E-ISLAND: EXPANDABLE INTERNET SUSTAINED LOAD AND DEMAND SIDE MANAGEMENT FOR THE INTEGRATION INTO VIRTUAL POWER PLANTS

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ABSTRACT

E-island is a R&D project carried out by a public private partnership consortium. Its members are the University of Applied Sciences Hamburg (HAW, Prof. Dr.-Ing. F. Schubert), the department of economics and employment of the city of Hamburg, Steag Saar Energie (H. Armbrüster, MBA), SUmBi eng. Cons. (Dipl.-Ing. H. Schäfers) and Envidatec GmbH. The project's central aim is to create a network (internet based) of 40 public properties at low and medium voltage level equipped with load management hard- and software. The network will be the basis for the examination of two tasks:

a) Make use of load shedding in individual public properties to smooth the resulting load curve of all public properties and b) pool sheddable load from individual public properties with the aim of selling it as reserve capacity to the virtual power plant (VPP) of Steag Saar Energie AG.

We expect that the intended system structure will be able to activate 3-5 MW load capacity deriving from sheddable load of the public properties involved depending on season (weather), time of day etc. This load capacity may then be used either to secure a predicted "peak free" load profile for all the public properties of Hamburg or be sold to Steag Saar Energie AG.

INTRODUCTION

In times of global warming and rising fossil fuel prices power production from renewable energy systems (RES) and/or combined heat and power production (CHP) is favored by politically implemented regulatory frameworks of a steadily increasing number of countries.

In 2006 the contribution of RES to the overall consumption of electricity in Germany reached a new high of 11.6% or 71,5 billion kWh in total [1]. This rapidly growing amount of electric energy deriving from decentralized generation creates new challenges for the operation of the distribution grid. Load (and frequency) fluctuations may increase due to the fact that on the one hand especially wind and solar power do not answer to grid operation plans but depend on weather conditions while on the other hand CHP management is normally based on heat demand rather than the current grid situation. Therefore in recent years great research interest has focused the connection of a higher number of decentralized generation units into virtual power plants (VPP) using fast (and reliable) communication technologies (e.g. TCP/IP) to create bigger units and to submit them to management regimes that reflect the need of the (distribution or transmission) grids.

Suitable communication methods and standards for the connection of small or medium generation capacities are the main focus of most VPP research activities. In [2] Arndt et al. list ten bigger VPP research projects with German participation which have either just been completed or are still running. They also give an overview over possible benefits from as well as the fundamental problems of successfully operating a VPP. Auer et al. [3] find that there are currently two German VPP operated by utility companies: The VPP "Unna" as described by Henning in [4] being operated by the municipal utility of the city of Unna and the VPP of Steag Saar Energy AG [5]. Both follow different target objectives. The former aims at optimizing the distribution grid of the city of Unna. This is done by managing the production of electric energy of the 5 (6 planned) connected CHP sites to avoid load peaks in the local distribution grid. This operation method applies to the gas grid as well (the CHP are gas powered) which leads to a multi parameter optimization problem. The aspect of load management is currently not included in the operation of the Unna VPP (though generally possible). Load management is treated as a minor point in a lot of VPP (research) projects. The theoretical importance of the integration of load management into VPP is often mentioned in studies but rarely is it made a point in field studies or projects.

Nevertheless load management (load shedding) can be a valuable contribution for the optimization of distribution grids and already plays a major role in the more price sensitive electricity markets of the USA as is described for the City and State of New York by Neenan et al.[6] or generally by Kamphuis et al.[7].

For the VPP of Steag Saar Energie AG large scale industrial load shedding plays a major role. Steag Saar Energie AG focuses on selling reserve capacity on the liberalized German reserve capacity market. In operation since September 2003 Steag's VPP combines industrial and municipal generation reserves with large scale consumer load shedding from industrial processes. For power distributors load shedding has been an established method for some 20 years now [3]. It is (or was in some cases) used for reducing critical loads in the distribution (or transmission) system. High loads are caused by large and medium scale industries processing raw materials such as

iron ore or bauxite, or using electric power for large scale engines (pumps etc.), heating or as process energy (e.g. large scale electrolysis in chemical engineering). In 2006 Steag Saar Energie's VPP connected over 40 different generation or load management units resulting in more than 1.000 MW qualified reserve capacity. With a VPP of that size Steag Saar Energie generated a 10% market share of the German reserve capacity market "Minutenreserve". Yet Steag Saar Energy's VPP only integrates units with at least 1 MW capacity.
"E-Island" combines the intentions of both VPP portrayed: a) compensating load peaks on the distribution grid of Hamburg and b) pooling sheddable loads < 1MW of a larger number of public properties and putting them on the reserve capacity market via Steag Saar Energy's VPP.

