# D4.5.2.2

# Description of Demand Response action results in different market situations

## Version 1.0



| | |
|---|---|
| Created: | 2014-3-6 |
| By: | Joni Aalto, Empower IM Oy<br>Jan Segerstam, Empower IM Oy<br>Pekka A.Pietilä, Empower IM Oy<br>Mikko Gröhn, Empower IM Oy |

## Table of Contents

# 1. Preface

This report is a part of the results from the fourth funding period of the Finnish national research project ”Smart Grids and Energy Markets”. The project has been funded by Tekes – the Finnish Funding Agency for Technology and Innovation. This report is based on the development work of Empower IM Oy in close co-operation with Oulu Energy. This report is related to SGEM’s Demand Response theme, while being also part of the results of the work package 4 “Active Customer, Customer Interface and ICT”.

The previous deliverable report “Demand Response Event Flow in a distributed market environment” outlined couple of example event flows, which illustrated the transaction flows required to achieve a change in the electricity demand side, once the need for demand response is determined by the electricity supplier or the end customer. This report will concentrate on the electricity supplier’s business processes in different electricity market places, while especially focusing on the time windows in which the certain market operations need to be executed. This way it is possible to estimate the requirements for the latency of demand response execution. Furthermore, the established latency requirements will be considered in terms of the capabilities of HEMS and AMR technologies, thus enabling to evaluate the usability of these technologies in executing demand response actions in different market situations.

## 2. Introduction

The goal of electricity supply business is to produce a defined profit level for the electricity which is sold to the end customers. This requires careful and continuous estimation of the volume of electricity supply and the estimated incomes for the sales as well as effective utilization of different electricity market places in order to acquire the required electricity with the lowest possible total costs. The cost of electricity for the electricity supplier varies in terms of time, which means that sometimes it would be beneficial if part of the electricity supply volume would be shifted to a later or earlier time.

The possibility to adjust the volume of electricity demand could be utilized at many stages of overall electricity procurement process, starting from the long-term procurement planning and ending to balance management closer to the delivery hours. The opportunities and needs for demand response emerge differently at different stages of overall electricity procurement process, while the features of the different electricity wholesale market products have an effect on this issue. Furthermore, the rules of different market places affect the time windows in which the demand response effect is needed to be achieved once an opportunity for demand response utilization is identified.

In order to utilize demand response in controlled way, the electricity supplier needs to have IT-system environment which allows it to monitor the electricity procurement process with sufficient accuracy so that the need for demand response can be determined and communicated onwards to the systems which eventually implement the actual load control operations in the end customer premises. Naturally, long-term procurement planning and hedging level adjustment set lower requirements for the latency of demand response action than actions which are done closer to the actual delivery hour. Therefore, it is possible that certain load control technologies are not suitable to be used with every market situation due to latency requirements which cannot be fulfilled.

Currently, the most potential technologies for load control operations are DSOs' AMR infrastructures and separate HEMS solutions which could be owned by e.g. electricity suppliers, end customers or service providers. The basic idea is that if the AMR infrastructures are utilized, the DSOs would receive the load control requests and implement them with AMR after possible review of the requests. In Finland the first HEMS systems offered by energy companies are emerging and this kind of systems can be estimated to become more common during the coming years. These kinds of additional products can provide a competitive advantage for the electricity suppliers in the future, once it can be expected that common Nordic retail market will increase the competition among the electricity suppliers.

The chapter 3 will discuss the electricity suppliers operations in the different phases of the overall electricity procurement process and in the different market places. The focus will be on understanding the process of forming the need for demand response in each case and the requirement for the time in which the demand response action should be carried out once the need has emerged. The chapter 4 is based on the discussion in the chapter 3, as it evaluates the usability of AMR and HEMS technologies to execute the required demand response actions which can emerge during the different phases of the electricity procurement process.

