides these energy related topics also sustainable water management is a focus areas. AEE INTEC is located in Gleisdorf, Austria, which is about 150 km south west of Vienna and 20 km east of the city of Graz.

- **ASIC**
  The Austria Solar Innovation Centre is a research and development institute organized in the form of a non-profit association which is committed to the distribution of renewable sources of energy in general and more specifically to the intensification of research in the field of solar technology. The ASIC has been involved in research and development in the

area of solar technology in Wels since March 2000. A platform has been created between research, training and commercial enterprise. The main tasks of the ASIC include research and development in addition to project management on the subject of solar energy.

- **klima:aktiv - the Austrian climate protection initiative**
  klima:aktiv is the Austrian climate protection initiative launched by the "Federal Ministry of Agriculture, Forestry, Environment and Water Management", embedded in the Austrian federal climate strategy. The primary objective of klima:aktiv is to introduce and promote climate friendly technologies and services.

- **Joanneum Research**
  Joanneum Research is a professional innovation and technology provider with a track record of 30 years in cutting-edge research at international level. It focuses on applied research and technology development, thus playing a key role in technology and knowledge transfer in Styria.

- **Austrian Battery Resarch Laboratory GmbH (ABR)**
  ABR GmbH is one of the largest independent testing laboratories for electrochemical energy storage systems in Europe. ABR works primarily in the area of R & D to develop own solutions for storage systems, primarily for automotive applications, such as Starter battery systems, micro, mild and full hybrid systems.

- **ARGE Kompost und Biogas**
  The ARGE Compost & Biogas Association Austria - as the umbrella organization of the national organizations – is now nine years active referring to numerous activities and has established itself fully in Austrian and European professional circles. The primary purpose of the ARGE is anything, which supplies the biogas plant operators and industry companies and gives them a positive image and a strengthening of their existence. ARGE achieves this purpose by participating in standardization, organizing training events, implementing research projects and by professional assisting in policy, regulation and laws which preserves the client interests. The ARGE is also involved in a wide extensive network between industry, science and law, which enables the ARGE to act for the purposes of the branch. Because of their extensive range of information (website (Link)) they look at the latest developments in the fields of compost and biogas.

5. Policy initiatives and plans

20 – 20 – 20 Targets Link

In January 2008, the European Commission presented a legal package on climate protection which is often referred to as the 20-20-20 targets. The proposals focus on a restrictive climate and energy policy and set new goals. By 2020, Europe shall thus:

- cut greenhouse gas emissions **by 20 %**,
- increase the share of energy from renewable sources **by 20 %**,
- increase energy efficiency **by 20 %**.

The burden of reducing greenhouse gas emissions will be shared by the Member States on the basis of their wealth. Austria is committed to reducing emissions by 16 % by 2020 as compared to 2005. This target applies to all emitters not subject to the emissions trading scheme set out in the European directive 2003/87/EC. However, this emissions trading scheme should also be further developed and more restrictively applied. Apart from the fact that, as of 2010, certificates will no longer be distributed free of charge, the sectors subject to the emissions trading scheme will be assigned a reduction target of 21 %. The new directive on carbon capture and storage is another important component of the efforts in climate protection. This directive promotes relevant technologies and the practice of geological storage of CO_2 emissions. Finally, the third pillar of the 20-20-20 targets is raising the share of energy from renewable sources. By 2020, the share of energy from renewable sources shall be increased to 20 % of total energy consumption, i.e. not only regarding electricity, but also heating, transport, etc. The contribution set for Austria is an increase in this share from 23.3 % in 2005 to 34 % in 2020.

The Kyoto Protocol Link

At a supranational level the Kyoto Protocol has been the central instrument of climate policy. All EU member states have agreed to share the climate burden and have committed to individual climate protection targets.

The Austrian target is a reduction of greenhouse gas emissions by 13 % as compared to the base year 1990 by the end of the so-called Kyoto period. An Austrian climate strategy for target attainment defined a series of instruments and measures, which cover all important areas, from the renovation of residential buildings, traffic regulations, the optimization of processes for the generation of electricity and heat to the promotion of renewable energy technologies. So far, these efforts have not produced the expected results. Current values of greenhouse gas emissions in Austria significantly exceed the original Kyoto targets - i.e. 15 % above the base value of 1990.

The energy end-use directive Link

Another central point of European energy policy is the energy end-use directive. It stipulates an increase in energy end-use efficiency by 9 % by 2016 as compared to 2006. This target does not require a "real" reduction in energy consumption in absolute numbers but a more efficient use of energy, i.e. driving more kilometers with the same amount of gasoline. Last but not least the common energy policy strives for a significant increase of the share of energy generated from renewable energy sources in Europe. This applies to both the energy end-use (i.e. heating, bio-fuels for vehicles) and transformation processes in the generation of electricity and heat.

Energy Strategy Austria Link

The aim of the "Energy Strategy Austria" is the development of a sustainable energy system, energy services for private consumption as well as for companies. The defined goals should provide the EU targets on climate and energy (20-20-20, Kyoto Protocol). Security of supply, environmental impact, cost, energy efficiency, social equity and competitiveness were fixed as frameworks in the Austrian energy strategy. In working groups concrete measures should be defined. Concerning storages and e-mobility two working groups; “storage and grid” and “mobility”; have been implemented.

Storages

Concerning storages further studies shall be conducted. Important topics in this case are CCS, gas storages and “environmental friendly storages”. Different market players (e.g. energy suppliers) will get an order to create helpful studies.

EVs and PHEVs

In 2020, in total 250,000 electric vehicles (proposed all-electric vehicles and plug-in hybrid vehicles) should be on the road in Austria. This represents a ratio of not quite 5 percent of the forecast of the total number of passenger cars in 2020.

