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AlpEnergy

Virtual Power System (VPS) as an Instrument to Promote Transnational Cooperation and Sustainable Energy Supply in the Alpine Space

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Summary

AlpEnergy (http://www.alpenergy.net) is an **European Territorial Cooperation Project** (http://www.alpine-space.eu/) bringing together power suppliers, development agencies, research institutes and public administrations from five different countries of the **Alpine Space** - France, Germany, Italy, Slovenia and Switzerland - to address the central issue of **renewable energy supply**.

Even if hydropower, solar and wind energy, wood and other biomasses are richly distributed throughout the area, they are unequally accessible because of many **territorial discrepancies**. The need to balance an increasing production and use of RES (renewable energy sources) requires a stronger and more extended electric grid capable of dealing with high levels of remote power generation. **Virtual Power Systems (VPS)** offer an alternative by using ICT technology for an intelligent combination of load management, storage and demand.

AlpEnergy focuses on both **technical** as well as **commercial aspects** to introduce an efficient operational model that aims at a standardization of both technologies and procedures. It intends to provide new knowledge-based incomes and business opportunities to local traditional and innovative enterprises, thus supporting the competitiveness of the Alpine ventures and making the Alpine space a showcase for other mountain areas in the world.

Project goals

The need to limit climate change implies that global green house gas emissions are quickly and strongly reduced, including a quick and strong decrease of C02-emisions from fossil electric power plants. Renewable energies and energy efficient measures are already, or are expected to be soon, competitive. To face these challenges, completely new approaches are necessary. This is where Virtual Power Systems (**VPS**) come into play.

Operators are asked to handle rising shares of renewable electricity in their grids, including those that are coming from fluctuating sources, such as wind and photovoltaic power stations. Technically speaking, this complicates the task of bringing purchase/sale of surplus electricity in pattern with the electric demand. As it is fairly hard to store electrical energy, generation and consumption have to be simultaneous. There is a need for intelligent energy management that coordinates different plants in a way that peaks demands are attenuated. VPS will allow insertion of a larger number of intermittent renewable energy production plants in the grid.

AlpEnergy aims at the analysis and modeling, the design and development, the **demonstration and test**, the evaluation and transfer of virtual power systems in **four** distinct **areas** of the Alpine space: the Allgäu region in Bavaria (Germany); the city of Mantua in Lombardia and the province of Belluno (Italy); the Belledonne chain area in the Rhône – Alpes region; and the Gorenjske region in Slovenia.

ALaRI participation

ALaRI (Advanced Learning and Research Institute, www.alari.ch) is an institute of Faculty of Informatics and part of Università della Svizzera italiana (USI, Lugano, Switzerland), established in 1999 with the mission of promoting research and education in Embedded Systems Design. USI-ALARI was created as a joint initiative of a number of Universities, Research Centers and Companies. From 2005 ALaRI is part of the faculty of Informatics (established at USI in 2004). The main areas of the current research activities at ALARI are: co-design

and optimization of pervasive systems, design of optimized hardware cryptographic devices, robustness analysis of cryptographic algorithms, design of hardware and software solutions robust to power analysis attacks; power modeling and optimization of wireless systems; high-level services for on-chip communication (QoS, security, power management, fault tolerance, etc.); multiprocessor reconfigurability.

ALaRI objectives in scope of the project ALaRI role in the project is related to the ICT aspects of the VPS concept in sense of determining and defining functional requirements and accordingly Information flow in VPS. More precisely, our goal is development of an ICT model of VPS according to guidelines adopted and defined by the consortium. ALaRI role is conceived as three step engagement. We should:

- Contribute to definition formulation of VPS concepts and models
- Create VPS modeling framework
- Basing on previously developed VPS models define Information flow

These tasks are mapped into project work description in Working Packages four (Analysis and Modeling) and five (Design and Development) as assessing ICT plans of proposed systems. The foreseen milestones according to these phases of the project are:

- The document on state-of-the art of VPS concept in Europe and discussion on exact VPS definition adopted for the project
- Determination of all elements of the Information flow model of VPS in terms of ICT
- Assessment of the ICT plans for the proposed system

The workflow has been logically encapsulated in terms of Work Packages and timelines are provided at the year by year level. In the sequel the ALaRI tasks are provided according to this division.

