IMPACTS OF SMART GRIDS ON ELECTRICITY RETAIL BUSINESS

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ABSTRACT

Smart grids will change the operational environment of the electricity markets revolutionary. These changes will have significant effect on electricity market players and the whole electricity retail business. These impacts are discussed in this paper. In the first part of this paper is introduced how the technology based on Advanced Metering Infrastructure (AMI) can be used to provide new ancillary services, which benefits the electricity retailers and the DSO's. Also the business potential of considered example service is introduced. At the second part of the paper, the further development of smart grids and its impacts on the electricity retail business in the future is considered.

INTRODUCTION

The development of the smart metering and smart grids has a growing effect on electricity network and retail business. In many European countries remotely readable energy meters, which base on AMR-technology (Automatic Meter Reading), will be installed in the near future, or have already been installed. For instance in Finland, remotely readable AMR-meters have to be installed before the beginning of year 2014 according to *Government Decree on settlement and measurement of electricity transactions* [1].

The main use of AMR-meters has been to gather up electricity consumption data in need of invoicing. Besides this, AMR-meters and AMI enable many functionalities and characteristics that can be exploited in developing new ancillary services, which improve efficient use of electricity and produce added-value to service user and the provider.

Smart metering and development of network infrastructures are changing traditional passive distribution networks towards active networks. This makes possible the development of whole new interactive customer gateway, which enables more adaptable use of customers' loads, energy storages and distributed generation. Important part of this interactive customer gateway is two way data transfer connections. These make possible real time data transfer between different electricity market players, and control of electricity end users' (customers) energy resources based on external control signals. The development of interactive customer gateway increases customers' role at the power markets and opens new opportunities for different electricity market players. For example, the electricity retailers' could manage their electricity production/procurements and consumption/sales more adaptable and introduce new more cost correlating pricing structures. Also the customers could benefit from new pricing structures and improved energy efficiency. In addition, the DSOs can get new incomes by providing the metering infrastructure, which can be used as a service platform. In the figure 1, is presented the concept of interactive customer gateway [2].

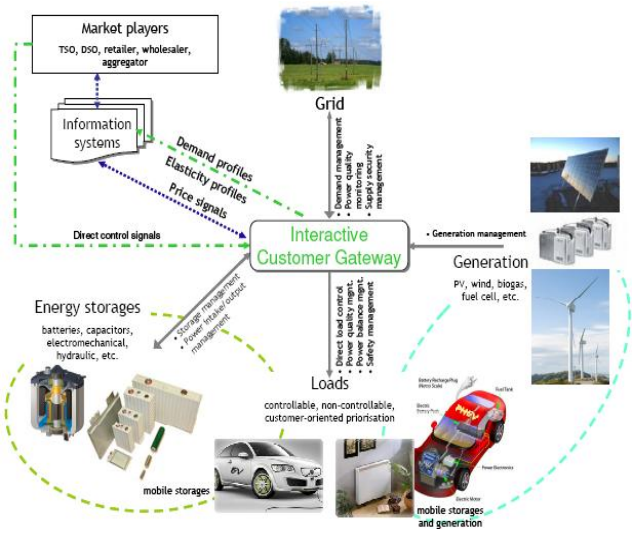

Figure 1. The concept of interactive customer gateway. [2]

In this paper is introduced the impacts of the development of smart grids on electricity retail business. Chapter 2 presents how AMR and AMI can be utilized in the near future in electricity retail business. Chapter 3 introduces some impacts of the further development of smart grids. Finally, conclusions are made in Chapter 4.

UTILIZATION OF SMART METERING

Thanks to smart metering, data from customers' electricity consumption and power quality can be retrieved more cost efficiently in the future. The possibility to get measurement data, and send, receive and execute load control commands by utilizing existing metering infrastructure, provides good opportunity to develop new ancillary services which benefits different electricity market players.

The measurement data from the remotely readable energy meters can be utilized in many ways in the electricity retail

business. The problem has been in many cases, that only the DSO, who is responsible from the metering, has been able to utilize this data easily and cost efficiently. In the future, there will be growing need to solve this problem. At the moment, in many countries different parties are questing solutions for this problem. For example in Finland, the utilization of the measurement data will be expedited by law. *The act on energy efficiency services for companies operating in the energy market* [3] provides that the local DSO's have to give electricity retailer, who sells the electricity to customers, the needed information for customers energy consumption reporting without any payments. This customers' energy consumption reporting is obligated for electricity retailers, and it have to be done at least once in a year. The aim of this customer reporting is to help customers improve efficient use of energy, but this law will also contribute mobility and availability of the measurement data, and ease the utilization of the measurement data in new ancillary services.