National Renewable Energy Action Plan for Austria

The 2010 National Renewable Energy Action Plan for Austria presents measures to achieve an increase to 34 percent, by 2020, of renewables as a share of gross energy consumption (in line with EU Directive 2009/28/EC). Compared to a reference scenario based on the data on energy consumption available up to 2009, final energy consumption is to be cut by 13 percent by 2020 in order to achieve the target. Sectors will contribute different shares to this goal. The largest contribution is expected from transport (–22 percent), followed by heating and cooling (–12 percent) and electricity (–5 percent). The directive's implementation is a dynamic process, to a large extent controlled by the envisaged energy strategy of the Austrian Federal Government.
(more details chapter 3)

Klima- und Energiefonds (Climate and Energy Fund) Link

The climate and energy fund is an institution of the Austrian government. It was founded in 2007 and has the goal to reduce greenhouse gas emissions in Austria by setting targeted pulses and initiating funding for projects. The Climate and Energy Fund is therefore a key instrument of the Austrian government for the achievement of climate protection (20-20-20 targets, Kyoto Protocol), higher energy efficiency (the energy end-use directive) and the development of innovative renewable energies. Since 2007 in total 35,000 energy and climate projects have been implemented with a total budget of € 600 Mio by the Climate and Energy Fund. The Climate and Energy Fund is responsible to keep the European targets (20-20-20) in mind and promote a “zero emission Austria”.

For the efficient operational implementation of the funding allocation the Climate and Energy Fund is supported by management agencies. These are currently the “Österreichischen Forschungs-förderungsgesellschaft mbh” (FFG), „Kommunalkredit Public Consulting GmbH“ (KPC) and the „Schieneninfrastruktur-Dienstleistungsgesellschaft mbH“ (SCHIG mbH).

Projects concerning energy storages and also smart grids, which also include the topic of storage, are big issues in the different programs. The following programs of the Climate and Energy Fund, which have a close link to energy storages, are registered in the following list.

- **Smart Cities – FIT for SET**
  This program attends to the topics renewable energies, energy efficiency, mobility, e-mobility and model regions. The vision of the Climate and Energy Fund for the program "Smart Cities - FIT for SET" is the first implementation of a "smart city" or a "smart urban region" and also includes neighborhoods, communities or other urban regions in Austria. The main task lies on the implementation of intelligent green technologies to build up a "zero emission city" or "zero emission urban regions" with a high quality of life. The program focuses on the areas of buildings, energy networks, supply and waste management, mobility, communication and information. The storage of energy is therefore an essential way to achieve the objectives, which are defined in the “Smart Cities – FIT for SET” program.

- **Smart Energy Demo – FIT for SET**
  The central objective is the implementation of the visible "Smart City" pilot and demonstration projects in which existing and already largely mature technologies, systems and processes are integrated to interacting global systems. The key strategic objectives of the program are aimed at improving energy efficiency, increasing the share of renewable energy sources and the reduction of greenhouse gas emissions.

- **Neue Energien 2020**
  This program attends to the topics renewable energies, energy efficiency, smart energy and awareness. In the program, ideas and concepts with long-term prospects have been realized by basic research and technological research and development work and implemented through pilot and demonstration plants. In addition to these primarily technology-related issues, the program has to work out the task to address social issues and knowledge for long-term planning processes. The program closed in 2011. The objectives of the program will be continued in the new program "e!Missi0n+.at – Energy Mission Austria", which started in 2012.

- **e!Missi0n+.at – Energy Mission Austria**
  This program attends to the topics renewable energies, energy efficiency and R&D. This program pursues the Climate and Energy Fund aims to reduce the cost of high-efficiency and low emission energy technologies and help ensure that Austrian companies play in this rapidly growing sector a leading role. The focus lies on collaborative projects between industry and science. The program is designed to convert scientific breakthroughs into innovative and sustainable products and services that provide business opportunities and make a contribution to reduce greenhouse gas emissions significantly.

6. Legislation

Because of the special economic, structural and technical and physical properties of the energy economy, the electricity and gas laws play an important role by handling different topics. These laws are linked to the production, transmission, distribution, sale and trading of electrical energy and gas. In Austria there is **no law**, which handles with the topic of energy storage in particular. All the mentioned topics are written down in laws, which have a strong link to other areas.

European Legislation

European directives do not directly have legal force in Austria, but become legally binding after they have been transposed into Austrian law. Austria therefore implemented the EU legislation into the national legislation. The e-control has collected several European legislative texts and provided them at the following link.

National Legislation

The E-Control, which is responsible for the regulation of the electricity and the gas industry market, has undertaken to provide translations of a number of major Austrian energy acts into English so as to inform interested readers about the national legislative situation. Most important are three laws, which describe the situation about legislation in the sectors electricity, green electricity and gas.

"Elektrizitätswirtschafts- und Organisationsrecht" (ElWOG)
Electricity Act, amanded in 2010 *Link*
This federal law provides rules for the organization of the electricity sector in Austria. The purpose of this Federal Act is to enact provisions on the generation, transmission, distribution and supply of electricity, as well as on the organization of the electricity sector. The further purpose of the federal act is to regulate the system charges and provide rules on billing, internal organization, unbundling and transparency of the accounts of electricity undertakings and to lay down other rights and obligations of electricity undertakings.

"Green electricity legislation" Link
This legislation was introduced in 2002 pursuant to the EU Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources, regulating eligibility of support and feed-in tariffs.

"Gaswirtschaftsgesetz"

Natural Gas Act *Link*

This federal law provides rules for the organization of the natural gas sector in Austria. The purpose of this Federal Act is to to enact provisions on the transmission, distribution, purchase and supply of natural gas, including network access and access to storage. The further purpose of the federal act is to regulate the system charges and provide rules on billing, internal organization, unbundling and transparency of the accounts of natural gas undertakings and to provide for other rights and obligations of natural gas undertakings; as well as to regulate the construction, extension, alteration and operation of natural gas pipeline systems.