THE PROJECT "E-ISLAND"

"E-island" (German title: "Insel") is a R&D project financed by the German ministry of education and research (BMBF). The project has started 09/2006 and runs through 09/2009. It is carried out by a public private partnership consortium led by the University of Applied Sciences Hamburg: The other members are

- the department of economics and employment of the city of Hamburg,
- Steag Saar Energie AG,
- SUmBi and ENVIDATEC, two German engineering companies.

The project is furthermore supported by REAP (*Resource Efficiency in Architecture and Planning*), a newly founded multidisciplinary research centre at Harbor City University, Hamburg and by the Technical University of Vienna.

PURPOSE

The project's central aim is to create a network (internet based) of 40 public properties equipped with load management hard- and software at low and medium voltage level. This network will be the basis for the examination of the following two research tasks:

1. Find out how and to what degree 40 independent load management systems can be synchronized with the aim to harmonize the resulting load curve rather than the individual ones of the involved properties.
2. Find out how much load can be cut off for how long with the aim of selling it as reserve capacity to the virtual power plant (VPP) of Steag Saar Energie AG.

It is expected that the 40 properties will be able to provide 3-5 MW reserve capacity depending on season, time of day etc. The resulting reserve capacity is going to be placed on the German reserve capacity auction market via the VPP of Steag Saar Energie AG.

METHODS

The reserve capacity (and load curve smoothing) potential is going to be examined by using modelling and day ahead simulation based on the realtime data of the properties involved. For this purpose a java based prognosis tool ("Profesy - PRediction of Optimized load profiles For Energy management SYstems") was designed for the project by the Institute for Computer Technology of the University of Vienna. It is now going to be extended and aligned. To obtain accurate real time meter readings and status data of the load management systems all properties involved will be equipped with Vida 84 communication modules by Nemonos using LON bus. The following figure shows the intended system structure.

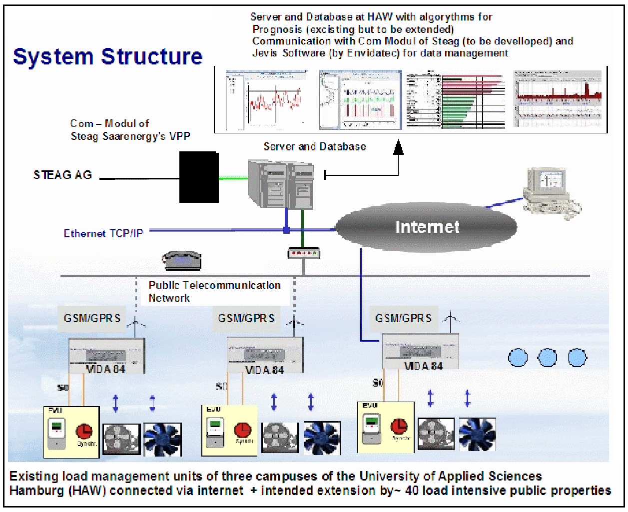

Fig. 1: Intended system structure of „E-Island".

During a first phase load profiles with a resolution of one step per minute are stored on the Vida 84 modules and transmitted to a server based database once per day. Weather data from the university's weather station and the load profiles are then used to train the prognosis tool.
The technical infrastructure (different building service technologies) of all properties involved is analysed to find and describe possible sheddable loads (ventilation, air conditioning etc.). Resulting from this we intend to build a model of the system using matlab/simulink and to simulate the system behaviour by taking into account the two aspects mentioned above.
The prognosis tool (in combination with simulation runs of the model) is going to be used to obtain an accurate forecast of the best possible load profile for the following day and provide reliable data about how much "free" load capacity can be put on the reserve capacity market via Steag Saar Energie AG's VPP during the single hours of the following day.
Access to the load management facilities of the single properties is going to be established via the implemented communication network with the aim of adjusting the

maximum load allowances of each single load management device automatically (or manually if necessary) from any integrated PC. The following figure shows a screenshot of an already programmed java applet (to be extended) displaying the individual load curves, the resulting load curve and the maximum load allowances for the load management facilities of the three campuses of the HAW.

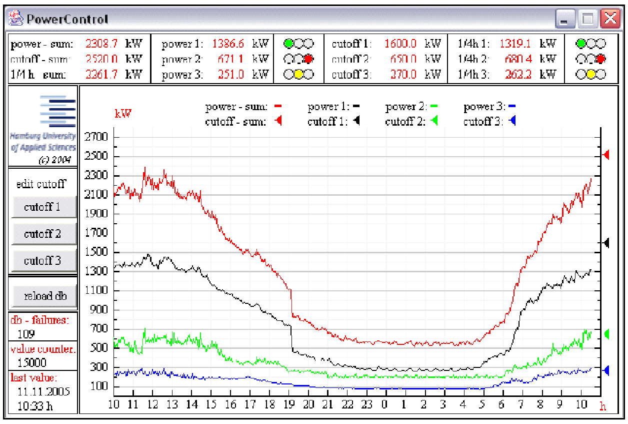

Fig. 2: Screenshot of java applet “power control”.

