Virtual Power Systems White Book

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in collaboration with:

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1 INTRODUCTION

1.1 The AlpEnergy project

This draft document has been elaborated within the project "Virtual Power Systems as an Instrument to Promote Transnational Cooperation and Sustainable Energy Supply in the Alpine Space" (AlpEnergy) under the European Territorial Cooperation Programme "Alpine Space" (ETC-ASP) 2007-2013.

AlpEnergy aims at the analysis and modelling, the design and development, the demonstration and test, and the evaluation and transfer of Virtual Power Systems (VPS) in four distinct areas of the Alpine Space: the Allgäu region in Bavaria, Germany, the City of Mantua in the Lombardia region, Italy, the Province Belluno, Italy, the Autonomous Region Aosta, Italy, the Belledonne chain area in the region Rhône-Alpes, France, and the region of Gorenjske, Slovenia.

The objectives of the project are:

- to capitalise existing potentials for electricity production from endogenous renewable resources and for demand management in existing economic sectors;
- to provide new knowledge-based income and business opportunities for farmers and traditional as well as innovative enterprises;
- to contribute towards security of affordable electricity supply in the Alpine Space, thus supporting the competitiveness of Alpine enterprises in general;
- to provide a basis for new electricity supply concepts optimizing the number of electricity grid lines in, and impact on, the landscape and for cleaner electricity generation, thus reducing the global and local environmental impact of electricity generation;
- to enhance worldwide business opportunities for Alpine enterprises and to contribute to growth, employment and sustainable development by making the Alpine Space a showcase for sustainable electricity supply with a strong vibrancy towards other mountain areas in the world.

These objectives reflect the motivations of the AlpEnergy project partners for investigating Virtual Power System (VPS) and Virtual Power Plants (VPP) in the light of their specific situations and views.

1.2 Scope, purpose and elaboration process of this document

This draft document is a preliminary result of the work on workpackage 4 (WP4), Analysis and Modelling of VPS. Its purpose is to provide a first summary of a common view of VPS within the consortium for providing a shared basis for the subsequent joint VPS modelling, design and development work. The intention is further to provide a valuable contribution to the discussion and development of VPS and elements of VPS, currently denoted in the ongoing debate in this field as Virtual Power Plants (VPP), Smart Grids, Smart Metering, etc., beyond the project duration and outside the project consortium.

This double intention made a distinction necessary at the level of the definition of VPS:

- General definition: responding to the question "What is a VPS?" and considering the general debate and development about VPP, VPS, Smart Grids, Smart Metering, etc.
- Specific definitions: responding to the question "Which features of a VPS are relevant, and need to be covered by the to-be-developed definition, in the light of the specific challenges and opportunities of the VPS which will be developed and implemented in the target areas of AlpEnergy? At this level the different national and regional views and concerns of the project partner are considered more specifically.

This document deals with the more general aspects of VPS. The specific situations in the project partners' home countries will be reflected in a fourth chapter that will be included in a forthcoming longer version.

In order to achieve the double target of this document, existing definitions and documents as well as the concrete challenges, opportunities and concerns within the project partners' countries of origin and regions have been reviewed. The findings have been put together in a multiple-step process of redaction, review and common discussion of several contributions. The main steps in this process were:

- Elaboration of a study on existing definitions of, and motivations for, Virtual Power Plants and Virtual Power Systems by the ALaRI - Advanced Learning and Research Institute all'Università della Svizzera italiana (USI)
- Elaboration of a preliminary paper on global and specific challenges motivating the development of VPS as well as on bullet points of different aspects related to VPS by B.A.U.M. Consult.
- Elaboration of an impulse presentation on different aspects and proposal for a definition of VPS, integrating the input from ALaRI, by B.A.U.M. Consult for the AlpEnergy kick-off meeting in Salzburg on 7-8 October 2008;
- General debate of all project partners on the VPS definition options emerging from the work of ALaRI and B.A.U.M. Consult during the kick-off meeting;
- Elaboration of an input presentation on VPS by Fondazione Politecnico di Milano for the meeting with ALaRI and B.A.U.M. at Milano on 6 November 2008;
- Joint elaboration of a shared view of different aspects and a definition of VPS at the meeting in Milano;
- Elaboration of a protocol on the results of the meeting in Milano by Fondazione Politecnico di Milano;
- Establishment of a first version of the White Book by B.A.U.M.
- Review of first version by project partners.
- Establishment of a second version of the White Book by B.A.U.M. taking into account the comments of the partners.

The present document is the general part of the second version of the White Book. It has not yet finally been accepted by all project partners.

2 CHALLENGES AND NEW OPPORTUNITIES

The development and implementation of VPS, VPP, Smart Grids, Smart Metering, etc. is motivated by a number of global and local challenges as well as by the emergence of new opportunities to generate benefits. A distinction is necessary here between general and specific challenges and opportunities - not to be mixed with the distinction between general and specific definition for VPS. The general challenges and opportunities concern everybody, while the specific ones concern only single stakeholder groups, for instance electric grid operators, established and new electricity producers, producers of components and systems for VPS, VPP, Smart Grids, and Smart Metering, potential suppliers of new services, electricity customers or public authorities. In this chapter, global challenges and opportunities will be described separately from those for specific stakeholder groups.

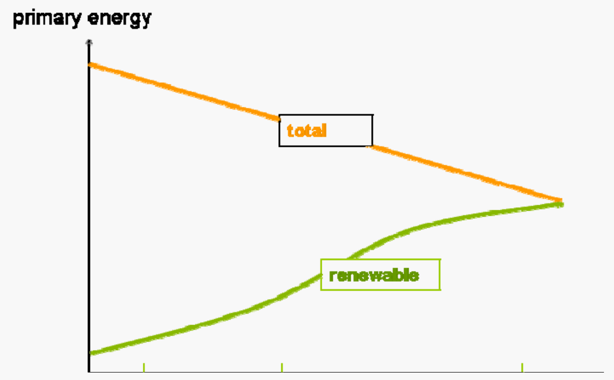
2.1 Global challenges and opportunities

The need to limit climate change implies that global green house gas emissions must be quickly and strongly reduced, including a quick and strong reduction of CO_2-emissions from fossil electric power plants. Renewable energies and energy efficiency measures are already, or are expected to be soon, competitive with CO_2 capture and storage. The former are mature technologies as opposed to the latter. For this reason, renewable energy use and/ or energy efficiency and saving measures must be extended very quickly.

Known resources of cheap conventional fossil energies (coal, lignite, mineral oil, natural gas) and uranium from concentrated ores have only a range of a few decades – even coal and lignite resources will have a short range when the strong global increase of the energy demand will continue. This implies that sooner or later either unconventional fossil energies or more diluted uranium sources must be explored, or renewable energies used.

Most energy efficiency and saving measures and some renewable energy technologies (e.g. wind power) are already, and the others are expected to be soon, competitive with the more expensive unconventional fossil energy sources (oil shale, methane-hydrates from the ocean bed, etc.) and uranium from diluted sources before the cheap conventional fossil energy resources and concentrated uranium ores will be exhausted. This implies that these unconventional fossil energies as well as diluted uranium sources will not be a cost-effective option compared to renewable energies and to efficiency and saving measures. In the light of these considerations, a shift towards renewable energy sources and/ or energy efficiency and saving measures is the only option and must be implemented in the next decades at the latest.

The gap between the exploration of fossil energy carriers and the global energy demand is widening quickly due to the strong increase of the energy demand in the newly industrialising countries, notably in the large nations China and India. This leads to rising prices for fossil energy carriers and puts pressure on the need to act and to combine renewable energies use with strongly reducing the energy input into the power generation system by efficiency measures and reducing energy consumption by saving measures.