Ordinance

Ordinances are implemented into national laws. They can describe certain issues in more detail. The following list shows a few of them, which are implemented into the national electricity and gas laws.

- Ordinance Determining the Requirements for Smart Meters 2011 Link
- Electricity Switching Ordinance 2012 Link
- Gas Smart Meter Requirements Ordinance 2012 Link
- Gas System Charges Ordinance 2013 Link
- Gas Market Model Ordinance 2012 Link
- Ordinance on Gas System Service Quality Link

Legislation for mobile Storage systems

At the moment there is **no legislation** for mobile storage systems (EVs and PHEVs) which attends to manage these kinds of storage systems. A standard norm (ISO 15118 – Road vehicles – Vehicle to grid communication interface), which take care of a standardization between the electric cars and the charging infrastructure, has been developed to handle with this special topic. At the moment the norm is under review. It shall adjust to the communication between the electric cars and the charging infrastructure and shall define a common standard or a standardized protocol. With this ISO 15118 it should be possible to get a hand on managing mobile storages in the future. A standardization of the total electromobility market is at the moment a wishful thinking, because problems like standardized plugs, infrastructure, roaming, etc. are problems which are not so easy to be solved in the near future.

7. Market

There are different reasons and conditions why institutions and organizations handle with the topic of energy storage in the market. The following list shall give an overview about the situation in Austria. In the different topics are only some exemplary examples listed.

- **Technical necessity**
  One reason why energy storages are needed is to balance the offer and demand of different energy sources. Therefore storages are a technical necessity to keep the energy system running. Especially the increase of renewable sources in the energy systems makes the implementation of storages a necessity instrument.

- **Business by operating storages**
  Energy storages have in addition to the technical necessity the advantage that operator of storage systems have to earn money by running their system. Especially operators of pump storage power plants have to make decision if they pump the water up to the storage lake or produce energy to balance the offer and demand of energy and to make a business out of that process.

- **Business by selling storages**
  In addition to operate storages institutions have interests to produce and finally sell storages to customers who run the storage. In Austria there are some companies which see a possible business model by putting products like storages on the market. Most of the companies concentrate on storages which are for a decentralized use (batteries, fuel cells, biogas). Other storages like pump storage power plants are mostly built by companies which are global player in this business (Siemens, Hydro Andritz…). In the following list are two companies – Gildemeister and Fronius – which focus on this topics batteries and fuel cell for the use of hydrogen.

  ✓ **Gildemeister – energy solutions, CellCube – Vanadium redox flow battery**
  The firm cellstrom GmbH is an Austrian provider of energy storage systems and overall solutions for a demand-driven, uninterrupted electrical energy supply. The storage of energy is based on vanadium redox battery technology. The company's own developments were started in 2002 and resulted in 2008 in the first energy storage system produced in series. Through the combination of renewable energies from photovoltaic, wind and/or a biofuel generator with the energy store, a defined electrical device can be completely and reliably supplied.
  Source: Link

✓ **Fronius energy cell – fuel cell – for stationery and portable hydrogen applications**

The company Fronius developed a project called “Energy Cell” for stationery and portable applications. The system consists of a photovoltaic plan and an inverter with the “energy cell”. The energy cell can be used to convert excess energy into hydrogen for storage, converting it back into useful power when needed.

Source: Link

- **Awareness for a sustainable energy system**

As mentioned before the increase of renewable energies in the energy system make the use of storage necessary. Therefore organizations are anxious to keep the focus on a sustainable energy system and support the use or the storage of these volatile energy forms especially when they incur. One organization which focus on this topic is the klima:aktiv.

✓ **klima:aktiv - the Austrian climate protection initiative**

klima:aktiv is embedded in the Austrian federal climate strategy, consisting of a bundle of measures of regulation, taxes, and subsidies. klima:aktiv has gathered all voluntary and supportive measures under one umbrella. In the four thematic clusters building, energy efficiency, mobility and renewable energy, specific programmes are carried out by different institutions. These programmes follow a comprehensive and systematic approach in supporting the market introduction of climate-friendly technologies, services and activities. klima:aktiv follows the idea of market transformation. Market transformation is a targeted effort to change the market. This approach’s main characteristic is an active and comprehensive inclusion of all relevant market players and stakeholders. The main advantages of a market transformation approach are comparably low costs and high sustainable effects. In this case, market transformation aims to raise the share of energy efficient products and services.

Source: Link

- **Basic Research**

Research and Development in the field of energy efficiency and renewable energies plays an important role in the energy strategy of Austria. These two topics are closely linked to energy storages. Austria has a lot of different funding projects which all take care of a sustainable energy system (see chapter 5). One focus of the funding programs is basic research. In the project “Symbiose” for example the focus lies on the linking between different energy systems and the integration of storages to this system.

- **Applied Research**
  Another big focus lies on the applied research. There are different topics which are investigated by several institutions. The following list shall give a short overview about the different activities and R&D approaches.