## 3. Formation of input data for demand response execution

This chapter introduces electricity supplier's long-term and short-term operations related to electricity procurement. The goal of the whole process is to cover the electricity supplier's estimated sales with the corresponding amount of procurement or own production with the optimal costs. Long-term procurement planning aims to secure a price level for a pre-defined share of total electricity procurement volume by making bilateral contracts with the electricity producers or by using the derivative products when the physical electricity trade still happens in the market place, while the difference between the realized market price and the price of the derivative product is monetarily settled between the seller and the buyer of the derivative product. Day-ahead trade happens before the day of delivery and it enables the electricity supplier to buy electricity to match the estimated hourly need for the coming day. Balance management starts after the day-ahead trade and it aims to keep the suppliers electricity balance at a planned level.

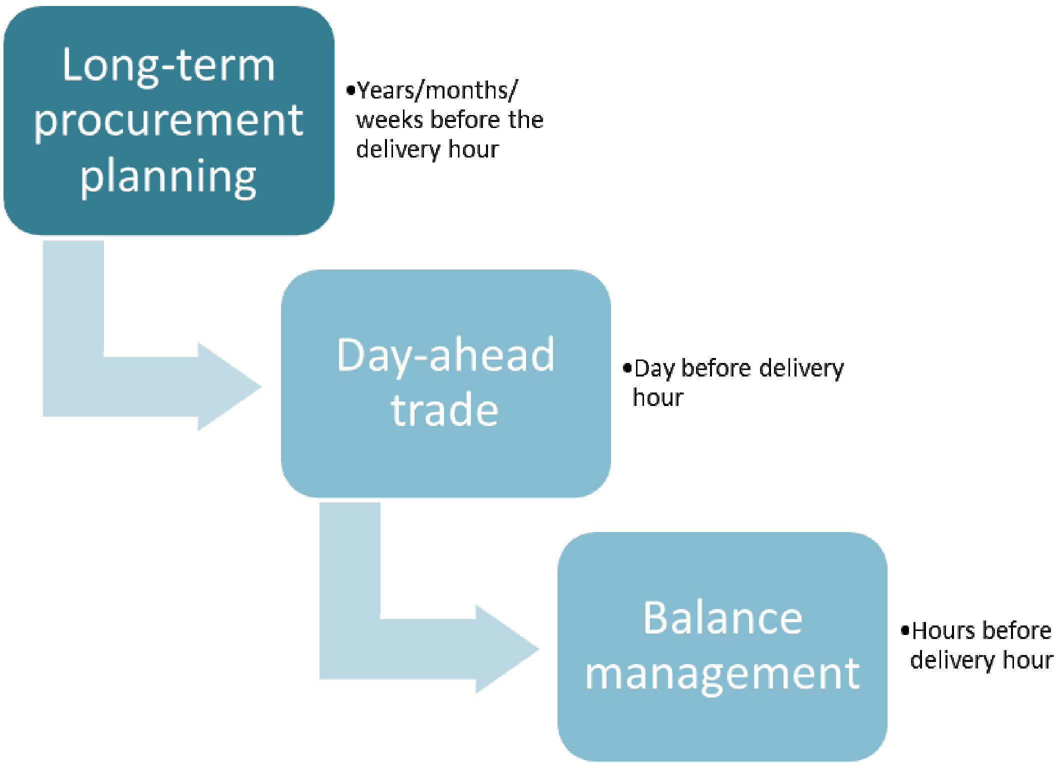


***Figure 1.*** *Electricity supplier's electricity procurement process*

Once the balance management ends, the balance settlement is made and the possible differences between the realized and planned electricity deliveries and procurement are covered with the imbalance power trade between the party in question and the balance responsible party or the TSO. Each of these phases produce information about how the demand side responsiveness could optimize the procurement costs. Additionally, each of these phases set requirements for the time window in which the demand response need should be communicated to the consumption places. When discussing about this subject, it must be noted that in the current electricity market model the possibilities to utilize demand response greatly vary between the electricity suppliers depending on the agreements related to balance responsibility and for example on which market places the supplier is active.