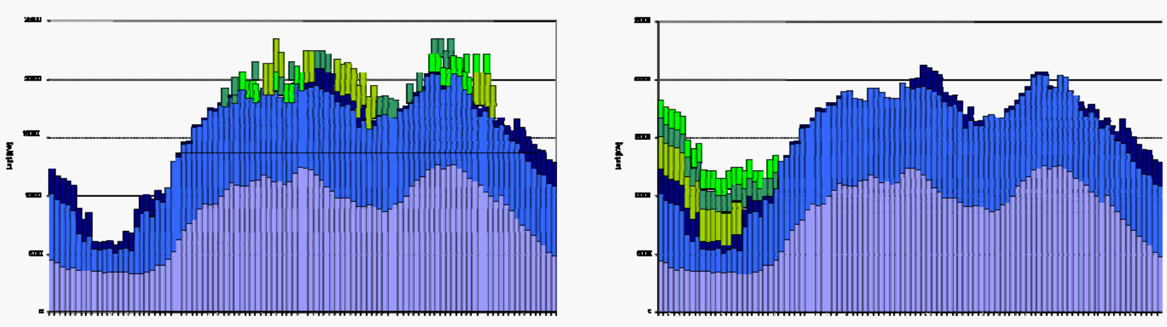
source: AlpEnergy

Pic. 2-1: The Challenge

In summary, a quick large-scale implementation of renewable energy technologies AND energy efficiency and saving measures is necessary to respond to the global climate change, the strongly increasing global energy demand, and the related price increase of conventional fossil energy carriers.

Now, those renewable energy sources with a large potential, solar energy and wind energy, provide electricity in an intermittent manner. Further, large amounts of electricity from solar and wind energy can only be provided by a large number of decentralised PV and wind power plants. A part of these plants will even not be located close to the consumers, but rather in less densely populated areas with little electricity consumption including offshore sites.

This challenges the existing electricity supply system which is designed to provide electricity through a relatively small number of central power plants most of which operate at a rather constant output power and are situated close to the main centres of electricity consumption. A tendency has been throughout the past decades to flatten the electricity demand curve such that at least a part of the electricity demand occurs rather constantly throughout the day and throughout the year. A constant demand can be met by the smallest number of power plants, and thus flattening the load curve allows satisfying the electricity demand without investing in too much reserve production, transmission and distribution capacity.


source: AlpEnergy

Pic. 2-2: Shifting loads to reduce peak demands

A number of new opportunities allow dealing with the new challenges:

- Renewable energy conversion plants, in particular modern wind power converters, are increasingly equipped with grid interfaces that allow providing grid services such as voltage and frequency stabilisation, phase shift (reactive power supply), and the capability to contribute to re-establishing the power supply after an electrical power outage.
- Very efficient electric appliances are on the market which allow by their lower electricity consumption to lower the overall need for electricity and to contribute to solving the challenges related to climate change and conventional energy resource depletion. Moreover, modern electric appliances can be equipped with intelligent interfaces that allow for integration of the appliances in comprehensive grid operation strategies. Thus, such new appliances can also contribute to facilitating the integration of a higher amount of intermittent renewable energy production facilities in the electric grid.
- New storage technologies are emerging which allow buffering at least small amounts of energy for short periods: compressed air, flywheels, improved types of batteries such as new and cheaper lithium-ion batteries, super-capacitors, etc.
- New ICT based measurement (e.g. smart meters) and data communication and analysis technologies allow for providing the prerequisites for a large-scale control of the electricity demand and supply, thus allowing better fitting the electricity demand to a more and more intermittent electricity supply.
- The liberalisation of the electricity market in the EU allows for easier implementation of innovative business schemes that fit to the new technological concepts and are drivers for new products, services and market roles in the power industries.

2.2 Challenges and opportunities for electric grid operators and utilities

The global challenges lead to an environment in which electric grid operators are increasingly obliged to handle rising shares of renewable electricity in their grids, including high shares of electricity from fluctuating sources such as wind and photovoltaic power stations. This complicates the duty of electric grid operators to secure electricity supply and quality of the electricity in the grid for all consumers at any time. Technically speaking, it complicates the task of bringing electricity purchase/ sale of surplus electricity in pattern with the electricity demand in the grid. This task has different aspects:

- Spatial aspect (grid topology): the electric grid needs to be developed such that the costs of transport and distribution of electricity are minimised, taken the distributed location of new electric plants using renewable sources into account.
- Time aspect: electricity needs to be generated such that the demand is always met, while the losses of energy along the generation, transmission and distribution chain are minimised.
- Economic aspect: bringing electricity generation and demand in pattern at any time and at any point of the grid implies new and additional measures which increase the cost of the grid operation; these costs are to be minimised.

- Business aspect: schemes of cooperation allowing to bring electricity generation and demand in pattern need to be developed, checked for their economic and legal consistency, and be set up between grid operators and electricity suppliers and consumers.
- Societal aspect: awareness of the issues and acceptance for the new technologies and forms of cooperation need to be created; notably, consumers need to follow a paradigm change and accept to become active partners of the grid operator.

These aspects imply the following challenges for grid operators:

- Handling increasing shares of renewable electricity, including electricity from fluctuating sources in their grids. This complicates the task of ensuring secure supply with high quality electricity at any time (time aspect).
- Handling an increasing number of independent power producers, including small and widely distributed producers in their grid. This complicates the task of ensuring secure supply with high quality electricity at any point of the grid (spatial aspect).
- Manage the overall cost of the electricity (economic aspect).
- Handling an increasing number of different contracts with new market actors such as independent power producers, external suppliers of electricity and external purchasers of surplus electricity (business aspect).
- Deal with new market actors in the field of power purchase which provide not only electricity, but also new services that go way beyond traditional sale of power.
- Modifying existing relationships with electricity consumers if these get involved in load management measures or become electricity producers in addition to being consumers, so-called prosumers (societal aspect).

A further challenge which is specific for grid operators with disaggregate grid areas are high electricity transmission costs for electricity transfers through connecting grid lines owned by other grid operators.

New opportunities for grid operators are:

- Lower metering costs and better protection against theft of electricity, fraud and non-paid invoices through intelligent smart meters.
- Better sizing and operation of grid infrastructure through new possibilities for real-time measurement and control of energy and power flow in all parts of the grid, including the low-voltage grid (optimisation of investments).
- Offering of further services to customers that are made possible by smart meters in connection with new communication technologies, e.g. communication and information services.
- Optimization of electricity purchase cost by shifting loads away from times with high purchase price to times with low purchase price.
- Operators of grids with a lot of electricity generation can even generate additional income from sale of surplus electricity available at peak load times if they succeed in shifting loads and/ or generation such that surplus electricity is available at peak price times. E.g.

grid operators with many PV installations in their grid could manage to sell surplus electricity from PV plants available at noon if demand is shifted such that it becomes lower than the electricity generation from PV plants (case that happens in parts of the German Allgäu region already at certain days).

- Expand the market for electricity towards heat pumps and electric vehicles which become more and more important in a general framework of rising oil prices, thus overbalancing lower electricity sales that are to be expected as a consequence of energy saving measures.
  However, one needs to note here that this is an opportunity for grid operators which quickly can run contrary to measures responding to the above-mentioned global challenges. E.g. it might lead to rising use of primary energy from fossil sources, thus running counter to climate gas abatement and reduction of use of limited energy sources. Further, it might lead to the need to strengthen the electric grid and to increase conventional power generation (case of France). For avoiding that heat pump use increases the overall primary energy consumption, heat pumps need to be used with a sufficiently high effective annual average coefficient of performance (COP). For avoiding that the development of new electricity appliances such as heat pumps or electric vehicles leads to exorbitant grid extension, the expansion of such markets needs to go hand in hand with increasing local generation from renewable energy sources, thus optimising the development of the electric grid.
- Use heat pumps and batteries of electric vehicles proactively as switchable loads and storage media, thus providing the prerequisites for an active participation in the electricity market and generation of benefits from optimum timing of electricity purchase and surplus electricity sale.
- Learn about the consumption patterns of consumers and their responsiveness for price and other incentives.

2.3 Challenges and opportunities for established and new electricity producers

VPS will allow integrating a larger number of (intermittent) renewable energy production plants in the grid. This allows a larger number of new electricity producers to enter the market, but also established electricity producers can expand their portfolio and increase the share of renewable energy plants within their production facilities.

The challenge for electricity producers is to comply with increasing obligations concerning the quality of the generated electricity and grid services in addition to the simple provision of kilowatt-hours. They can meet this challenge by making use of the latest available technologies.