  - **Energy Research Park Lichtenegg-Pesendorf (Energieforschungspark)**

    The project Energy Research Park in Lichtenegg-Pesendorf (Lower Austria) is operated by the regional energy supplier EVN with public and private partners (Fachhochschule Technikum Wien, Wicon Engineering, Verein Energiewerkstatt, Solvento Energy Consulting, Arbeitsgemeinschaft Erneuerbare Energie Wien-Niederösterreich, ÖGUT and Klima- und Energiefonds). 2011 the EVN started the project by implementing a test area for small wind turbines, photovoltaic plants and energy storage systems. The main objective is to test the interaction between wind energy and solar energy in combination with an energy storage system. Total costs of investment are approx. 450.000 EUR. Ten different small wind turbines with a total capacity of 36kW are built and tested in combination with a 10kWp photovoltaic plant with the goal to select the best solution for customer requirements of the EVN. At the same time a vanadium-redox-flow battery (Cellstrom GmbH) with a capacity of 10kW and an energy capability of approx. 100kWh is tested.
    The production of electricity, the overall annual output as well as analysis of sound and wind speed are tested periodically. The goal is to test the performance and the long term economic efficiency of these units and – based on this experience – to develop a market-ready and customer-friendly product. Furthermore the potential of such units and the potentially arisen power grid requirements should be detected.
    Source: Link

  - **ASIC**
    The Austria Solar Innovation Centre is a research and development institute organized in the form of a non-profit association which is committed to the distribution of renewable sources of energy in general and more specifically to the intensification of research in the field of solar technology. The ASiC has been involved in research and development in the area of solar technology in Wels since March 2000. A platform has been created between research, training and commercial enterprise thanks to the financial support of the region of Upper Austria, the city of Wels and the electric power company of Wels. The main tasks of the ASiC include research and development in addition to project management on the subject of solar energy.

ASIC is providing the following specific services:

- Measurement of solar thermal collectors and photovoltaic modules
- Functional and revenue monitoring of thermal solar plants and PV systems
- Project management and concept development in the field of renewable energy
- Simulations to support planning activities
- Determination of optical characteristics of materials
- Consultation which is not specific to firms or products
- Lectures
- Training

The ASIC is organized in the form of an association and is supported financially by the region of Upper Austria, the city of Wels, the electric power company of Wels and the firm Fronius.
Source: Link

- **AEE Intec**

AEE – Institute for Sustainable Technologies (AEE INTEC) was founded in 1988 as an independent research association and is now one of the leading institutes for applied research in the fields of solar thermal energy, low-energy and zero energy buildings as well as in energy efficiency in industry. Besides these energy related topics also sustainable water management is a focus areas. AEE INTEC is located in Gleisdorf, Austria, which is about 150 km south west of Vienna and 20 km east of the city of Graz. The core activities are the sustainable use of energy and resources and the development of components, systems and strategies that enable the quick and widespread use of renewable energy sources and energy efficient technologies. Within these scopes the projects of AEE INTEC range from developing and testing prototypes, to initiating, monitoring and analyzing of pilot and demonstration plants as well as consulting, know-how transfer, training and supervising numerous theses. AEE INTEC is integrated into a network of national and international co-operation. Among others, it is a member of the European Renewable Energy Research Centers Agency (EUREC) and the European Technology Platform for Renewable Heating and Cooling.
Source: Link

- **Regulation of Market**
  Besides all the technical aspects, it is also necessary to define a framework for all market participants. All of them have to play by the same rules.

  - **E-control**
    The Energy Control Austria (E-control) is responsible for the regulation of the electricity and the gas industry market. They have to ensure that all market participants play by the same rules. Source: Link

  - **Austrian Bio-Methane Register: Certification System for the feed in of Biogas**
    The Austrian Bio-Methane Register is online since 1st August 2012. It was established by the AGCS (Austrian Gas Clearing and Settlement Inc.) and coordinated by taskforces consisting of members of the gas industry and the ARGE Kompost&Biogas (program management klima:aktiv biogas). The implementation of a proof of origin for feed in bio-methane is overcoming the essential obstacle for traceability. With the help of the Austrian Bio-Methane Register a precise classification is possible now, even if production and utilization is locally divided. Buying bio-methane customers have now the assurance that the purchased bio-methane was effectively feed in to the gas grid for them.
    Source: Link

  - **Vehicle to Grid (V2G)**
    At the moment there is **no legislation** for mobile storage systems (EVs and PHEVs) which attends to manage these kinds of storage systems. A standard norm (ISO 15118 – Road vehicles – Vehicle to grid communication interface), which take care of a standardisation between the electric cars and the charging infrastructure, has been developed to handle with this special topic. At the moment the norm is under review. It shall adjust to the communication between the electric cars and the charging infrastructure and shall define a common standard or a standardised protocol. With this ISO 15118 it should be possible to get a hand on managing mobile storages in the future.

- **Make storages ready for the market**

  All these different conditions by integrating storages to the energy system, which are listed in this chapter, have in the end one reason – putting energy storages to the market and integrate them to the energy system. Austria has from this point of view a leading role. On the one hand Austria is “gifted” with a high amount of hydro power – especially with pump storage – and on the other hand the government has a strong focus on the energy aims of the EU and Austria. Therefore they provide funding for basic and applied research for different institutions and strengthen the awareness for a stable sustainable energy system. Austria in this case accelerates the development of storages and makes them ready for the market.

8. R&D

Data on R&D in Austria

Total Expenses for R&D activities

Austria has spent € 8,610 Mio for R&D activities in 2012. Compared to 2011 the expenses for R&D increased about 4.2 %. The total expenditures for R&D run up to 2.8 % of the GDP. The average in the EU is at 2.0 %. Austria, together with Finland, Sweden, Denmark and Germany are those countries that have a higher R&D ratio as 2.7 %. Austria has therefore a leading role in the field of R&D in the European Union.

Employees in the R&D sector

In 2009 approximately 56,000 people have been employed in the sector of R&D. About two third (67.9 %) of them work in the industry sector and 26.7 % are employed in the higher education sector (e.g. universities, R&D institutes,…). Another 4.7 % fiddle with R&D activities at public institutions.

R&D in sectors

In Austria the R&D activities take mainly place in the industry sector. Exactly 68.1 % of all R&D expenditures refer to this sector. Another 26.1 % of R&D expenditures are managed in the higher education sector. The other 5.3 percent of the activities relate to other state agencies.

R&D focus

About 19.1 % of the total expenditures for R&D activities refer to basic research. Another 35.4 % of the total expenditures are required for applied research projects. 47.1 per cent of expenditure is spent on experimental development.