## 3.1. Long-term electricity procurement planning

This operation aims to reduce the risks related to electricity procurement, as a price of electricity can be secured for a certain amount of electricity procurement. Practically this phase includes the determining of hedging levels for the procurement portfolios and planning of the purchase of corresponding derivative products (year products, month products, week products etc.) as well as making bilateral contracts with the electricity producers. Also the usage of possible own production plants is planned. This way the so called open position of the electricity procurement is decreased. As an example the electricity supplier can have defined that 80 % of estimated electricity procurement is hedged for the next half a year, 60 % for the following six months and 40 % for the six months after that. This way also the predictability of the electricity supply business is increased. Practically this process enables to secure a price of electricity procurement for the volumes which match the weekly and daily average consumption rates.

Theoretically, there are two main options to how the electricity supplier could utilize demand response in long-term procurement planning. Firstly, if the demand response capacity could be used to adjust the week and day level average consumption powers, or even longer periods, this opportunity could be used when designing the hedging levels for the electricity procurement. This means that potentially a greater share of procurement could be hedged with e.g. a derivative product. Secondly, the possibility to effect the fluctuation of the consumption could enable to enlarge the open position of the electricity procurement, thus leaving a larger share of electricity to be acquired e.g. from the day-ahead market place, with the realizing day-ahead prices. In certain market situations this could enable additional profits. Naturally there are many factors which affect this kind of optimization process such as the volume of controllable loads, type of the controllable loads, fluctuation of electricity market prices and fluctuation of electricity supplier's sales curve.


***Figure 2.*** *Part of the product structure of NASDAQ OMX DS Future-products. [1]*

The derivative products cover a long period of time and the trading time horizon is up to six years [1]. Long-term contracts are yearly products and the short-term products are week or day products. Longer products are divided into shorter products when the due date of the product approaches. In other words, e.g. year products are divided into the quarter products, which are eventually divided into the month products and so on. Trading is continuous in the NASDAQ OMX Commodities market place during the hours of operation.

In terms of this short evaluation, the long-term electricity procurement planning process produces following input for demand response utilization. The decisions and actions of this phase are made relatively long time before the actual delivery. Therefore also the decisions related to the demand response capacity allocations and utilization are also made with similar time span and the information of the need for demand response from this point of view is clear. The goal is to adjust the consumption fluctuation to correspond the optimized hedging strategy. On the other hand, if the demand response capacity is used to enable greater open positions, the need for demand response utilization will emerge during the trading processes in the day-ahead and intraday market places.

## 3.2. Day-ahead trade

The next step in the electricity supplier’s electricity procurement process is the day-ahead trade. In the Nordic power market this market place is called the Nord Pool Spot. The electricity buyers and sellers place buy and sell bids to the market place and as an outcome the hourly market prices for electricity are formed for the following day. These prices indicate the marginal production costs for the production capacity which is needed to cover the estimated electricity consumption. Currently, majority of buy bids are not flexible, which means that the buyer is ready to buy the required amount of electricity regardless of the price. This is not an optimal situation, as it is profitable mainly for the producers. Generally, there is a need for more flexible offers, in which the volume of procurement would be lower if the prices are at high level. To sum up, the demand response should be included already to the price formation process of the day-ahead market place. In order to increase flexibility, the market participants are enabled to place so called flexible hourly bid, which means that energy consumers can decrease their consumption during a single hour with the highest realizing market price. [2]