RESULTS AND CONCLUSIONS

On the deadline of this paper the project has only been running for four months. Nevertheless we are able to present some preliminary findings concerning the resulting load profile of the public properties involved.

The city of Hamburg is charged for the peak load of about 170 public properties. Most of these properties account for yearly load peaks of less than 400 kW. Figure 3 shows that in 2003 only 37 properties had higher peak loads.

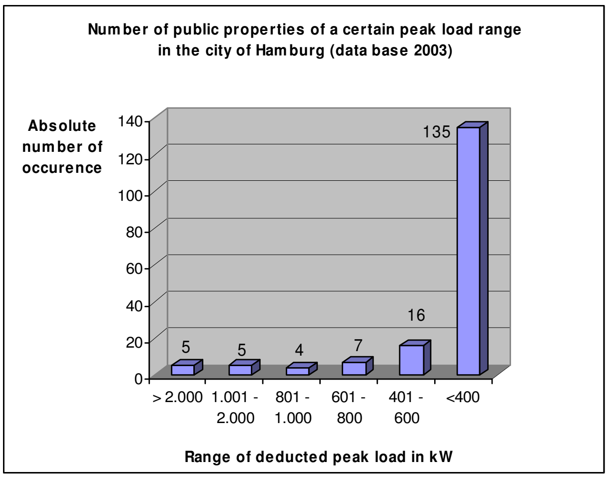

Fig.3: Total number of properties of a certain peak load range.

In 2003 a total peak load of 58.560 kW was brought to account. About 65% of this amount was caused by the 37 more load intensive properties as is shown in Figure 4. All of these properties had yearly peak loads exceeding 400 kW. Therefore all properties exceeding a yearly peak of 400 kW in the years 2003 – 2005 were selected for the project. This applies to 40 properties in total.

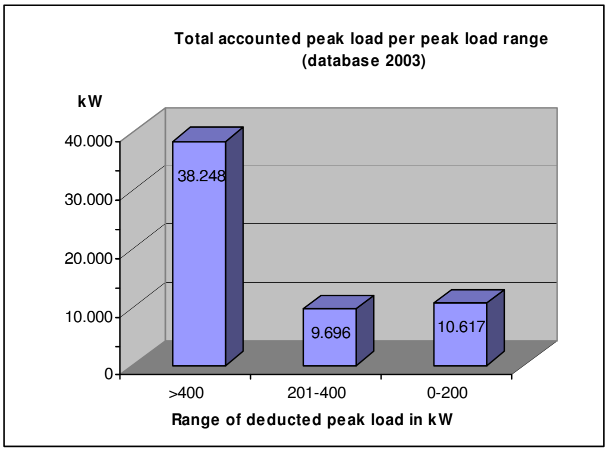

Fig.:4: Total accounted peak load per peak load range in 2003.

Further investigation of the daily load profiles of these 40 properties showed that the resulting load profile did not exceed 25.300 kW in 2005. But because the single load peak of each property is accounted for on a yearly basis, the City of Hamburg paid for more than 35.000 kW in 2005 (just for the 40 properties). This demonstrates the blending effect of a larger number of overlying load profiles. Most often charged peak loads are far from real grid strains and more of a method to charge an additional fee than to influence (let alone optimize) grid strains.

Nevertheless the obtained daily sum profiles of the investigated properties show some unexpected load peaks and are far from being a well shaped curve. Figure 5 shows the load profile for January 5, 2005 as a stacked profile of the 40 single load profiles (1step per15 minutes). The peak load nearly reaches 25.000 kW and the curve shows about 15 single peaks some of which are up to 2 MW high.

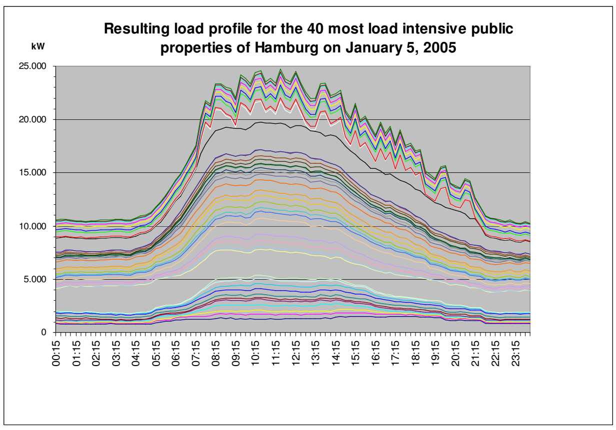

Fig. 5.: Resulting load profile for the 40 investigated public properties on January 5, 2005.