R&D priorities of sectors

The various sectors have different priorities in the R&D activities. The higher education sector has a strong focus on basic research. About 2/3 of the total expenditures for basic research can be assigned to this sector. Also the industry sector with 1/4 of the total expenses for basic research has a strong interest in this field. Activities in the field of applied research are more interesting for the industry, 2/3 of total expenditure refers to this sector, than for the higher education sector (nearly a third of the total expenditures for this sector). R&D projects and activities in the field of experimental development are most interesting for the industry sector. Nearly 95 % of the total expenses for experimental development can be allocated to the industry sector.

R&D in federal states

The focus of the R&D activities differs in the different regions. The following allocation shows the different interest of the nine federal states in Austria.

- 38.1 % - Vienna
- 17.8 % - Styria
- 15.2 % - Upper Austria
- 9.1 % - Tyrol
- 8.1 % - Lower Austria
- 5.2 % - Carinthia
- 3.2 % - Salzburg
- 2.7 % - Vorarlberg
- 0.5 % - Burgenland

National Funding Agencies

National funding agencies are departments, which initiate funding programs and handle the different projects.

Climate and Energy Fund

The climate and energy fund is an institution of the Austrian government. It has the goal to reduce greenhouse gas emissions in Austria by setting targeted pulses and initiating funding for projects. The Climate and Energy Fund is therefore a key instrument of the Austrian government for the achievement of climate protection (20-20-20 targets, Kyoto Protocol), higher energy efficiency and the development of innovative renewable energies. Since 2007 in total 35,000 energy and climate projects have been implemented with a total budget of €600 Mio by the Climate and Energy Fund. The Climate and Energy Fund is responsible to keep the European targets (20-20-20) in mind and promote a “zero emission Austria”.

<u>Focus of Climate and Energy Fund:</u>

- R&D
- E-Mobility
- Mobility
- Renewable Energy
- Energy Efficiency
- Model Regions
- Building & Remidiation

Austrian Research Promotion Agency (FFG)

The Research Promotion Agency (FFG) is the national funding institution for industrial research in Austria. The FFG supports Austrian companies, research institutions and researchers from a wide range of grants and services and represents Austrian interests at European and international level. The FFG cared for the Climate and Energy Fund since 2007 a total of 457 projects. 2010 corresponded to a total funding in the amount of 44.15 million euros.

Focus of Austrian Research Promotion Agency:

- Life Science
- Information Technology
- Materials and Manufacturing
- Energy and Environment
- Mobility
- Space
- Safety and Security
- Human Resources

Kommunalkredit Public Consulting (KPC)

Kommunalkredit Public Consulting (KPC) assisted in the implementation and management of a variety of program lines. In essence, the KPC is specialized in the development, implementation, management and support of funding programs, primarily in the area of environmental and climate protection, and the international carbon market. Since 2007 the KCP concluded for the Climate and Energy Fund 27,320 projects. In 2010 the total funding amount has been at 73.97 million euros.

Focus of Kommunalkredit Public Consulting:

- Energy Supply
- Energy Savings
- Water and Waste
- Dangerous Waste
- Traffic & Mobility

R&D projects concerning storage

Austria has a strong focus on R&D and on different type of projects, which link to different sectors in the market. In the R&D projects a focus concerning storage systems is recognizable. The Technical University of Vienna (Link - R&D activities) implemented different R&D projects about storages. The following list shall give a brief insight into the R&D activities.

Source for this list: Link

- **SYMBIOSE - System interconnecting optimized decentral hybrid storage**

  Duration: 01.03.2012 - 28.02.2014
  Project Leader: Wolfgang Gawlik (University of Vienna)
  Project Staff: Martin Boxleitner, Markus Heimberger, Rainer Schlager
  Institute: Institute of Energy Systems and Electrical Drives
  Funding Agency: Austrian Research Promotion Agency (FFG)
  Project Partner: Institut für Energietechnik und Thermodynamik, ENRAG GmbH, Vorarlberger Kraftwerke AG

  By coupling the existing parallel infrastructures like electricity, gas and heat networks new opportunities and possibilities for storages and conversion technologies can be developed. The project concentrates on the optimal positions, technologies and the dimensions of the different hybrid storages and how they can contribute to transforming the energy system. The influence of different types of storages will be analyzed in this project.

- **Development of compact modular pump turbine for decentral energy storage**
  Duration: 01.03.2011 - 28.02.2014
  Project Leader: Thomas Wolbank (University of Vienna)
  Project Staff: Matthias Samonig
  Institute: Institute of Energy Systems and Electrical Drives
  Funding Agency: Austrian Research Promotion Agency (FFG)
  Project Partner: Institut für Energietechnik und Thermodynamik
  The project HYDMOD aims to reduce CO2 emissions due to the use of an innovation in decentralized pump storage. This will be reached by a modular approach in the design of the components which includes also saving cost. Further objectives are a self-contained starting, the ability of off-grid operation and support the recovery of the main power grid after a break-down.
- **MBS - Multifunctional Battery Storage System**

Duration:	01.03.2010 - 28.02.2013
Project Leader:	Wolfgang Prüggler (University of Vienna)
Project Staff:	Marion Glatz
Institute:	Institute of Energy Systems and Electrical Drives
Funding Agency:	Austrian Research Promotion Agency (FFG)
Project Partner:	---