Utilization of measurement data

Near future aim in many countries is that the measurement data, provided by new metering infrastructures, will be more easily available for different electricity market parties. This improves the possibilities to develop for instance load modelling and energy consumption forecasting methods, and ancillary services based on these.

Historical measurement data, which consist of the measured customers' energy consumption for at least one year period, can be used to develop state estimation, load modelling and energy consumption forecasting based on customers load profiles. In [4] is presented a method where AMR meters are used to enhance DSE (distribution state-estimation). In [5] is studied utilization of AMR-meters in improving accuracy of load modelling. First, in this method, customers are re-grouped more precisely according to their electricity consumption. Secondly, the load models are updated. For the most important customers can be generated individual load models, if necessary. The load models are updated according to continuously cumulating consumption data, which improves the forecasting accuracy. By adding the temperature correction and appropriate week-day and seasonal grouping, the load models can be generated even more adjustable and accurate.

Studies [6] and [7] present the methods for the utilization of real time measurement data in improving short-term load forecasting (STLF) accuracy. These studies presents, that the energy consumption measurement data, which AMR meters can provide, can significantly improve the load modelling and load forecasting accuracy. This provides good opportunities to develop new ancillary services, which can for example help electricity retailer to manage its electricity procurements more accurately. One method for this is presented in [8] and [9]. The main idea of this AMR-based load forecasting is that real-time consumption data, which can be retrieved from AMR-meters whenever it is needed, can be used to update electricity consumption forecasts near the usage hour. According to this new more accurate consumption forecast electricity retailer can then manage its' electricity procurements near the usage hour. This can be done for instance at the after-spot markets, or by using retailer's own controllable production or loads. As a result of this, the need for buy typically more expensive electricity at the regulating power markets decreases.

In the figure 2 is presented a flow chart, which demonstrates how AMR and AMI, and the measurement data which they provide, can be utilized in managing electricity retailers' electricity procurements in the future.

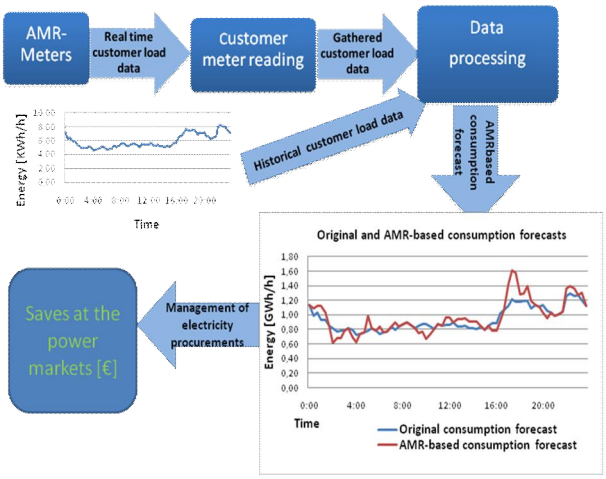

Figure 2. Utilization of energy consumption data in the management of electricity retailers' electricity procurements

Profitability of considered ancillary services

Case-example calculations, presented in [8], shows that AMR-based load forecasting can offer significant saving potential during the regulating power price peak. Calculations are done by using real electricity prices at the time of regulating power price peak 5 Jan 2009. The considered electricity retailer have 80 000 customers and the total sales of electricity are 200 MWh/h. During the three hours, when the regulating power price rice at the highest over 1000 €/MWh, it would have been possible for this electricity retailer to achieve over 9000 € saves by using AMR-based load forecasting.

In the [9] is presented extended consideration of the business potential of AMR-based load forecasting. In these calculations is used real electricity spot- and regulating power prices during the year 2009. Under the examination is the same electricity retailer than in previous calculations in [8]. This examination reveals, that the AMR-based load forecasting would have been able to provide total saving potential of 56 000 € during the year 2009 for this one electricity retailer. This corresponds approximately one percent from annual operational profits of the retailer.