At this phase the electricity supplier utilizes forecasts about the estimated electricity supply as well as production forecasts. The fixed deliveries which have been agreed in OTC-market have an effect to the volume of day-ahead trade need. From demand response capacity utilization point of view, the market price forecast is a valuable source of information. Naturally the consumption is desired to be allocated to the hours with the lowest predicted market price. At this phase the electricity supplier forms the day-ahead trading bid, which includes the optimized demand response capacity allocation based on the latest forecasts. Nevertheless, it must be noted that at this point it is too early to lock the demand response capacity allocation plan. This can be done only after the publication of the market prices and the accepted day-ahead bids. At this phase the electricity supplier’s balance position is formed and the balance management begins, which aims to secure the planned day-ahead balance position. In the Nordic power market, each of the participants are under balance responsibility which obligate the parties to retain their planned balance position as efficiently as possible. Typically the market prices for the following day are published in the Nordic power market around 12:30 CET. More information related to day-ahead trading and the day-ahead order types in Nord Pool can be found from Nord Pool Spot web-sites [3][4].


***Figure 3.*** *Demand response capacity allocation as part of the day-ahead trade.*

Balance management begins once the day-ahead trade is completed. The results of the day-ahead trade form the basis for the balance management as the electricity balance for the electricity supplier is formed. The balance responsibility requires that the market participant actively take actions in order to minimize the difference between the planned and realized purchases and deliveries. Therefore, for example intentional use of imbalance power is not allowed.

## 3.3. Balance management

The day-ahead trading is based on the forecasts which are made one day prior to the actual day of delivery. Therefore, it is not possible to accurately cover the actual realizing electricity deliveries, as there can be changes in many of the affecting parameters such as consumption and production forecasts, due to changes in weather forecasts and for example changes in production unit usability. On the below, the figure 4 illustrates the balance management process in simplified fashion.

It is common that the electricity supplier defines operating limits for balance management. This means, that once the estimated imbalance of the certain hour exceeds the limit, some correcting actions are made. The availability and the types of measurements form the production plants and from the consumption points define how often the estimated imbalances can be updated for the coming hours. One possibility is to control the volume of own production or affect consumption with a demand response action. The adjustment of own production can affect only the production balance. Additional alternative is to trade in the Nord Pool's intraday-market place called Elbas. In the Elbas market place it is possible to place bids for the electricity delivery of the hours which already have a published day-ahead market price. Trading is continuous and the bids can be placed one hour prior to the delivery hour at latest and the minimum order volume is 0.1 MWh. More information about Elbas market place can be found from Nord Pool's web-site [5].