Fluctuation of renewable energy technologies (e.g. Photovoltaic and Wind) is a challenge for energy systems of the future, since they will be significantly based on such sources. Storage systems are a solution, which provides multifunctionality far beyond the energy supply of single houses. By "pooling" of local storage capacities, the energy balance market can be addressed and by that contributing to stability and security of the total electricity system. Additional financial means by partner EVN enables the installation of a real system, making possible by that the design and planning as well as real modeling of a Energy system, which a) Guarantees a reliable as well as highly renewable energy supply of a house, with the additional features of optimization and visualization. b) Moreover, modeling of electricity supply according to schedule from such PV/Battery-Combinations including an economic/technical feasibility study. c) The overall potential as well as the supranational impacts will be investigated finally The communication of fluctuating generation (PV, Wind) together with the innovative storage (Vanadium Redox) of Austrian origin is the main challenge. By performing scenarios as well as political economic studies an energy future will be designed where decentralized energy generation as well as the general value of fluctuating electricity sources will be increased for small systems as well as for the whole electricity System. Small systems are aiming at minimizing costs, according to current and future energy tariffs. For the energy company, pooling of hundreds of such systems will enable him to participate on the energy balancing market. Basically 5 questions will be addressed by this project: 1. How to design the communication interfaces of an energy battery system, which is charged by fluctuating sources (PV and Wind) a. in relation to the supply of the building (load and consumption) b. related to the communication with the public electricity grid 2. How to minimize the total energy costs for the (private) consumer. (on Basis of two advanced tariff models) 3. How to maximize the benefit of this system on the energy balancing market 4. Is an autonomous operation for a typical house possible and if yes, at which costs? 5. What is the total potential for such systems in Austria, what are the consequences of a wide dissemination? Recommendations for the energy authorities will be given as final result of the project.

- **PV-Best Use -Optimial utilisation of Photovoltaics with special consideration of the use of electric vehicles as a temporary storage**

Duration:	01.09.2011 - 28.02.2014
Project Leader:	Reinhard Haas (University of Vienna)

Project Staff: Raphael Bointner, Maria Assumpcio Lopez-Polo
Institute: Institute of Energy Systems and Electrical Drives
Funding Agency: Austrian Research Promotion Agency (FFG)
Project Partner: ATB Becker

The aim of this project is to optimize the production and use of electricity of Building integrated Photovoltaic at minimal costs with special consideration of the use of electric vehicles as a temporary storage. Based on these results the optimal combined funding- and marketing strategies for PV and electric mobility are identified.

- **Optimized cross-system for a decentralized energy storage**

Duration: 01.04.2012 - 31.03.2014
Project Leader: Heimo Walter (University of Vienna)
Project Staff: Michael Lauermann
Institute: Institute for Energy Systems and Thermodynamics
Funding Agency: Austrian Research Promotion Agency (FFG)
Project Partner: ---

- **B2G - Building to Grid**

Duration: 01.07.2010 - 31.12.2012
Project Leader: Georg Kienesberger (University of Vienna)
Project Staff: Mario Faschang, Thomas Gamauf, Alexander Wendt
Institute: Institute of Computer and Technology
Funding Agency: Kommunalkredit Public Consulting (KPC)
Project Partner: Siemens Austria AG, Salzburg Wohnbau GmbH, AIT Austrian Institute of Technology GmbH, Salzburg AG für Energie, Verkehr und Telekommunikation

One third of the world-wide energy use and its respective emissions are linked to commercial and residential buildings. Despite this prominent position, buildings are still a passive player in modern energy networks. The industrial and transportation sector are increasingly embedded in an active manner, while buildings still act as unidirectional endpoints and are treated as "black box". Active members of smart grids can contribute to the overall optimization of the energy system by being operated flexibly and by sharing information with the grid. Buildings host a number of significant energy-consuming processes, like heating, ventilation, air-conditioning (HVAC) and lighting. Many processes have operational bandwidths in terms of set-points and scheduling which can be used if needed. Aggregating a number of buildings would lead to even larger flexibility and larger loads that can be dispatched. Strategies like "demand response" (DR; loads, reacting on events in the energy grid) are in its infancy because two key factors are still unsolved: The Smart Grid does not know the states of the load processes, and even if, there is no standard way to communicate them. Both is needed for intelligent algorithms that harmonize loads with grid operations. This is the reason why DR is still open-loop control, where DR-events are broadcast to the loads without knowing the potential consequences. No planning and anticipative reactions are possible in such a system. An intelligent system would take the process state of the customer facilities into account, and would get feedback about the reactions. A traditional DR system can neither estimate the magnitude of a reaction to a DR-event, nor how long this reaction may last, because the loads do not expose information on their current state. It is the goal of the project to close that gap and to investigate in a series of experiments where the limits of intelligent buildings in a Smart Grid are. For this a number of generic load models for buildings must be developed and embedded into an interoperable communication infrastructure. Particular insight is expected by putting building control and grid control into relation, currently these two systems are optimized separately. The investigated objects will be medium and large-size residential and commercial buildings, the test cases will be conducted semi-automatically. Results are figures about the operational potential of "active" buildings and communicable and aggregatable load models, constituting a stepping stone to the intelligent, smart-grid enabled building.

- **Optimised regional energy balancing in electric power grids using intelligent energy storage concepts**

  Duration: 01.01.2009 - 30.06.2011
  Project Leader: Georg Kienesberger (University of Vienna)
  Project Staff: Klaus Pollhammer
  Institute: Institute of Computer and Technology
  Funding Agency: Austrian Research Promotion Agency (FFG)
  Project Partner: Institut für Energiesysteme und Elektrische Antriebe, Andritz AG, Arsenal Research, Fronius International GmbH