A farer going challenge for electricity producers is to act on a changing and more and more complex electricity market. In particular, operators of renewable energy plant in countries with grid feed-in laws will face the challenge to market increasing parts of the generated electricity on the free market instead of getting a fixed feed-in remuneration.

VPS can provide an appropriate framework for bringing higher shares of renewable electricity on the free market.

2.4 Challenges and opportunities for producers of VPS components

The stakeholder group of VPS component producers encompasses producers of smart meters, communication and control equipment for electric grids and others, as well as any producer of electric power supply equipment who integrates or is challenged to integrate appropriate interfaces in its equipment that allows for communication with other VPS components.

Challenges that such producers face are:

- Lacking proven concepts for VPS
- Lacking standards for communication in VPS
- Lacking legal framework at least for parts of VPS or for some of the aspects of VPS

All these challenges make the market entrance of new producers and the introduction of new products by existing producers highly risky.

However, VPS provide also a very important new opportunity for producers of VPS components:

- New quickly emerging and potentially very attractive markets for new products.

2.5 Challenges and opportunities for new service providers

New service providers could play a role for the development, set-up and operation of VPS at several levels. The challenges for new service providers or existing service providers who want to offer new services are the same or similar to those of producers of equipment for VPS (see previous sub chapter). The market opportunities for new service providers comprise among others:

- Acquisition, analysis and provision of data on electricity generation and demand, notably in the electricity distribution grid.
- Acquisition and provision of meteorological data and production forecasts for PV and wind energy plants.
- Operation of local electricity exchange platforms for utilities, independent producers and consumers with switchable loads for aggregating electricity demand and generation to bands that can be traded at the European Electricity Exchange.
- Provision of communication and information services either linked to the local trade of electricity or to entirely different content (like so called smart Home appliances).

2.6 Challenges and opportunities for electricity consumers

VPS need the cooperation of consumers who are ready to switch their loads in order to ensure a better adaptation of the demand to the possibilities of (cheap and climate friendly) supply of electricity. This implies that consumers get more actively involved as partners in the electricity generation-provision-use chain and better informed about details of their own electricity consumption pattern, thus offering new opportunities for consumers such as:

- Possibility to make use of inherent storage capacities, e.g. cold or heat storage capacity inherent to the existing facility such as cold rooms, heat storage tanks, etc., for remunerated load shifting.
- Wider range of options for optimizing the electricity purchase and – for companies – the overall business process.
- Reduction of electricity consumption, and thus costs, by better detection of saving potentials, related either to the implementation of efficient electric appliances and devices or to changes in consumption patterns.

The challenge is:

- To determine exactly optimization potentials in the framework of an emerging market without established references and models, e.g. for electricity purchase contracts.
- To provide real time access for independent producers and consumers to information like actual prices, availability of power from renewable resources, forecasts etc. and the possibility to react on such information accordingly (e.g. through automated regulation algorithms).

2.7 Challenges and opportunities for public authorities

Public authorities are first of all representing the general public and their interests should therefore coincide with the latter. However, public authorities do not face alone the global challenges mentioned above and in their specific role the challenges they are facing are specific as well. Opposed to that, the opportunities provided by the actual situation with regard to VPS for public authorities consist broadly speaking in the chance to contribute to a more sustainable energy supply, i.e. meet exactly the general public's interest.

Specific challenges which public authorities are called to deal with are:

- Define a legal and regulatory framework which ensures that maximum use is made of available renewable energy sources and that non-renewable energy sources are used with maximum efficiency.
- Allow emerging new business models that are required for implementing VPS.
- Ensure that the liberalization of the electricity market leads effectively to more cost-effective electricity supply, a broader competition and the emergence of new market players, while the quality of electricity and sustainability concerns are taken into account.
- Find a way to outbalance the legislation concerning gauging and invoicing (that requires that relevant data on electricity consumption are assessed and stored for invoicing – in the case of flexible tariffs it may represent a huge amount of data) with the legislation concerning protection of data privacy (that requires that as little data as possible is assessed and stored).

3 GENERAL DEFINITION AND DISTINCTION OF DIFFERENT TYPES OF VPS

3.1 General definition of VPS proposed within AlpEnergy

The VPS is a system of distributed power production and consumption linked by an electric network (typically a distribution network), suitably completed by a communication system (electronic network). The spatial extension of a VPS may vary from very small settlements to entire countries. The elements forming a VPS can be concentrated in one area or spread over a larger area, they can determine the whole electricity supply and consumption of an entire area or only the electricity generation in, and consumption of, a few facilities within an area.

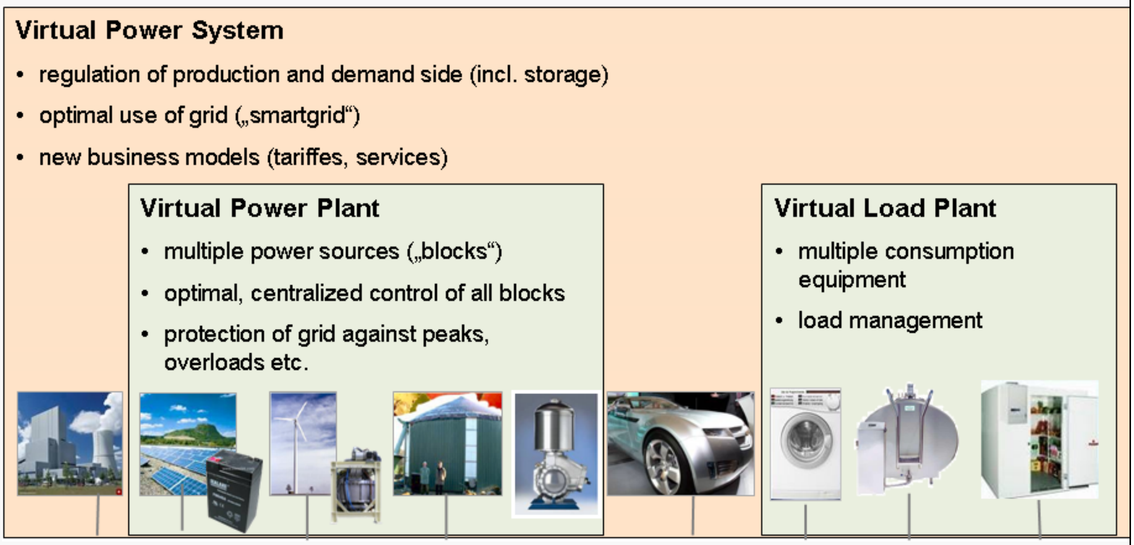
The existing electricity supply system is of course also a system of power production and consumption linked by an electric network and suitably completed by a communication system. The first distinctive feature of a VPS compared to the existing electricity supply system is that the power production is more distributed, i.e. provided by a larger number of smaller units, and mainly based on renewable energy resources including combined heat and power plants (CHP). It is mainly the intermittent nature of solar and wind power and the generally smaller size, and therefore distributed location, of almost all renewable power plants compared to most conventional power plants which make the consideration of VPS necessary. Consequently, VPS concerns mainly, but not exclusively, the distribution part of the electric grid system.

In a VPS, the power supply is typically provided by more than one renewable technology and by more than one power plant. All the generation resources can be summed up in a single energy production profile. If in the limit, a VPS comprises only production facilities, but no consumption units, it is called a Virtual Power Plant (VPP). A VPP represents a boundary case of a VPS[1].

> A Virtual Power System integrates, manages and controls distributed energy generators and storage capacities and links their technical operation to the demand of consumers and the energy market.

A VPS comprises a number of consumption units whose power demand is measured and can be actively controlled. This is the second distinctive feature compared to the existing electricity supply system which is widely lacking communication infrastructure in the distribution grid and does not allow active control of most consumption units. The loads can be aggregated to shape a single power consumption profile. If in the limit, a VPS comprises only consumption units, but no production facilities, it is called here a Virtual Load Plant (VLP). A VLP represents the boundary case of a VPS opposite to a VPP.