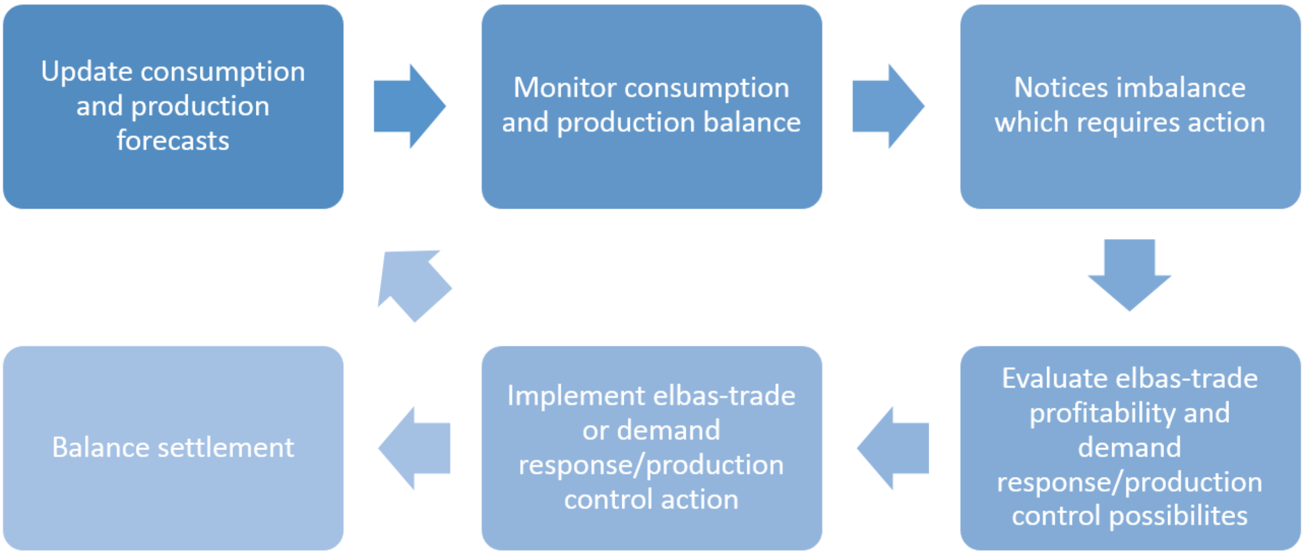


***Figure 4.*** *Electricity supplier's balance management process*

Balance management is a continuous process and it ends only after the deliver hour. It can be for example possible that elbas trade is first utilized to correct the electricity balance and additional imbalance adjustment is done inside the delivery hour with e.g. demand response actions. The figure 5 illustrates an example situation in the electricity supplier's consumption balance for the coming five hours. In the hour 1 there is a risk that the electricity supplier's negative imbalance requires imbalance power purchase from the balance responsible party, which can increase the total cost for the procurement. Now, during the hours 2-5 the situation is converse as there is an estimated positive imbalance situation. Situations like in the figure 5 could be partially corrected with a demand response action. Some of the consumption from the hour 1 could be shifted to the hours 2-5, while the overall estimated imbalance volume during the hours 1-5 would decrease closer to zero. Balance settlement is made after the delivery hours, when the actual realized electricity trades between the market parties are settled and the imbalances are settled between the market participants and the balance responsible parties.

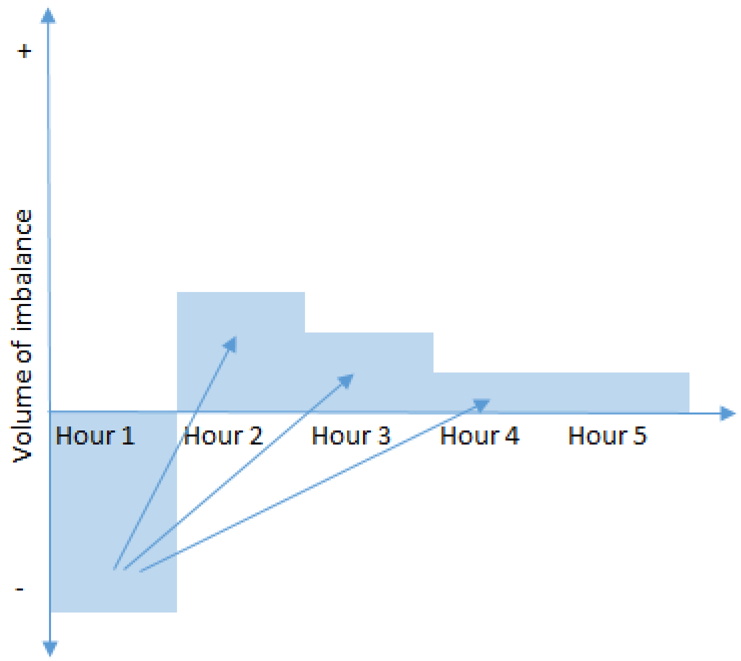


***Figure 5.*** *Example situation in the electricity supplier's consumption balance.*

When compared to the long-term procurement planning and day-ahead trading, the balance management has increased requirements for the systems which are used for demand response execution and for the information exchange related to these actions. The Elbas trade requires that the demand response actions can be executed 1-12 hours after an accepted bid. The reguirements from the balance management point of view are even more strict as it would be beneficial if the consumption could be affected even inside the delivery hour as it would enable to make adjustmentst based on the latest possible forecasts. If the demand response action plans are delivered too early before the delivery hour, there is a risk that additional actions are required to be made closer to the delivery hour. This can increase monetary costs of demand response utilization, depending on the cost structure of the demand response execution.