Based on the studies [8] and [9], it can be concluded, that in the near future new AMR-based ancillary services can provide additional benefits in electricity retail business. Still, it has to be remembered, that these studies base on case examinations, which include some assumptions that affect significantly on the final results. Especially the improvement of the forecasting accuracy and the cost of data transfer have significant effect on the final results. Consequently, for example the development of data transfer technologies, and lowered data transfer costs resultant of that, can improve the profitability of the ancillary service.

DEVELOPMENT OF SMART GRIDS – NEW CHALLANGES

Traditional passive distribution networks are changing towards active distribution networks, where distributed generation (DG), load controls and energy storages can be used in active control of the network. This will increase the amount of dynamic phenomena's in the networks, and set new challenges for DSO's and electricity retailers in network monitoring, load modeling, consumption forecasting and electricity procurement management.

Increase of dynamic phenomena's set electricity retailer's challenges especially in the estimation of electricity consumption. Increased amount of load controls and small-scale DG is one reason for this. Another important reason is, that customers own independent actions and those effects on consumption are hard to predict. In the future, for example forecasting of customer EV (Electrical Vehicle) charges is a challenging task. Unpredictability of customers' loads and control actions in micro-level makes customers' electricity consumption forecasting difficult. These increase retailers' risk of balance error, which is result from the difference between electricity procurements and sales. Retailers' are exposed also other risks, such as procurement cost risk that consists as a result of electricity procurements at the wholesale markets and reselling at fixed rates at the retail markets, and electricity price risk that is result from the variation of electricity spot- and regulating power prices. In the smart grid environment these, and also other possible new risks, for example related to conflicts between the retailer's and the DSO's interests in utilization of DR [10], have to be eliminated as effectively as possible. Therefore, new more accurate and comprehensive optimization methods are needed.

The development of smart grids forms new risks for retailers. On the other hand, the smart grid environment provides also new opportunities to manage these risks and develop retail business more profitable. For example, the increased amount of distributed energy resources (DER) can provide retailer new possibilities to decrease its geographical (price area) risk, which is result from the limitations of transmission capacity. Also the increased amount of measurement data available from different parts of networks opens many possibilities to develop new methods and applications. Possibility to get accurate and real-time data can be utilized for instance in developing customers load forecasting more accurate. This creates also base for the development of more sophisticated electricity procurements optimization methods. In the figure 3 is presented one model for electricity retailer's electricity procurement optimization in the smart grid environment.

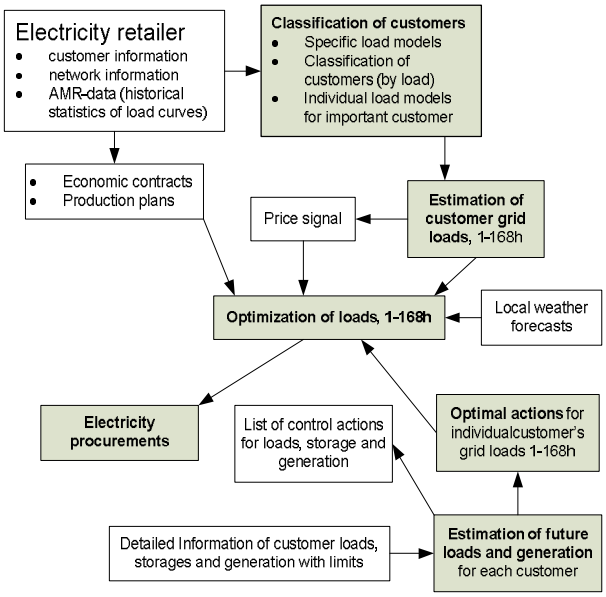

Figure 3. Optimization of electricity retailers' electricity procurements in the smart grid environment.

In the figure 3 optimization, the possibilities to send and receive external signals, and retrieve real time data from loads and production are utilized. Based on these, loads, production and energy storages are controlled according to best available information and forecasts so, that retailer's electricity procurement costs will be minimized.

Impacts on retail business and electricity markets

In the near future, the profitability of electricity retail business can be improved by utilizing new ancillary services, which base on the utilization of AMR- and AMI-systems. However, the further development of the smart grids and interactive customer gateway will have even greater impacts on electricity markets and retail business. Especially the development of real-time and low cost data transfer together with the sophisticated automation and control applications will have great impacts.