  Present situation: The increasing energy demand requires a massive extension of electric power generation capacities. This process leads to energy systems which are more and more de-centrally organized and utilize more renewable energy sources. The demand structure is dynamically changing its pattern and is extremely difficult to forecast. In Austria, especially solar energy, biomass, wind and mini-hydro will play an important role in the future. Assuming positive framing conditions, there will be 20% of domestic power production covered by solar energy according to the recently published “Photovoltaik Roadmap” until 2050. The partly fluctuating feed-in and the even more dynamic development with respect to the varying loads are key challenges for the distribution sector. Besides the sophisticated integration of power generators the adequate storage of energy is the key task to be mastered. Storage management is possible in the following ways: Storage of primary energy carriers (water, biomass), Storage of secondary energy carriers (electric energy, indirect storage via pumped storage plants, biogas), Load management as a load balance tool (Demand Side Management and load management such as load shifting or shedding) The primary objective of OREANIS is to compensate the natural generation fluctuations of renewable energy technologies by intelligent storage, control and optimization of the energy demand and generation. Thus, an efficient load balancing mechanism in the regional grid can be achieved. Within the project basic issues and the premises for industrial research will be evaluated. Thus the basis for solutions for the challenges of network operation will be created In order to do so the potentials of the three mentioned strategies will be evaluated and a concept for their optimal integration will be elaborated. Subject of Research: OREANIS investigates how; despite of the fluctuating generation caused by renewable generation, a regionally balanced energy and power provision can be managed. The energy balance considers the traditional generation units, the possibilities of energy storage and the options of demand side management.

- **SGMS-V2G - Smart Grids model region Salzburg - Implementationplan for Vehicle to Grid interface development**

  Duration: 01.06.2010 - 31.05.2011
  Project Leader: Wolfgang Prüggler (University of Vienna)
  Project Staff: Marion Glatz, Friedrich Kupzog, Rusbeh Keyvan Rezania
  Institute: Institute of Energy Systems and Electrical Drives
  Funding Agency: Austrian Research Promotion Agency (FFG)
  Project Partner: Salzburg AG für Energie, Verkehr und Telekommunikation, Institut für Computertechnik, Siemens Austria AG

  New concepts for user interfaces (visualisation and graphical user interface) for e-mobility costumers within the Smart Grids model region of Salzburg are developed; parameters and cost/benefits of a future Vehicle to Grid implementation will be evaluated by this feasibility study. Based on this, an implementation plan for suitable software developments (experimental development) as well as a demonstration phase are derived.

- **SmartResponse – Demand Response for Austrias Smart Grids**

  Duration: 01.07.2010 - 31.12.2012
  Project Leader: Thomas Leber (University of Vienna)
  Project Staff: Thomas Gamauf, Georg Kienesberger, Marcus Meisel, Martin Pongratz
  Institute: Institute of Computer Technology
  Funding Agency: Kommunalkredit Public Consulting (KPC)
  Project Partner: Österreichische Akademie der Wissenschaften, KERP Research Elektronik und Umwelt GmbH

  Automated demand response has the potential to be an essential future tool for maintaining the balance of supply and demand in electrical energy systems with a very high density of generation from renewable sources. This project is tackling the problem of missing demand response implementations in Austria by analyzing demand response as a multidisciplinary phenomenon with technical, social, economic and ecologic aspects, in order to identify barriers and starting points for future developments.

- **V2G-Strategies – Development of vehicle to grid related e-mobility deployment strategies for Austrian decision makers**

Duration:	01.05.2010 - 31.11.2012
Project Leader:	Wolfgang Prüggler (University of Vienna)
Project Staff:	Christoph Leitinger, Markus Litzlbauer, Rusbeh Keyvan Rezania
Institute:	Institute of Energy Systems and Electrical Drives
Funding Agency:	Austrian Research Promotion Agency (FFG)
Project Partner:	Salzburg Netz GmbH, Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H.

Technical, economic and ecological impacts for Austria's energy system (until 2050) due to massive e-mobility penetrations are examined. The options of system related e-mobility integration in urban and rural case studies are analyzed developing active grid integration as well as new business models (e.g. loading strategies, balancing services) for Grid to Vehicle and Vehicle to Grid concepts. As key results a tailor made guideline and action plan for Austrian decision makers are derived.

- **Super-4-Micro-Grid**

Duration:	01.01.2009 - 30.06.2011
Project Leader:	Günther Brauner (University of Vienna)
Project Staff:	Martin Boxleitner, Christoph Groiß, Michael Chochole
Institute:	Institute of Energy Systems and Electrical Drives
Funding Agency:	Austrian Research Promotion Agency (FFG)
Project Partner:	Zentralanstalt für Meteorologie und Geodynamik, TU Wien Institut für Wasserbau und Ingenieurhydrologie, TIWAG – Tiroler Wasserkraft AG, Vorarlberger Illwerke, Verbund Hydro Power AG

The future shortage of fossil resources, caused by increasing demand of industrialized countries and industrialization of developing countries will affect the security of supply and accelerate the climate change. As a result, the motivation arises, to change to a sustainable and renewable energy generation. The central question in the Project Super-4-micro-grid is: "can the Austrian electricity demand be fully covered by renewable generation, and if so, how?"

- **Energy storage of the future – Energy Storage for renewable energy as a key technology for future energy systems**

  Duration: till Feb. 2012
  Project Team: Joanneum Research, University of Vienna
  Funding Agency: Austrian Research Promotion Agency (FFG)

  The aim of the project was to give an overview of current and future energy storage technologies, concerning their state of the art, possible future developments as well as their field of application. Furthermore the possibilities of energy storages for mobile use and the possibility of “vehicle to grid” to provide electricity were analyzed. 28 examples of consumer and producer-related energy storage applications for electricity, heat and fuels were set up and assessed, taking into account their technical, economic and ecological characteristics. For a successful implementation of energy storage technologies the future energy storage demand for renewable energy has to be determined. Based on the current supply and demand regimes in the Austrian energy system (“current-situation”) an analysis model (“EStore Austria”) of a sustainable Austrian energy system (up to 100 % renewable energy supply) was set up. With this model the possible energy storage demand within four different scenarios were determined. These four scenarios differ in the share of renewable energy, in energy efficiency as well as in the demand of energy services. Based on this study a guideline for relevant stakeholders of the energy economy in Austria was set up.