[1] In many publications VPP designate not only a system comprising exclusively electricity generation facilities, but also systems including consumption units. However, the definition of VPP is not homogeneous and clear throughout the literature. For this reason, the name VPP is in Alpenergy reserved for systems comprising generation, but no consumption facilities, whereas the new name "Virtual Power System" is introduced for underlining that a combination of generation and consumption is meant.



source: AlpEnergy

Pic. 3-1: Definitions

However, a VPS in the full sense comprises power production and consumption units which are jointly managed (in terms of energy and/ or power balance) in order to get extra benefits. It exploits a proper communication network, in a wider perspective a tailored ICT system, for managing electricity generation and consumption (e.g. for balancing as far as possible generation and load time profiles) in order to maximize these benefits. An additional support for better balancing production and demand can come from the efforts to reduce electricity demand while keeping up the same living comfort.

The VPS may also include energy storage units for improving its performance with regard to synchronizing electricity generation and consumption. Storage units in the proper sense convert electricity after it has been generated into another form of energy (chemical, rotational, pressure, etc.), store the energy in that other form, and reconvert it into electrical energy. However, this form of storage in the proper sense is also the most expensive option and leads to the highest energy losses.

Two other forms of storage options can be identified along the energy conversion and use chain:

- Storage of energy before conversion into electricity, e.g. in the form of biomass or water in barrages (option limited and already widely used)
- Storage of energy service (heat generated by heat pumps, cold generated by cooling devices, charged electric vehicle) after provision by electricity

The second option is the most promising and up-to-now represents only a very little explored option. It is very attractive because it makes use of storage units which are inherent to the load, such as cold rooms which inherently store cold or heat storage tanks of heat pump systems. Making use of this storage of an already provided energy service requires however that the load can be controlled, i.e. the second distinctive feature of a VPS. For this reason, this form of storage is generally called load management.

3.2 Main motivations for and developments facilitating VPS

The decrease of communications costs and the larger availability of new technologies (ICT) are the main development facilitating communication with a large number of distributed electricity production, storage and consumption units, and thus the effective (and viable) implementation of VPS as defined above. They allow in particular the communication within the electric grid between the primary station (high voltage/ medium voltage interface) and dispersed entities (generators, loads, storage facilities). This allows responding to the following main motivations to investigate VPS:

1) to effectively manage the assessment of electricity consumption data (metering) to prevent electricity theft, fraud and non-payment of electricity bills;
2) to ensure the power balance between the generation and the load profile even in presence of embedded dispersed generation, including fluctuating renewable energy sources and mobilising the potential electricity savings;
3) to reduce energy losses in the electric grid;
4) to enhance the electric grid performance with regard to power quality and coordination of relaying/ protections in presence of dispersed generation.

The last point is an increasing concern expressed by the most important regulatory and normative bodies at EU level such as ERGEG, CENELEC.

3.3 Criteria for evaluating VPS

For the evaluation of the performance of VPS criteria are necessary which reflect the quality by which VPS fulfil the expectations and respond to the motivations for their design and implementation. To this purpose, three categories are defined within which more detailed criteria can be developed:

1) Environmental impact, notably expressed by the degree to which VPS allow the integration of renewable energy sources in the electricity supply system;
2) Overall cost-effectiveness at the level of a single enterprise/ VPS, taking into account costs (energy losses in the grid, investments in grid development, electricity purchase conditions, expenditures for measurement, data handling and communication infrastructure, storage and reserve units) and income (supply contracts with customers and income from sale of surplus electricity);
3) Overall cost-effectiveness at the level of the whole society: same as 2, but taking into account external costs and financial transfers between the single company/ VPS and the society (taxes, subsidies, etc.);
4) Service quality, notably the supply security, taking into account by which degree the actual and forthcoming regulations concerning the quality of electricity supply are observed, but also the quality of the customer service, including new service options.

3.4 Specific cases and topologies of VPS

The intention of this document is to provide a general definition of a VPS which is sufficiently wide for covering all relevant specific cases and topologies. The general definition should contain all definitions of VPP, Smart Grids and similar notions which are actually used in the debate about the issues to which VPS should respond. Further, the general definition should be "connectable" to existing notions which denote the existing electricity supply system.

The table below displays the VPS, related notions and notions describing the existing electricity supply system against a number of features of the geographical area concerned, and the supply, consumption, storage, power transmission or communication sub-systems. Features which mark a difference between specific cases of VPS and to other systems are:

Geographical extension: *large* or *limited* to a community or region.

Geographical compactness of considered area: a *connected* area does not have grid lines crossing a neighbouring area for connecting two points within the area; opposed to this, a *disconnected* area is either composed of different disconnected parts or formed such that grid lines crossing neighbouring areas for connecting two points in the area can not be avoided – practically this implies grid use fees to be paid to a different grid operator.

Size of generation units involved: either *large* (typically a few 100 MW) or *small* (from a few kW to a few 10 MW).

Size of loads which are controlled: either *large* (e.g. large loads in industry) or *small* (e.g. loads in trade or households).

Storage: this concerns only storage of electrical energy in the narrower sense (see above); the most used storage technology is pumped-water storage, other technologies comprise compressed air, flywheels, batteries, super-capacitors, etc.

Electric grid involved: the distinction is between *high, medium and low voltage grids*; "involved" means that a generation or load unit is connected to, or several such units are linked by, such a type of grid.

Communication system: all electric supply systems have communication systems; the distinctive feature is in which part of the electric grid such communication systems operate and which kind of generators or loads are connected to it.

	Existing electricity supply system	Existing electricity supply system + few DES[2]	VPP	Smart grid	VPS	MOMBOX	Autonomous mini-grid	Existing large consumers	Existing small consumers
Geographically extended area	X	X			(X)	X		X	X
Locally or regionally limited area			X	X	X		X		
Geographically connected area	X	X	X	X	X		X	X	X
Geographically disconnected area			(X)		(X)	X			
Large generation units involved	X	X	(X)	(X)	(X)	X			
Small generation units involved	(X)	X	X	X	X		X	(X)	
Large loads controlled	X	X		X	X			X	
Small loads controlled				X	X	X	X		
Pumped-water storage involved	X	X	(X)	(X)	(X)	X	(X)		
Other storage involved	(X)	(X)	(X)	(X)	(X)	(X)	X	(X)	
Linked by/ connected to high voltage grid	X	X	(X)	(X)	(X)	X		(X)	
Linked by/ connected to medium voltage grid	X	X	X	X	X	X		X	
Linked by/ connected to small voltage grid	X	X	X	X	X	X			X
Communication between large generation units and/ or in high and medium voltage grid	X	X	(X)	(X)	(X)	X		X	
Communication with large loads	X	X	X	X	X			X	
Communication in distribution grid and/ or with small generation units and loads			X	X	X	X	X		

The grey part of the table designates VPS and all kinds of systems which are similar to VPS. The general definition of a VPS has been designed such that it encompasses most definitions of similar systems and most realisations of such systems. In the table, an X marks a feature that is normally realised, an (X) a feature that might be realised, but normally is not. A red circle marks a feature of a VPS that is not realised by the respective similar system. As one can see, the general definition of a VPS given above is effectively the most comprehensive definition. Of course, the exact filling of the table depends on the respective definition of a VPP, Smart Grid, Autonomous Grid or similar system. As mentioned above, the definitions given in the actual debate are not always in pattern to each other.

[2] DES = decentralised renewable sources

In the present debate, sometimes the notion of “commercial VPP” appears and in analogy a “commercial VPS” could be defined. This is not done here for two reasons:

1) A VPS as defined above requires a commercial component. So, a “commercial VPS” is nothing else than the sum of the commercial aspects related to a VPS.
2) If a VPS is not physically realised, i.e. if generation and load are not physically balanced, but only “in the books”, most benefits, in particular the better integration of high rates of intermittent renewable energy sources, can not be realised. Thus, it does not make much sense to speak about a VPS. In such a case the commercial balance is not much different from what happens in usual grid operation anyway.