The utilization of load controls and automation systems combined with new pricing methods provides great possibilities to promote demand side management (DSM) and improve DR. This with the generalization of DER can improve electricity price elasticity and decrease electricity price peaks and their effects, which have it own impacts on electricity market players and their business. For example, the

retailer's balance risk can increase, if the retailer cannot forecast other market players control actions enough accurately. On the other hand, in a longer term, the development of control applications and interactive customer gateway (picture 1) can improve retailers' possibilities to manage its procurement's more efficiently at the markets. This with the decrease of electricity price peaks can improve the profitability of retailer's business.

Possibilities to utilize controllable loads, energy storages and generation will have significant impacts on many market players and their business. For instance, the DSOs can get extra incomes by providing service platform based on its existing metering infrastructure, for the utilization of these controllable energy resources. Also other market players can get additional benefits by utilizing this service platform and new ancillary services.

The increase of DR and price elasticity lowers electricity price peaks but has also other impacts on the power markets. These impacts can change the significance of the regulating power markets. The increase of controllable loads and energy storages can lead to situation where energy reserves are mainly in the loads instead of generation. If the amount of controllable energy resources in the distribution networks will rice high enough, and those can be controlled fast enough, this can decrease the need for regulating power generation capacity. This would change the whole nature of the regulating power markets and inquire modification of the trading methods on these markets.

The development of smart grids and it impacts will effect significantly on the market players business. In a retailer's point of view, the three main impacts of the development of smart grids in a chronological order are;

- Generalization of AMR and AMI increases the amount of available measurement data, which can be utilized in new functions and ancillary services.
- Increasing amount of DSM and DR may decrease the predictability of the customers' loads, and thus increase retailers' risks at the markets
- Development of sophisticated control applications makes possible more advanced control of customer loads, which provides excellent possibilities to improve optimization of electricity procurements and improve the profitability of retail business.

CONCLUSIONS

The development of smart grids will have significant impacts on electricity retail business. Both, the impacts on the market models and on the markets players have to be analyzed. Possible new risks and opportunities are important to analyze beforehand, so that the market players have enough time to prepare on these. As conclusions, in the near future AMR- and AMI-systems can be utilized in new ancillary services which can provide additional benefits for different market players. In a long term, the development of the smart grids can improve DR and promote price elasticity by decreasing electricity price peaks and their effects. Also the market structures have to adjust on the changes of operational environment. Still, more analyses are needed to estimate the impacts of the development of smart grids, which will be presented in the future research.

REFERENCES

[1] *Valtioneuvoston asetus sähköntoimitusten selvityksestä ja mittauksesta 66/2009* [Government Decree on settlement and measurement of electricity transactions], given on 5 February 2009.

[2] T. Kaipia, J. Partanen, P. Järventausta, 2010, "Concept of Interactive Customer Gateway", *Research report of INCA project*

[3] *Laki energiamarkkinoilla toimivien yritysten energiatehokkuuspalveluista 1211/2009* [The act on energy efficiency services for companies operating in the energy markets], given on 22 December 2009.

[4] A. Mutanen, S. Repo, P. Järventausta, 2008, "AMR in distribution state estimation", *Nordic distribution and asset management conference*, Bergen, Norway

[5] A. Mutanen, 2010, "Customer Classification and Load Profiling Based on AMR Measurements", *Project report of INCA Project*

[6] W. Charytoniuk, M.-S. Chen, 2000, "Very short Term Load Forecasting Using Artificial Neural Networks," *IEEE transactions on Power Systems*, Vol. 15, No.1, pp. 363–268

[7] R.E.Abdel-Aal, 2004, "Short Term Hourly Load Forecasting using Abductive Networks," *IEEE Transactions on Power Systems*, Vol. 19, No.1, pp. 164–173

[8] P.Valtonen, S. Honkapuro, J.Partanen 2010, "Improving Short-Term Load Forecasting Accuracy by Utilizing Smart Metering", *Cired Conference*, Lyon, France

[9] P.Valtonen, S. Honkapuro, J.Partanen 2010, "AMR-based ancillary services – New business opportunities for electricity retailers", *Nordic distribution and asset management conferenc*e, Aalborg, Denmark

[10] N.Belonogova, T.Kaipia, J.Lassila, J.Partanen, 2011, "Demand Response – Conflict between Distribution System operator and Retailer", Accepted to be presented in Cired, Frankfurt, Denmark