APPENDIX and supplementary material

Index

a. Review of existing sources and literature

Chemical storage – Project “COMTES”, Source: Abstract Comtes Innostock_Final.pdf
AEE INTEC, Feldgasse 19, Gleisdorf, Austria,

ENERGIESPEICHER DER ZUKUNFT-Energiespeicher für erneuerbare Energie als Schlüssel-Technologie für zukünftige Energiesysteme
K.-P. FELBERBAUER et. al.
Download link:
http://www.joanneum.at/fileadmin/user_upload/news_images/RESOURCES/Energiespeicher_der_Zukunft_Publizierbar_EB.pdf

Erneuerbare Energie in Zahlen 2010
http://www.lebensministerium.at/umwelt/energie-erneuerbar/ERneuerbare_Zahlen.html
Source: Lebensministerium

Study:
Jahresbericht e-control
http://www.e-control.at/de/konsumenten/news/aktuelle-meldungen/jahresbericht-2011

Study:
Speichertechnologien – Lösungen für die „Aufbewahrung“ von Energie
http://www.klimafonds.gv.at/assets/Uploads/Broschren/Science-Brunch-Broschren/8speichertechnologien.pdf

Study:
Positionspapier – Smart Gas Grids in Österreich
http://www.ovgw.at/ufile/5/355/Positionspapier_Smart_Gas_Grids_2011-10.pdf

Study:
Abschlussbericht e-connected
http://www.klimafonds.gv.at/assets/Uploads/Studien/Abschlussberichte-connected1.pdf

Laws:
Neue Rahmen für das Österreichische Energiegesetz
http://portal.tugraz.at/portal/page/portal/Files/i4340/eninnov2012/files/pr/PR_Peter.pdf

Statistic:
Statistikbroschüre e-control 2012
http://www.e-control.at/portal/page/portal/medienbibliothek/statistik/dokumente/pdfs/Statistikb12_D_Einzelseiten_FINAL.pdf

Presentation:
Elektromobilität heute und morgen
http://www05.abb.com/global/scot/scot320.nsf/veritydisplay/cffe99a7a550c070c12579ca005b8133/$file/Pra_20B-Elektromobilitaet_120315_ho.pdf

Laws:
Liberalisierung des Österreichischen Energiemarktes
http://www.e-control.at/portal/page/portal/medienbibliothek/recht/dokumente/pdfs/gt-Liberalisierung-idf-2012-03-09.pdf

Laws
ELWOG
http://www.e-control.at/portal/page/portal/medienbibliothek/recht/dokumente/pdfs/elwog-bgbl1-112-2008.pdf

Laws
Energierecht Österreich
http://oesterreichsenergie.at/%C3%9Cberblick_Elektrizit%C3%A4tsrecht.html

Projects
Geforderte Projekte – Energiesysteme, Netze, Verbraucher
http://www.ffg.at/sites/default/files/allgemeine_downloads/energieregionen.pdf

Study
Marktbasierte Beschaffung von Regelreserve
http://portal.tugraz.at/portal/page/portal/Files/i4340/eninnov2012/files/lf/LF_Friedl.pdf

Study
Wasserkraftpotentialstudie
http://www.energiestrategie.at/images/stories/pdf/36_veo_08_wasserkraftpotenzial.pdf

Projects
Flywheels
http://www.hausderzukunft.at/results.html/id6007

Projects
Integration dezentraler Energieerzeugung und Speicher
http://www.ait.ac.at/research-services/research-services-energy/systemuntersuchung-netze/integration-dezentraler-energieerzeugung-und-speicher/

Statistic
Ergebnisse des Ökostromberichts 2010
http://www.e-control.at/portal/page/portal/medienbibliothek/oeko-energie/dokumente/pdfs/pressemappe-oekostrombericht-2010.pdf

Institution
Österreichs Energie
http://oesterreichsenergie.at/herausforderungen-durch-das-oekostromgesetz.html

Programs
Klima- und Energiefonds
http://www.ffg.at/sites/default/files/downloads/call/ffginformationen_zur_4_as_ne_2020.pdf

Programs
Klima- und Energiefonds
http://www.ffg.at/neue-energien-2020-das-programm

Institution
Klima- und Energiefonds
http://www.klimafonds.gv.at/ueber-uns/struktur/

Programs
E!Missi0n+.at
http://www.klimafonds.gv.at/assets/Uploads/Downloads-Frderungen/eMission/leitfadeneMissionRZLinks.pdf

Institution
e-control
http://de.wikipedia.org/wiki/E-Control

Institution
Kommunalkredit
http://www.umweltfoerderung.at/kpc/de/home/umweltfrderung/

Institution
FFG
http://www.ffg.at/

Study
Energiestrategie Österreich
http://www.energiestrategie.at/images/stories/pdf/longversion/energiestrategie_oesterreich.pdf

Law
e-control
http://www.e-control.at/en/law

b. Key contacts and resources

Chemical storage – Project “COMTES”
Source: AEE INTEC, Feldgasse 19, Gleisdorf, Austria, Contact person Wim van Helden
email: w.vanhelden@aee.at

Study:
ENERGIESPEICHER DER ZUKUNFT-Energiespeicher für erneuerbare Energie als Schlüssel-Technologie für zukünftige Energiesysteme
http://www.joanneum.at/jr/news/news-single-display/article/energiespeic-1.html
K.-P. FELBERBAUER et. al.
JOANNEUM RESEARCH Forschungsgesellschaft mbH
RESOURCES - Institut für Wasser, Energie und Nachhaltigkeit
Energieforschung
Elisabethstraße 18/II
A-8010 Graz
Austria
e-mail: karl-peter.felberbauer@joanneum.at

c. Other material