3.5 Relevance of specific cases for benefits realized by VPS

Up until now, not so many VPS have been realized and statements about benefits that can be generated by VPS must be formulated with some precautions. However, some rough lines can be indicated on the basis of preliminary model simulations and first experiences:

1) Provided the right conditions are fulfilled, decentralized power generation that is interconnected to the low or medium voltage grid can reduce the ohmic losses in the electric grid. A modelling of the Italian grid has shown that this is the case until a certain density of decentralized power generation as long as the use of transmission grid lines, and respectively the losses in the high voltage/ medium voltage transformers, is reduced. From that optimum point on, increase of decentralized power generation leads to higher use of the transmission grid lines and the losses rise again.
2) The expected benefits of VPS can be better realized if the VPS is locally or regionally extended, not inter-regionally.
3) For a full realization of the benefits of VPS, load control and modification of consumption profiles are mandatory.
4) In particular in areas with weak electric grids or remote areas, the concept of VPS promises benefits in terms of loss reduction and savings in grid infrastructure extension.

3.6 Implementation levels of VPS

The implementation of VPS has to be done at several levels:

Technical: physical connection and consistent control of the generation, storage and consumption equipment

Contractual: specific system of contracts between different producers and consumers which make sure that production and consumption are in line as far as possible

Commercial: specific accounting grid (“Bilanzkreis”) ensuring commercial balance of production and consumption even for a large number of small producers and of consumers

Different approaches to VPS can be distinguished also by the way how they proceed at each of theses levels, the number of producers and consumers involved, and the degree to which production and consumption are matched.

4 SPECIFIC VPS OF INTEREST FOR PROJECT PARTNERS AND THEIR COUNTRIES

In the course of the discussions held for the preparation of this White Book, it was decided that a more detailed presentation of the different national electricity supply systems in the project partners' countries should be included. This is done in this chapter. The respective national situations have been described by the project partners from the respective countries:

Italy: FPM

France: RAEE, INPG

Switzerland: AlaRi-USI

Germany: B.A.U.M. Consult

Slovenia:

For each country, the following points are discussed:

1) Network structure (transmission/distribution)

2) Incentives in place for RES (general, photovoltaic)

3) National / local specificities

4.1 THE ITALIAN CASE

With respect to the VPS definition, FPMs details its proposal:

- w.r.to the Italian electric system the VPS, must have a local nature;
- the goal is to achieve losses reduction thanks to the production of the electric power close to the consumption;
- in the Medium voltage network (local nature), if the electric power production and consumption are synchronized, it's possible to gain a benefit in terms of postponing the transmission network upgrade/expansion;
- for the scattered consumers the VPS will improve the security of supply;
- the proposed local nature of the VPS is correlated with the potential in the exploitation of the "small sized" renewable resources available on the territory, with a reduced impact on the landscape;
- the VPS will also encompass generation from CHP (Combined Heat and Power production), considered in the renewable class thanks to the relevant improvement in the overall conversion efficiency achievable with this technology (it's relevant to point out that the CHP technologies are implicitly synchronized in terms of generation/consumption power profile);

- it has been agreed that also minor shares of non-renewable resources can be considered in the VPS (in order to get a better synchronism between generation and consumption, or for back-up purposes);
- finally, the local nature of the proposed VPS makes the business model feasible considering the resources available for the research, in the AlpEnergy project, for its implementation.

The presented VPS model refers to the Italian power system (more precisely, is consistent with the Italian technical/economical/regulatory framework) but can be applied with minor changes to (almost) all the power systems considered in the AlpEnergy project.

To cope with the different characteristics/requirements of the systems considered in the Alpenergy project, it has been proposed to develop a general definition of the VPS, with the aim to include all the possible applications; on the other hand, a specific definition is proposed, with the aim to better define the benefits achievable with the VPS implementation.

4.1.1 Network structure

Italian transmission network has been developed by ENEL (the vertically integrated state-owned utility) to a high degree of performance. In the last decade, the property and the operation of the transmission network (RTN, Rete di Trasmissione Nazionale) has been taken over by TERNA (formerly GRTN).

As a consequence, Italy has a very meshed grid system that covers the whole of Italian territory: every area of country is synchronously connected to the electric grid (only Sardinia is connected by a DC link). The network is strongly meshed in the northern area, while center and south areas are less developed. This is particularly significant, as in the last years a strong expansion of the wind energy use in the south of Italy put at stake some 132 kV connections (area of Naples).

As a consequence, the wind energy production of some plants in that region is curtailed.

Some obligations for wind plants to be equipped with an interface allowing the plant to be monitored and regulated externally are already in force. A proper economic regulation is being studied.

At small scale (MV network), grid reinforcements (developments) are frequently necessary even if a single photovoltaic plant is to be connected to the grid.

Starting January 1 2009, the obligation for grid operators has been tightened to strengthen and expand the electric grid proactively and providently in order to allow renewable energy plants to be connected as quickly as possible to the grid if a plant is being built at any point in Italy. This obligation is contained in the recent Delibera 99/08 by Italian Regulator (Autorità per l'energia elettrica e il gas, AEEG). The actions necessary to establish the required grid capacity have to start as soon as a potential operator of an independent renewable energy power plant has paid the connection fee.

As in most other European countries, the Italian electric grid is equipped with a comprehensive communication and control system at high (132/150 kV) and extra-high (380/220 kV); medium voltage level is partially covered (control and automation). Communication and control features at the low voltage level are not in place. This could turn out critical in the near future as the number of intermittently generating renewable energy plants, in particular photovoltaic installations, feeding into the low voltage level grid is rapidly increasing.

In order to respond to this situation and to prepare the establishment of grid control and management systems in the medium voltage distribution grid, new rules for decentralised electricity generation units have been formulated for the medium voltage level (Norma CEI 0-16), valid since September 2008.

A similar standard is being for the low-voltage level (Norma CEI 0-18, presumably valid from 2011). Some obligations for all active (generation) plants to be equipped with an interface allowing the plant to be monitored and regulated externally will be in force in the near future. A proper economic regulation will be studied.

4.1.2 Incentives in place for RES

Introduction

At the moment, Italy has developed two ways to boost the deployment of RES:

- Green certificates (then GC) and omnicomprensiva tariff;
- Conto energia;

Each of them will be briefly described below.

Green Certificates and Omnicomprensiva Tariff

The GC are the structure of incentives for RES developed after the introduction of the liberalized energy market (D. Lgs 79/99 and following modifications of Law 244/07 and 239/04 and D.Lgs. 387/09). Since then, operators of more than 100GWhe/year are obliged to have a percentage of the overall production coming from RES, with the minimum values fixed each year as following:

Year	*Minimum share*
2001	*2%*
2002	*2%*
2003	*2%*
2004	*2,35%*
2005	*2,7%*
2006	*3,05%*
2007	*3,8%*
2008	*4,55%*

The increase of RES power planned for 2012 is equal to +0,75%/year.

For RES power plants that started operations before 2008 (and provided by the IAFR qualification, "Impianto Alimentato da Fonti Rinnovabili"), to each MWhe/year produced a GC is associated. GCs are issued for the following period:

- *8 years for power plants fueled by non-biodegradable waste that started operation within 31/12/2006 and non RES-fueled co-generation plants coupled to district heating.*
- *12 years for all RES plants that started operations from 1-4-99 to 31-12-07;*
- *15 years for RES plants that started operations since 2008.*

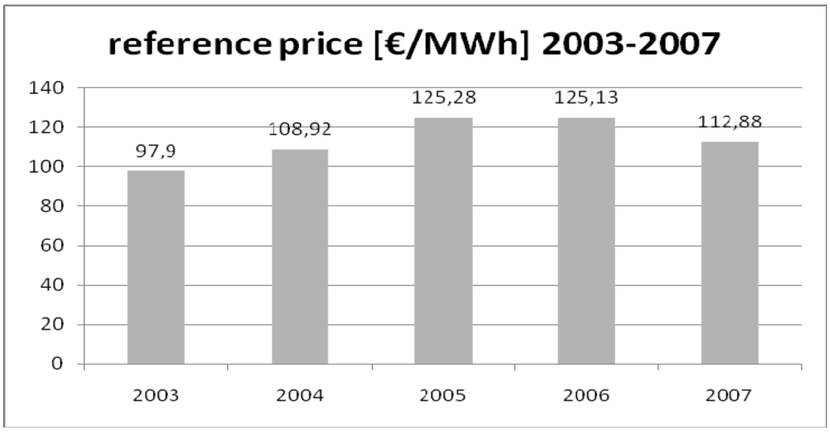
RES plants that started operations from 2008 will receive for 15 years GC equal to the net production of electric energy multiplied by a coefficient, according to the renewable source. Plants smaller than 1 MWe, for each MWhe produced, have the opportunity to choose between a GC and a contribution (called "tariffa Omnicomprensiva" particularly worthy. Both the form of incentives (GC and "tariffa Omnicomprensiva") are reported in the following table.