Responsible for the recurring peaks are two properties of the Port Authorities of the City of Hamburg. It is not yet evident what causes these huge load peaks. The investigation of the technical infrastructure of the properties is scheduled for February/March.

First assumptions have been made about how much sheddable load may be expected. These were based on the experience of the two participating engineering companies with the installation of load management systems in public properties. A preliminary estimation of the load management potential of all 40 properties leads us to the assumption that the remaining 38 properties should be able to erase the load fluctuations caused by the two properties of the port authorities. A probable "optimized" load profile which we are confident the system will be able to generate is displayed in figure 6. The resulting load profile shows remaining peaks which do not exceed 200-300 kW as can be seen in figure 7. The profile is bell shaped and should be well predictable. (Nota bene: This is a hypothesis not real data as displayed in figure 5!)

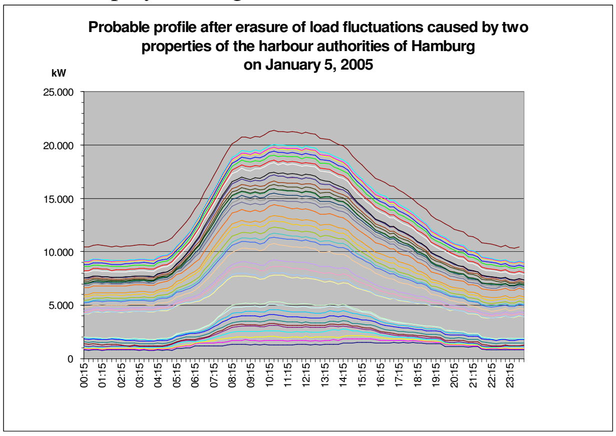

Fig.6: Probable load profile for January 5, 2005 after erasure of load fluctuations via load management (hypothetical data).

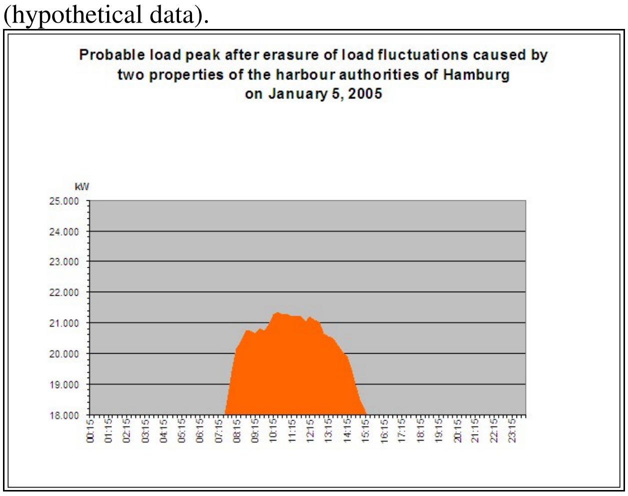

Figure7.: Probable load peak after assumed erasure of load fluctuation via load management of remaining properties.

The Figures show that the load management capacities of the 40 investigated properties may well be able to make a significant difference in the load peaks of the resulting load profile.

Further investigations of the technical infrastructure will follow to be able to simulate the real load management potential more accurately.

For the conference in Vienna we might be able to present these findings as well as first assumptions on the modeling of the obtainable capacity reserves. And although we will not yet be able to show figures about marketed amounts of reserve capacity, we will be able to give an overview of the expected marketing procedure and the financial potential this project might have for the city of Hamburg as well as for other cities and for its application on the distribution of energy in general.

REFERENCES

[1] J. Lackmann, 2007, "Erneuerbare Energien brechen erneut Rekorde", German Federal Association of RES (Bundesverband Eneuerbare Energien), press release, January 04 2007.

[2] U. Arndt, S. von Roon, U. Wagner, 2006, "Virtuelle Kraftwerke: Theorie oder Realität?", BWK, Vol. 58 Nr. 6. 52-58.

[3] H. Auer et al., "Faire Wettbewerbsbedingungen für virtuelle Kraftwerke", 2006, Berichte aus Energie- und Umweltforschung, 45/2006, published by the Ministry of Transport, Innovation and Technology, Vienna, Austria.

[4] E. Henning, 2005, "Virtuelle Kraftwerke nicht nur für Energieversorger interessant", EW, Jg 104 (2005), Nr. 13, 38-40.

[5] J. Strese, 2003, "Das virtuelle Regelkraftwerk", EMW, Heft 6/03.

[6] B. Neenan et al., 2003, "How and why costumers respond to electricity price variability", Neenan Associates, Lawrence Berkeley National Laboratory, Pacific Nothwest National Laboratory

[7] R. Kamphius et al., 2004 "Market-oriented online suply demand matching", CRISP – Distributed intelligence in critical infrastructures for sustainable power.