# 4. Usability of HEMS and AMR technologies in different market situations

The input information for the demand response execution from the processes which were described in the chapter 3 are basically measurable in megawatt hours. Still the information exchange related to the demand response requires that this need is converted in to measurement point or measurement point group specific information about which of the consumption units in the electricity suppliers electricity balance are required to be affected in order to achieve desired outcome from demand response execution. In any case, the demand response need which is measured in megawatt hours needs to be converted to control commands to single load control units in the consumption points eventually. The demand response information exchange message structures are currently developed in SGEM Task 4.5.3. The message structure is being built for information exchange between the electricity suppliers and supplier’s own load control equipment (e.g. HEMS) or DSOs which offer controllability with AMR infrastructure.

In this chapter the usability of different load control technologies are discussed. The main focus will be on the estimated latency of DR execution. This is evaluated based on the discussed requirements from the electricity supplier’s electricity procurement process point of view, which was discussed in the chapter 3.

The AMR infrastructure will have at least some role in the overall market wide demand response operation as it provides the official consumption rates for the billing purposes. Still, the great amount of money invested to the infrastructure supports the additional utilization of the AMR infrastructures and two-way communication channels to the private customer level consumption places. Though, the AMR infrastructures are mainly designed to be able to acquire required measurement data over a certain measurement collection time span, typically hours. This enables to optimize the traffic in the DSO’s communication network, as all the meters are not necessarily required to be reached at the same time. From this point of view, the AMR infrastructure typically support demand response actions in which there is enough time to deliver the load control commands to the metering devices to be ready once the actual hour of demand response actions arrives. More instant demand response actions would require delivering a large amount of load control messages instantaneously to the metering devices. Naturally technology develops fast, but this is a situation for the near future. Also, the future decisions related to the development of electricity market information exchange practices will have an impact on the implementation of market wide demand response actions. This include decisions related e.g. to the possible data hub type centralized information exchange.

The electricity supplier’s own load control equipment (e.g. HEMS) which could be integrated to the electricity suppliers systems in a more straight forward fashion could be an option, if coupled with advanced communication technologies which can provide fast connectivity and wide bandwidths for communication with the demand response units.

## 4.1. Long-term electricity procurement planning

As discussed in the chapter 3, the long term planning of electricity procurement is made over a long time span. The needs are to be able to affect the average consumption rates on week and day level. From this perspective, it can be estimated that both, AMR infrastructures and future HEMS infrastructures, would be sufficient and capable of being used in this process.

One possible utilization method for HEMS infrastructures would be that a set of initial data would be delivered to the HEMS devices. This initial data would set the limits for the HEMS device in which the adjustment of average energy usage would be made over a pre-defined time period. The initial data would include the information which is formed during the long-term procurement planning.

The AMR infrastructures could be utilized in quite similar fashion, while it must be noticed that probably in this case the smartness of the system is needed in the upper level systems. The electricity supplier's long-term procurement planning could produce a view of how the consumption points should averagely behave over a longer time periods to support e.g. the hedging process. A load control calendar could be defined and delivered to the AMR meters. This calendar would be executed over the pre-defined time period to produce a desired effect on the consumption in the electricity supplier's electricity balance.

## 4.2. Day-ahead trade

Based on the chapter's 3 discussion, the day-ahead trading market forms a need to be able to execute demand response actions approximately with a latency of 12-36 hours. The utilization plan for the demand response can be formed during the day-ahead bid planning process, but the final timely need for the demand response for the following day can be formed once the day-ahead prices and realized bids are published. Therefore both, AMR and HEMS could be used in this process. The AMR based functionalities are already being piloted by some of the DSO's and the results have been encouraging. In these cases the functionalities have been based on the update process of the load control calendar for the next day. Also, the first HEMS systems which currently utilize realized spot prices are emerging in the Nordic power market. Furthermore, as the decisions of how demand response will be used is done multiple hours prior to the delivery hours it gives time to react if the systems are not operating correctly. This kind of situation could emerge if the load control infrastructure is not reached due to e.g. technical difficulties. Thus, corrective actions can be made e.g. in the intraday market place.