	CV	Omnicomprensiva
Fonte	Coefficient	c€/kWh$_e$
Wind (<200 kW)	1,0	30
Wind (>200 kW)	1,0	na
Wind offshore	1,1	na
Geotermic	0,9	20
Wave	1,8	34
Hydro	1,0	22
Waste biodegradable, biomasses different from the following.	1,1	22
Biomasses and biogas from agricolture and breeding.	*	*
Biomasse e biogas for high performance co-generation plants and re-use of thermal power in agricolture	*	na
Gas from waste and biogas different from previous.	0,8	18

** In the case of bio-masses and biogas from agriculture and breeding the incentives structure is as follows:*

- *Size < than 1 MWe: CV for the electric energy production with a coefficient equal to 1,8.*
- *Size > more than 1 MWe: the same of the previous or a contribution of 30c€/kWh.*

In the following picture is reported the average value of GC for the period 2003-2007.



Conto Energia

For PV power plants Italy has developed this new structure of incentives that depends on the range of power of the plant and on its characteristics but it is granted for 20 years:

		Type of solar power plant		
Nominal Power of the plant (kW)		*1 – non integrated*	*2 – partially integrated*	*3 – integrated*
A)	*1≤P3*	*0,40*	*0,44*	*0,49*
B)	*3<P≤20*	*0,38*	*0,42*	*0,46*
C)	*P>20*	*0,36*	*0,4*	*0,44*

In this case a more 5% of the incentive should be added in case of auto-consumption of more than 70% of the electric power produced. It is worth to notice that the incentives are provided for all the energy produced in the plant.

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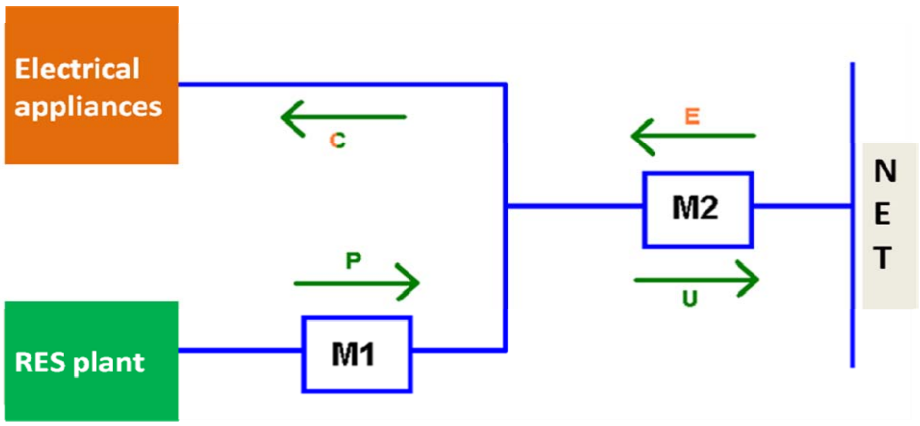
Further Incentive: "net metering"

All RES (including high efficiency co-generation plants) within 200 kW have a further incentive, i.e. the called "scambio sul posto" or "net metering": in this case, according to the next picture, producers have the opportunity to exchange energy directly to the net.



The net metering allows the auto-consumption of energy delayed in time, in the sense of compensation of the energy given to the net when exceeding the internal consumption with the energy absorbed internally in scacity of production, with a maximum delay in time equal to 3 years. In this sense the electric grid can be considered a Bank for the Renewable Generators, if Production and Consumption are in the same bus.

This structure of incentives has been recently changed, shifting from a compensation of the kWh produced and consumed to the compensation of the value of the energy produced and consumed within 3 years.

Other opportunities to trade energy, open to all RES, are the following:

1) Indirect sale

The Energy produced is directly managed by the Authority (Terna), or the local distributor (depending if the plant is connected to the National Transmission Grid or to the local distributor). The indirect sale has the following costs:

- *132 € annual fixed (for year 2009);*
- *0,5% of the value of Energy managed (max 3.500€);*
- *0,0270 c€/kWh for the transmission of energy.*

Plants connected in low voltage (LV) or medium voltage (MV) receive a contribution of 0,344 c€/kWh for the costs of transportation that are avoided, with some increment of 4,2% for MT and 9,9% for BT to take into account the avoided net losses.

This opportunity is suggested when the net metering would be unprofitable.

Considering RES plants of less than 1 MW the minimum price granted by the authority for year 2009 is the following:

- *0,1011€/kWh up to 500.000 kWh/year sold;*
- *0,0852 €/kWh from 500.000 kWh/year to 1.000.000 kWh/year sold;*

- *0,0745 €/kWh from 1.000.000 kWh/year to 2.000.000 kWh/ year sold.*

For more than 2.000.000 kWh/year sold and for plants larger than 1 MW, the price of energy depends on the market.

2) direct sale

The Energy is directly sold to the electric market, with prices depending on this market. This opportunity is chosen only for big plants (>1 MWe) since it presents high fixed costs and thus it is not convenient for small RES plants.

4.1.3 National / local specificities:

- very complex market structure/incentives for RES
- high levels of Power Quality (leading position in EU)

We need to investigate about a VPS leading to a higher system efficiency

We propose to study an innovative VPS able to:

- Increase the exploitation of the RES DG (2020 target?)
- Reduce the losses
- Reduce/delay the investments for the network improvement
- Avoid any negative impact on Power Quality

Thanks to this "improvement" it is possible to envisage new markets rule suited for the VPS

This will allow for further incentives (current incentives are already significant…).

4.2 THE GERMAN CASE

4.2.1 Network structure (transmission/distribution)

Germany has a very dense electric grid system with very few spots of the country which are not connected to the electric grid. In the course of the rapid and strong expansion of the wind energy use in the north of Germany, a reinforcement of grid lines at medium and high voltage level has become necessary. For instance, the wind energy production in the northern-most Bundesland, Schleswig-Holstein, is at present throtteled by 7% on the annual average due to insufficient grid capacity. In Brandenburg, the wind park operator ENERTRAG has built on its own a medium voltage electric grid for collecting the electricity produced by its wind parks and feeds the electricity from that electric grid into a high voltage transmission grid line. At small scale, grid reinforcements are frequently necessary even if a single photovoltaic plant is to be connected to the grid.

Against this background, the obligation for grid operators has been tightened to strengthen and expand the electric grid proactively and providently in order to allow renewable energy plants to be connected as quickly as possible to the grid if a plant is being built at any point in Germany. This obligation is part of the Renewable Energy Act (EEG, see next paragraph) and the tightened rules are valid since 1st January 2009 (§9 EEG 2009, expansion of grid capacity). The actions necessary to establish the required grid capacity have to start as soon as a potential operator of an independent renewable energy power plant is in an advanced planning state. If the grid operator does not undertake the necessary actions to enhance the grid capacity, he might have to pay a compensation to the independent power supplier concerned (§10 EEG 2009).

As in most other European countries, the German electric grid is equipped with a comprehensive communication and control system at high and medium voltage level, but is at present completely missing communication and control features at the low voltage level. This is expected to lead to problems with grid operation and management in the near future as the number of intermittently generating renewable energy plants, in particular photovoltaic installations, feeding into the low voltage level grid is rapidly increasing.

In order to respond to this situation and to prepare the establishment of grid control and management systems in the low voltage distribution grid, tightened rules for decentralised electricity generation units have been formulated for the medium voltage level (Mittelspannungsrichtlinie, valid since 1st January 2009 with some rules applying for PV plants from 1st January 2010 or 2011 on) and are being prepared for the low-voltage level (Niederspannungsrichtlinie, presumably valid from 1st January 2011 on). Within the EEG, the obligation for all renewable energy plants to be equipped with an interface allowing the plant to be monitored and regulated externally has been put into force for all plants with more than 100 kW nominal power (§6 EEG 2009, conditions for grid connection). The grid operator is allowed to regulate the feed-in power of renewable energy plants until grid extension measures make such regulation superfluous. However, the grid operator has to compensate the plant operator for the lower income from electricity sale accordingly (§12 EEG 2009, hardship regulation).