ALaRI tasks for 2009

The entire AlpEnergy project is partitioned in seven work packages. In this year our tasks span through Work Packages 4 (Analysis and Modeling) and 5 (Design and Development). It is important to mention here that due to additional insertion of two partners (Regione Autonoma Valle d'Aosta and Consorzio BIM Piave di Belluno - Italy) earlier this year, the workflow in those two Work packages is under revision and the consortium is considering rescheduling of certain tasks in form of tasks order permutations and deadlines extensions.

Tasks are in general interconnected and based on developing a modeling methodology that goes from general to more specific issues. Our work has been adapted to reflect multidisciplinary nature and flexibility of the concept. Here are listed single tasks to be performed.

1. Tasks of the Work Package four

1.1. Definition of VPS concept

The VPS as a concept that is novel and still under development requires permanent discussion and adjustments according to newly obtained results in the process of realization. The definition of VPS and state of the art in the field is supposed to be presented in the 'VPS White book'. This task is accomplished in collaboration with BAUM. This task has been closed even though the possibility to update the White book according to obtained results from field implementations remains.

1.2. Definition of a general abstract model and description of best practice

In scope of this task, ALaRI has been asked to develop a general system level of the VPS. The best practice transfer should be defined upon concretion of pilot realizations and their mapping into the model. Changes in the consortium composition impacted greatly the realization of the task, so that the previously set deadline is under revision. This task is supposed to be performed in collaboration with all other project partners.

1.3. Evaluation of the general information model for different regions of the interest

Upon the creation of pilot projects (originally in Allgäu and Gorenjska, additionally in Belluno and Val D'Aosta) the general abstract model should be adjusted (if needed) and enhanced to support custom instantiation of concrete cases (i.e. support different realization methods). The task should be performed in collaboration with Algeu, Elgo, Belluno and Val D'Aosta, the deadline is under revision.

2. Tasks of the Work Package five

2.1. General framework for Canton Ticino

The aforementioned general information overview should be scaled and adopted for regional circumstances. The local instances of VPS (pilot implementations) would serve as a prototyping model. The local situation in Canton Ticino should be elaborated and mapped into the framework according to previously developed rules. The task is supposed to be done upon provided inputs from partners implementing pilot setups the deadline is under revision.

2.2. Definition of the Information Flow model of VPS

This task represents a key element of the ALaRI engagement in the project. In scope of this task the determination of key VPS stakeholders and their functional requirements is envisaged. The VPS is accordingly represented as a modular structure in which functionalities are distributed to appropriate components. Interaction, interconnections and communication standards among elements must be provided. The task is ongoing and it should be performed in collaboration with other partners and especially with ELGO.

Performed work and obtained results

VPS is a novel concept still under development and in the phase of pilot implementation. The constant interaction among stakeholders and feedback from the field realizations should result in regular adjustments and upgrades of the originally envisaged theoretical concept. ALaRI has being playing proactive role in 'VPS White paper' updating. The improved version of the document has been approved at the Partners meeting in Kempten (May 27). Realization of this document concludes the task described in 1.1 section of the report. Nevertheless, the white paper is supposed to be flexible and adjusted according to results obtained from pilot realizations, some parts of the document might be updated till the end of the project.

The VPS is an entity with complex internal and external relations. So, upon defining the VPS concept itself ALaRI has determinate the place and role of VPS in wider environment of power systems relating their appropriate elements (please see Fig.1). Moreover, the possibilities for **integration in SmartGrid** are studied. The result of this work is presented in a form of publication at relevant international conference [5]. This work represents a kind of a bridge between task assignments delegated to ALaRI in tasks described in the 1.1 and 1.2 sections of the report.