## 4.3. Balance management

Intraday balance management further increases the requirements for the latency of demand response execution. In this case the actions should be possible to be implemented in hours, most preferably in such a short time that the actions would be possible to be made even inside the delivery hour. This would greatly challenge the capabilities of AMR infrastructures, especially if there is some additional monitoring activities of the DSOs which are involved. Intraday operation could require that the electricity suppliers are straightly connected to the AMR meters, which is highly unlike based on the current knowledge and regulation. Close to real-time operation set requirements, which most likely require some sort of home automation systems and fast communication channels to the devices.

When operating close to the delivery hours, there is less time to react if something is not working as planned. For example if the electricity supplier decides not to correct estimated imbalance with elbas trade, but with the demand response action. Now, if the demand response units cannot be reached as planned, there is not necessarily time to correct the situation with the elbas trade. On the other hand, if the demand response is used to place sell bids to the Elbas market place and the bid goes through, there is always a risk that demand response units are not reachable, while the situation could lead to greater imbalance, which needs to be corrected with imbalance power, thus increasing the overall electricity procurement costs.

# 5. Summary

In the current electricity market, the electricity suppliers have different strategies and possibilities to utilize the different available market places for the electricity procurement. Also the available input information varies as well as the requirements from the balance responsibility, which could have been implemented in different ways. In the future, the situation will most likely remain similar and the market environment will have new features as the distributed resources increase and the smart devices become more common. This will also increase the complexity of the electricity market environment.

Once the electricity suppliers have different ways to operate in the market places, also the possibilities to utilize available demand response capacity are different. The question is that how the electricity supplier wants to allocate the demand response resources to the different phases of the overall electricity procurement process. Some of the suppliers can choose to utilize the resources only to adjust the longer term average consumption, while others can choose to use them only in intraday balance management activities, or demand response capacity will be allocated to different market places based on the load control device which is installed in the consumption place. This is greatly affected of what kind of load control possibilities will emerge in the electricity market e.g. how widely the DSOs will offer their AMR infrastructures for load control purposes and what kind of steering possibilities these kind of services will practically offer. Also the structure of information exchange in the future electricity market will have a significant effect on this issue, as well as issues such as whether the DSO always needs to know about the load control operations in their electricity network area.

Based on the current available knowledge and in terms of this report, it is likely that AMR infrastructure could be used to support demand response utilization during the long term procurement planning and day-ahead trading, but once the intraday balance management begins and the reliable and fast actions are needed close to the delivery hours, more straight forward connectivity to the consumption places is needed with additional automation devices and advanced communication technology to support the required operation. Therefore, if both kinds of resources would be available it would give a possibility to allocate them differently to be used in the different phases of overall electricity procurement process.

## 6. References

[1] NASDAQ OMX. [WWW]. [Referred to 22.1.12014].
http://www.nasdaqomx.com/transactions/markets/commodities/markets/products/power

[2] Nord Pool Spot. [WWW]. [Referred to 23.1.2014].
http://www.nordpoolspot.com/TAS/Day-ahead-market-Elspot/Order-types/Flexible-hourly-bid/

[3] Nord Pool Spot. [WWW]. [Referred to 27.1.2014].
http://www.nordpoolspot.com/TAS/Day-ahead-market-Elspot/

[4] Nord Pool Spot. [WWW]. [Referred to 27.1.2014].
http://www.nordpoolspot.com/TAS/Day-ahead-market-Elspot/Order-types/

[5] Nord Pool Spot. [WWW]. [Referred to 28.1.2014].
http://www.nordpoolspot.com/TAS/Intraday-market-Elbas/