The present EEG encourages grid and plant operators to search for better alternative solutions allowing to avoid costly grid capacity enhancements. However, such solutions and the necessary contractual formulations need then to be found by the partners concerned themselves.

4.2.2 Incentives in place for RES (general, photovoltaic)

The most relevant incentive for electricity generation from RES in Germany is the Renewable Energy Act (EEG). The EEG is based on the principle that electricity generated from renewable energies is to be collected by the next situated grid operator and to be remunerated according to a legally fixed minimum price which ensures profitable operation of renewable energy plants if they are built according to good current practice and at market prices for components and systems. The grid operator is allowed to invoice the additional cost from the compulsory electricity purchase from operators of renewable energy plants to the upstream grid operator and the total costs are distributed according to a complex scheme among all grid operators in Germany and are finally included in the electricity bill of the consumers. In 2006, the additional costs of electricity in Germany due to the EEG were 0.75 ct/kWh. They are expected to reach their maximum in 2015 (1.5 ct/kWh) and then decrease again to reach 0.2 ct/kWh in 2030.

The philosophy behind the EEG is that the legally ensured possibility of profitable operation of renewable plants leads to an installation boom of such plants which triggers the market and finally leads to decreasing costs of electricity generation from renewable sources due to production capacity effects. The real results achieved by the EEG were far above the initial expectations and excellently demonstrate that the principle worked. In 2008, 15.3% of the electricity produced in Germany came from renewable sources out of which about two third can be traced back to the EEG and its predecessor, the Stromeinspeisegesetz (grid feed-in law) of 1990. The latter has led to the boom of wind energy use in Germany which made Germany the largest wind energy user in the world. The EEG is in force since 1st April 2000 and has not only ensured the continuous development of the wind electricity generator, but triggered also a similar rapid development of electricity generation from other renewable energy sources, in particular from biogas and from photovoltaic plants. All in all the feed-in legislation has lead to 65,000 – 78,000 additional jobs and 100 million tons of CO_2 reduction in Germany in 2006. The total investments in renewable energy plants triggered by the EEG are expected to reach 95 billion € (60% of all investments in renewable energies) for the time between 2005 and 2020.

The successive amendments of the EEG in 2004 and 2008/2009 as well as a number of intermediate adaptations have responded to a several issues that have arisen in the mean-time, but in particular to the decrease of the cost of electricity generation from renewable energies which was achieved as a desired and expected result of the EEG. The presently most relevant issues to which the last amendment responds at least partially are:

- To smoothly shift away from a guaranteed remuneration of electricity from renewable sources to more and more free sale of this electricity on the market, thus integration renewable energy generation successively in the free electricity market.
- To encourage operators of renewable energy plants to use or sell the generated electricity locally in the immediate neighbourhood of the plant, thus releasing the electric grid.
- To ensure that operators of renewable energy plants contribute to measures ensuring stable grid operation.

Elements of the amended EEG of 2008/2009 which respond to these issues are notably the option of temporary sale of the electricity outside the framework of the EEG (§17 EEG 2009, direct sale), the option of partial own use of electricity from photovoltaic plants (fostered by a premium of 18 ct/kWh in 2009 for each kWh generated from a PV plant and used in the immediate vicinity of the plant, regulated by §33(2) EEG 2009), and the obligation to equip renewable energy plants with a power of more than 100 kW with an interface allowing external monitoring and control (§6 EEG 2009, see above). Thus, own use of PV electricity is more profitable than complete feeding into the electric grid at least if the electricity purchase tariff is higher than 18 ct/kWh (without taxes). This provides an incentive for households that operate a PV plant to control their demand such that the own use of PV electricity is maximised.

The present version of the EEG does not yet favour the storage of electricity, but foresees this option in §16(3) EEG 2009. Proposals have been formulated to include a premium for electricity from renewable energies that is temporarily stored in order to compensate fluctuations of the generation that can not be absorbed directly by consumption, but these proposals have not yet been integrated into the law.

4.2.3 National / local specificities

In addition to the above-said which is already quite specific for Germany, one could stretch the following points as specific for the situation and ongoing developments in Germany:

- The German government has set-up a specific programme for the development and practical implementation of VPS. Within this programme six German regions are currently working on the realisation of VPS which include a broad range of different VPS options, both at the supply and demand side and storage.
- The main motivation for setting up VPS is the huge and rapidly increasing rate of electricity generation from intermittent renewable energy sources.
- The existing electric grid is very narrow-mashed, strong and reaches all points of the country, but developments are necessary for absorbing the huge amounts of electricity from wind parks in northern and from biogas and PV plants in southern Germany. Many of these plants are situated in parts of the country where the demand is lower than the present and expected forthcoming generation of electricity from renewable sources and the existing grid is not always dimensioned sufficiently strong for absorbing this electricity generation. Further, new electricity transmission lines are needed from the north to the south, in particular because of the foreseen strong development of off-shore wind energy generation.
- One of the more difficult to-be-solved legal issues in relation to VPS is the antagonism between the legal rules for handling private data and the rules for invoicing. The antagonism concerns only private households and only as far as completely dynamic electricity prices are implemented as a measure to explore the potential of demand side management.

4.3 THE SWISS CASE

In Switzerland, the Swiss Federal Office of Energy (SFOE) belonging to the Department of the Environment, Transport, Energy and Communications (DETEC) is responsible for management of energy, pursuing the following objectives:

- Guarantee a sufficient, well diversified and secure energy supply that is both economical and ecologically sustainable.
- Impose high safety standards in the areas of production, transportation and distribution of energy.
- Promotion of efficient energy use, increase the proportion of renewable energy in the overall energy mix and reduction in the level of CO2 emissions.
- Promotion and coordination of energy research and support to the development of new markets for the sustainable supply and use of energy.

4.3.1 Network structure (transmission/distribution)

Switzerland's electricity market is greatly fragmented. The supply of electricity is secured by some 900 companies, including 7 generation and transmission companies and approximately 80 producers. Many works operated by municipalities also supply water and gas. In some cantons and cities, a single vertically-integrated company is responsible for the entire supply chain, while in other cantons, supplies are secured by a variety of companies. The public sector stake in the capital stock of electricity supply companies (approximately 5.6 billion Swiss francs) is currently around 80%, while the remaining 20% is held by private-sector companies (at home and abroad).

As a natural monopoly, the electricity network does not face direct competition. Its construction and maintenance are based on international standards and recommendations of recognized organizations. Since the security of the overall network depends on that of each separate section, network operation has to be subject to minimum technical and operating requirements.

For all network operators, a high level of supply security is assured thanks to the existence of a comprehensive network of high-voltage transmission lines which means that reserve capacities can be utilized jointly. For this to function, the operation of the system has to be co-ordinated on an international basis. Until now, the 7 Swiss transmission network operators have used the regulations of the Union for the Coordination of Transmission of Electricity (UCTE) as industry guidelines within Switzerland. They also established a subsidiary called ETRANS to function as a coordination centre. But the aim now is for an independent network operator ("Swissgrid" - http://www.swissgrid.ch/) to operate the system on the basis of a legal mandate.

4.3.2 Incentives in place for RES (general, photovoltaic)

The use of renewable energies is a main focus of SFOE and ambitious targets for 2010 have been issued:

- 3%, or +3,000 gigawatt hours (GWh) more heat is to be produced from renewable energy sources versus 2000
- 1%, or +500 Gwh more electricity is to be produced from renewable energy sources versus 2000
- The production of electricity from hydropower is to be maintained at the level of 2000.

In order to meet such objectives appropriate measures were implemented.