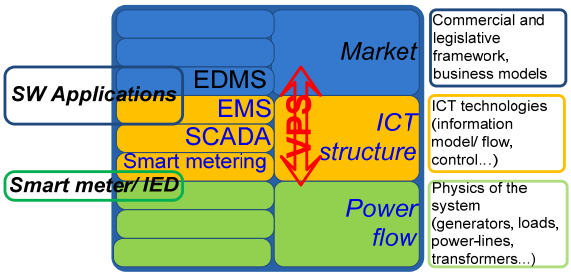

Figure 1: Layered structure of modern power systems and place of VPS inside it as defined by AlpEnergy

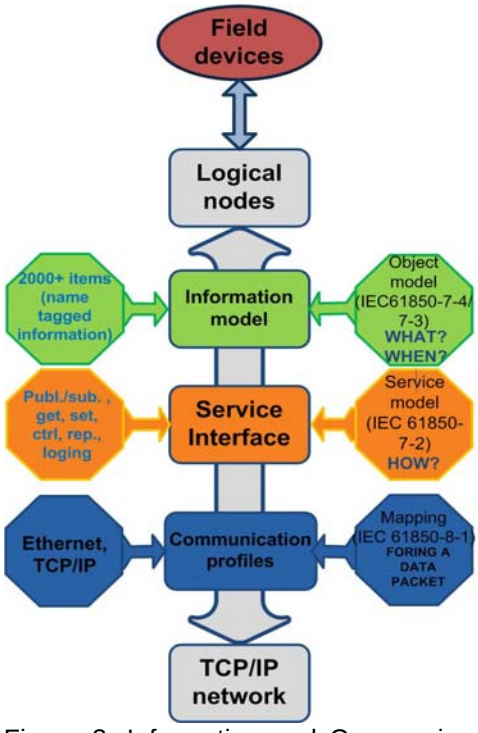

Figure 2: Information and Communication model of modern DER

In scope of AlpEnergy project, VPS is logically encapsulated according to the model of Virtual Power Plants developed in other relevant international projects [1] in **Commercial VPS (CVPS)** and **Technical VPP (TVPS).** On the other side, the structure of VPS must reflect one existing in modern power system.

One of our tasks consists of development of a general abstract model of VPS (please see section 1.2). This task requires definition of stakeholders and their requirements which is later transformed into system components and their relations [6]. In order to successfully tackle this challenge, ALaRI has been created the appropriate modeling methodology which starts from the general *context diagram* (which shows in a very general sense *actor* involved in certain activity) and goes into direction of considered aspect. This concept has been exposed in several publications accepted for presentation at relevant conferences [5,6]. This work corresponds to project tasks described in sections 1.2 and 1.3 of the report.

Dealing with safety critical services as electricity supply is, VPS must comply with high reliability and security standards set by traditional power systems. At the other side, VPS is an interdisciplinary concept that requires holistic and flexible approach. Moreover VPS must be able to adapt to variety of implementation technologies, communication standards, wide range of possible realizations (small to large scale) and also different commercial and legal environments. Bearing in mind these facts we have developed a modeling methodology that reflects these requirements regarding ICT structure (i.e. Information Flow) and helps:

- Modular design (supporting component based design and plug-and-play capability)
- Interoperability among components (facilitating maintenance and upgrade)
- Scalability (being able to adopt to different sizes)
- Optimization of resource utilization
- Creation of common understanding platform for stakeholders

We have defined VPS as a structure composed of three basic elements:

- **Monitoring structure** composed of Advanced Metering Infrastructure, Smart Meters and sensors; **Control structure** that consist of Intelligent Electronic Devices (IEDs), Programmable Logic Controllers (PLCs) and Actuators (refer to Fig. 3)[5]
- **Communication protocols** defined according to emerging international standards (refer to Fig. 2)[2,3]
- Software based **Control Center** composed of SCADA, Energy Management System (EMS) and Energy Data Management System (EDMS) (refer to Fig. 4)[4,7]

Those elements are later shown at the level of components. The modular structure and their interconnections are represented using UML based diagrams [4,5,6,7].

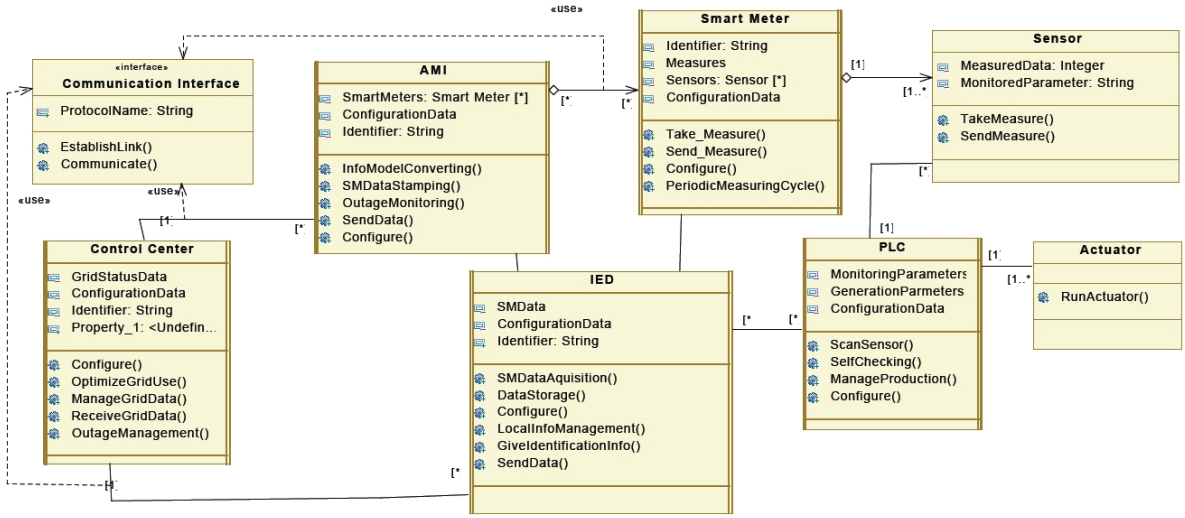

Figure 3: UML class diagram of ICT structure of VPS

As the Control Center represents the key enabler of VPS we provide a detailed outlook into this system element (refer to Fig. 4) as a finer grain representation of one part of above model. The detailed description of the modeling methodology is provided in [7].

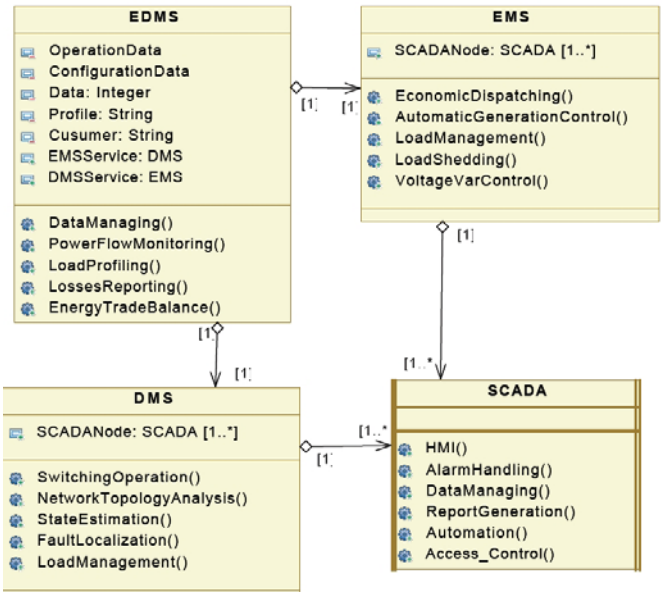

Figure 4: Control Center structure - class diagram

According to division of VPS in CVPS and TVPS we can say that EDMS corresponds in a certain way to CVPS functionalities while the rest of the system corresponds to TVPS.

ALaRI was actively taking part in all partner meetings and moreover has been asked to provide **two presentations** at those meetings:

- **VPS from ICT point of view** - given at partners meeting held in Kempten on May 27th
- **Study on feasibility of meta-VPSs** (joint transnational marketing of renewable power) – given at partners meeting held in Belluno on October 27th

The detailed description of performed work, in fact all elements of the system as well as their interactions is given in publications (weather published or still under review). This work corresponds to the task described in the 2.3 section of the report. Due to project workflow rescheduling more efforts than originally foreseen for this period has been invested so that the task has been driven close to the end much ahead of given deadline.

National Collaboration

VPS is a novel concept that requires careful approach; the consortium intends to find full internal common agreements on conceptual definitions before involving institutions located in the different partners' areas that are not belonging to the AlpEnergy consortium.

So far, our engagement in AlpEnergy project required tight collaboration with other partners related to VPS definition, identification of stakeholders and functional requirements determination. Once the required input (in technical and commercial terms) from other regions is provided we plan to identify the appropriate partner at the local and/or national level in order to provide the most efficient strategy for development of regional VPS general framework.

International collaboration

AlpEnergy is an **Interreg IV Alpine Space Programme** funded project. It gathers partners for different countries and fields. **Regional power suppliers and distributors**: *Allgäuer Überlandwerk GmbH* (Germany), *Elektro Gorenjska* (Slovenia), *Elektro Gorenjska, podjetje za distribucijo električne energije* (Slovenia); **Public regional policy makers and counselors**:*Provincia di Mantova*, *Regione Autonoma Valle d'Aosta, Consorzio BIM Piave di Belluno* (Italy), *Allgäu Initiative GbR* (Germany) and Rhônalpénergie-Environnement (France); **Business support centers**: Regionalna razvojna agencija Gorenjske (Slovenia), Rhônalpénergie-Environnement (France), B.A.U.M. Consult GmbH (Germany) closely cooperate with observer *SIR* (*Salzburger Institut für Raumordnung und Wohnen);* **Research partners**: *Fondazione Politecnico di Milano* (Italy), *ALaRI - Advanced Learning and Research Institute all'Università della Svizzera italiana (USI)* (Switzerland), Institut National Polytechnique de Grenoble (France)

In scope of the project ALaRI has been collaborating with all partners and especially closely with *BAUM* and *Fondazione Politecnico di Milano*. ICT structure modeling requires cooperation with experts in power systems so that *ALaRI* established fruitful collaboration with partners outside the consortium i.e. *University of Novi* Sad (Serbia). The very next step consist of collecting data from partners implementing concrete pilot implementations that are in process of realization in Belluno, Allgäue, Val D'Aosta, Gorenjska and Mantova.

The evaluation of 2009 and perspectives for 2010

The work carried out during this year has been impacted mostly buy changes introduced in planed workflow due to introduction of new partners and delay in pilot implementations. For this reason we have been forced to stall implementation of tasks dependent on other partners and to in turn invest more efforts on tasks in which our work has been mostly independent (this mostly concerns a task described in 2.2 subsection).

ALaRI has successfully answered to all requests from the leading and other partners and our work has been evaluated as very successful at all partners' meetings. In following year we plan to intensify collaboration with other partners especially those who are supposed to perform pilot implementations as their feedback is crucial for successful continuation of our work that concerns best practice transfer.

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Annexes

- Publications relevant for this project are copyrighted and moreover some of them are still under the review. For this reason public exposure of these documents is not allowed.