Compensation Schemes

On 23 March 2007, as part of the passage of the Electricity Supply Act (StromVG) the Swiss parliament also revised the Energy Act (EnG). The revised Energy Act stipulates that electricity production from renewable energies must be increased by at least 5.4 billion kilowatt hours by 2030. This corresponds to around 10% of current electricity consumption (2007: 57.4 billion kilowatt hours). To this end, the Energy Act contains a package of measures aimed at promoting renewable energies and energy efficiency in the electricity sector. Compensatory feed-in remuneration enables producers of renewable electricity from hydro power (up to 10 megawatts), photovoltaic, wind power, geothermal power and biomass to feed in their supplies to the Swiss electricity grid from 1 January 2009 at fixed compensation rates in order to finance the additional costs not covered by market prices (additional costs = reference price - market price). The term of remuneration is between 20 and 25 years, depending on the technology. Compensation rates are based on the production costs of reference facilities, corresponding to the most efficient technology in the year of construction. In the following table, the price paid for energy produced from solar cells (new installations) are shown. Different remunerations are foreseen for wind, biomass and geothermal energy sources.

Type of plant	Plant Size	Remuneration (Rp./kWh)
Free-standing	≤10 kW ≤30 kW ≤100 kW >100 kW	65 54 51 49
Built-in	≤10 kW ≤30 kW ≤100 kW >100 kW	75 65 62 60
Integrated	≤10 kW ≤30 kW ≤100 kW >100 kW	90 74 67 62

To finance the compensatory feed-in remuneration costs, with effect from 1 January 2009 a maximum surcharge of up to 0.6 cents per kilowatt hour will be levied on Swiss electricity end consumption. The amount of the surcharge is determined annually by the Swiss Federal Office of Energy according to demand and taking into account market prices. In the case of current end consumption in Switzerland, approximately CHF 344 million are available per year to finance all measures under the revised Energy Act. The program was very successful and all the planned installations were actually created, at the moment it is necessary to enroll in a waiting list in order to eventually receive the planned contribution.

Cantons and municipalities may also contribute to renewable energies bonus. The funding changes from canton to canton. As an example cantonal funding for building a domestic solar thermal facility ranges between 5748 CHF (i.e. 45% of the cost of installation) for Basel canton to no funding for Ticino, Schweiz, Zug and Obwald.

4.3.3 National / local specificities

HydroPower

Hydropower meets approximately 60% of the country's electricity requirements. There are very few suitable locations available for new large-scale hydropower plants, but it will be possible to generate significant – and in many cases, inexpensive – additional quantities of green power in the future by renovating and efficiently operating existing facilities. The expansion potential for small-scale hydropower plants (i.e. those with a capacity of up to 10 MW) is around 2,200 GWh p.a., and SwissEnergy (http://www.bfe.admin.ch/energie/00458/index.html?lang=en) aims to help exploit it through appropriate promotion measures.

Wood Energy

Wood-fired systems for district heating through to production of electricity from wood via high-capacity cogeneration plants (in the megawatt range) exist in Switzerland. There are plans to introduce new technologies such as gasification in the course of the next few years, but these will also have to be made marketable.

Other BioMass

The large-scale cultivation of plants for energy production in Switzerland is hardly a feasible proposition.

Wind Energy

In its "Wind energy concept for Switzerland", the federal government defined the criteria governing locations for wind power plants in terms of both suitability for energy production and requirements concerning the protection of nature and the environment. According to this concept, wind power plants may only be constructed at suitable locations. Wind energy will continue to make only a small but low-cost contribution towards a sustainable supply of electricity in Switzerland. With the support of SwissEnergy, it should be possible to produce between 50 and 100 gigawatt hours of electricity from domestic wind energy by 2010.

Geothermal Energy

It is expected to be exploited in future, following improvements of technology in this field

Rural Areas

Given the peculiarity of the Swiss territory it is of cumbersome importance to provide electrical facilities in small isolated neighborhoods or villages in the alpine valleys. Particular solution to improve efficiency of such deployments are highly encouraged.

4.4 THE FRENCH CASE

4.4.1 Network structure (transmission/distribution)

Transport network

RTE (electricity transport network) is the manager of the public French electricity transport network (voltage > 50 kV). RTE runs, maintains and develops this network of 100,000 km line of high and very high.

The network is composed of two group of lines :

- Long transport lines 400 kV, which transport electricity on long distance (hundreds of kilometers). On this network are connected the inter-connexion lines with the neighbouring countries and all the nuclear power plants.
- Regional dispatching lines with three voltage levels : 225, 90 et 63 kV. This network is used for the regional dispatching till the distribution network in mean voltage (20 kV), or directly connected to big industries.

RTE is a subsidiary of EDF (since the opening of the market).

Distribution network

ERDF is a subsidiary of EDF (since the opening of the market).

Local energy syndicates are in charge of the distribution network. In France, the collectivities have the responsibility for electricity distribution. This responsibility is to gather in syndicate representing hundreds of collectivities.

ERDF runs, maintains and develops the distribution network for the energy syndicates who keep the responsibility.

« Les régies » (non nationalized distribution company) in opposition with EDF are local small companies who are in charge of distribution and sale to the final client. They are present in approximately 5 % of the territory.

Voltage level below 50 kV

Distribution substations are the bridges between the transport network and the distribution network. They are connected to the transport network of 90kV, 63 kV or 225 kV in the high density consumption areas.

ERDF runs more than 2100 distribution substations, of which 9 % in 225 kV/HTA.

HTA network (high voltage A)

All the departure from the distribution substation constitute the HTA network. The number of departure per substation is between less than 10 to 50. HTA departure feed the substation of the clients connected in HTA and the substation in HTA/BT called «public distribution» being used for the feeding of low voltage clients. Voltage between phases in HTA in 20 kV.

BT network (low voltage)

Departures from HTA/BT substation constitute the BT network. In areas fed by underground lines, substation in HTA/BT can feed :

- 120 to 150 individual houses (50 to 60 with electric heating),
- 250 to 300 housing in collective building (100 to 130 with electric heating).

The connexion BT (low voltage) is the connexion between the BT network and the doorstep of the electric installation of the user. This connexion feeds only one user. The new connexions are sized to18 kVA and made in single phase (2 wires - 90 A), excepting if the needs of the user are special (three phase machine) or if the network has not the sufficient capacity to feed in good conditions the installed capacity in single-phase.

For the bigger power the connexion are three phases connexions, up to the limit 250 kVA.

4.4.2 Incentives in place for RES (general, photovoltaic)

The feed-in tariffs where introduced in France in 2001 and revised several times. Most of the feeding tariff were reevaluated in 2006.

Technology	Decree	**Contracts length**	**Tariffs for new installations**
Hydroelectricity	1er march 2007	20 years	**6,07 c€/kWh** + bonus from **0,5 to 2,5** for small installations + bonus from **0 to 1,68 c€/kWh** during winter according to regularity of the production
Biogaz	10 july 2006	15 years	Between **7,5 and 9 c€/kWh** according the power, + bonus for energy efficiency from **0 to 3 c€/kWh** , + bonus for methanization : **2c€/kWh** .
Wind energy	10 july 2006	15 years (onshore) 20 years	- **onshore** : **8,2 c€/kWh** during 10 years, then **2,8 to 8,2 c€/kWh** during 5 years according to the potential. - **offshore** : **13 c€/kWh** during 10 years, then **3 to 13 c€/kWh** during 5 years according to the potential.

		(offshore)	
Photovoltaïc	10 july 2006	20 years	- **Metropole** : **30 c€/kWh** , + bonus for building integration : **25 c€/kWh** - **Corse, DOM, Mayotte** : **40 c€/kWh** , + bonus for building integration : **15 c€/kWh** .
Geothermal energy	10 july 2006	15 years	- **Metropole** : **12 c€/kWh** , + bonus for energy efficiency from **0 et 3 c€/kWh** - **DOM** : **10 c€/kWh** , + bonus for energy efficiency from **0 et 3 c€/kWh**

4.4.3 National / local specialties:

- Huge network in France : more than 1,2 millions km
- Only 5 % of the network are run by local small public enterprises in rural areas or in few urban centers (Grenoble, Strasbourg, Briançon…).
- The distribution network has a voltage level of 20 kV.
- Recent trend for increasing of wind energy and PV connexion.

4.5 THE SLOVENIAN CASE

4.5.1 Network structure (transmission/distribution)

4.5.2 Incentives in place for RES (general, photovoltaic)

4.5.3 National / local specialties: