PRACTICAL IMPLEMENTATION OF DEMAND RESPONSE IN FINLAND

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ABSTRACT

In this paper, we have studied the potential, incentives, and obstacles of the practical implementation of the demand response (DR) in Finland. We have discovered that there are remarkable amount of the controllable loads, which can be controlled via smart meters. Furthermore, market places for DR already exist, and it is possible to gain economic benefits from DR. However, the roles and responsibilities of the stakeholders are unclear, and heterogeneity in systems and solutions hinder the actualization of the load controls. Furthermore, there may appear conflicting interests, as the sharing of the costs and benefits seem to be unequal in some cases, and contradicting needs for load controls between stakeholders may occur. As solutions to overcome the discovered obstacles, we suggest that more standardization to interfaces between stakeholders' ICT systems is needed, stakeholders' roles and responsibilities in the demand response process need to be clarified, and modifications in regulations are needed, to ease the problems concerning missing incentives and the conflict of interests.

INTRODUCTION

The active participation of the demand side is typically referred to demand side management (DSM), which includes energy efficiency (EE) and demand response (DR), see for instance [1]. These demand side actions are beneficial from technical, economic, and environmental perspectives for all the market participants. Furthermore, recently installed smart meters, of which penetration level for instance in Finland is close to 100 %, have brought enabling technology into customer gateway. Finnish Government Decree (66/2009) requires DSOs to install remote readable meter for at least 80 % of customers. Furthermore, according to this decree, meter has to register hourly electricity consumption, and "the metering equipment shall be capable of receiving and executing or forwarding load control commands sent through the data transmission network" [2]. However, we have not yet seen the full scale implementation of the DR resources, as a consequence of some barriers, which may be technical, economic, organizational, or structural.

In this paper, we will study the key obstacles, which are hindering the large-scale implementation of the demand response in Finland, and further, we will propose suggestions to overcome these revealed barriers. Our key focus is in the DR services, which could be implemented through smart meters. Although we have analysed the Finnish case, most of the lessons learnt can be generalized to other market areas as well. A part of the research results have been earlier published in [3].

The structure of the paper is following. Further in this chapter, we will introduce our research methodology and discuss about the general benefits and barriers of the DR, by a brief literature review. Furthermore, in second chapter, we will present the situation of the DR market places and load control potential in Finland. In third chapter, we will discuss about the obstacles, which are preventing the large-scale implementation of the demand response, especially in our Finnish case. In last chapter, we will make our conclusions and suggest some solutions for the discovered hindrances.

Research methodology

The results of our study are mostly based on questionnaires to stakeholders, expert workshops, and techno-economical simulations. At first, DSO (Distribution System Operator) questionnaire was sent to all Finnish DSOs (in total 84 DSOs) in March 2014. A response was given by 30 DSOs, thus, response rate was 37 %. Furthermore, respondent DSOs account for 75 % of the customers and 72 % of network length of all the Finnish DSOs.

Retailer questionnaire, again, was sent to Finnish electricity retailers in September 2014. We got in total 18 answers form 16 companies. These respondent companies account for 19 % of the Finnish electricity retailers. In the case of the retailers, the amount of the public background data is more limited than in the case of the DSOs. However, we can roughly estimate that these retailers have 1.5 million customers, which represent about 45 % of the total amount of the retail electricity customers in Finland.

Furthermore, a manufacturer questionnaire was sent to the manufacturers of the smart meters, in which the technical properties of those meters, which are broadly in use in Finnish DSOs, was studied. This questionnaire covers five different metering manufacturers, of which meters are installed for 75 % of customers. Moreover, there was also a questionnaire for designers and other experts of the real estate electricity installations. In total, 51 experts provided an answer for this questionnaire.

In addition to questionnaires, we have had three expert workshops (December 2013, May 2014, and September 2014), in which we have gathered the viewpoints of different market actors (i.e. customers, DSOs, TSO (Transmission System Operator), and retailers), concerning the practical implementation of the DR. The workshops focused on the obstacles and benefits of the DR from different actors' point of view, technical solutions, and legislation issues.

Furthermore, we have run technical and economic analyses, in which we have studied the properties of the electricity markets and distribution networks from the perspective of the demand response. In these calculations, we have used the data of the actual distribution network (469 distribution transformers, 457 km of MV network, and 793 km of LV network), actual hourly electricity consumption of 7 612 customers, and historical price information from different market places.

Benefits, barriers, and prerequisites for DR

Typically, savings in energy bill, better performance of electricity markets, reduced risks of imbalances, and reduced needs for additional generation, distribution, or transmission capacity are seen as key benefits of DR [4]. The utilization of DR can be categorized to five types of services, as illustrated in [5]; (1) portfolio optimization of the market actors, (2) structural congestion management of the DSO and TSO, (3) occasional congestion management of the DSO and TSO, (4) balancing of the demand and supply in TSO level, and (5) ancillary services for TSO. Based on the above list, all the stakeholders could gain benefits from DR. The benefits of the retailers and DSOs are discussed more detailed in [6] and [7], for instance.

To enable above mentioned services, different types of DR contracts can be offered to end-users. In [5], there are mentioned five types of contracts: time-of-use pricing (ToU), fixed load capping, dynamic pricing, dynamic load capping, and direct load control. Based on analyses presented in [5], it seems that direct load control offers most versatile set of services, while fixed load capping and ToU can be used only for structural congestion management. ToU has been used over the past three decades in many cases to control the electricity heating in Finland. In this research work, we have studied the possibilities to shift from ToU to direct load control.

Although above mentioned significant benefits could be achieved by DR, there are obviously some barriers, which are preventing its success. Key barriers are related to consumers, producers, and market and program structures, as illustrated by Kim and Shcherbakova [8]. They have mentioned that producer side key barriers are unclear responsibilities, concern of the recovery of investments, and disincentives of the managers to do such actions, which could decrease the revenues of the company. Moreover, as consumer related barriers they list the issues such as limited knowledge of the customers, information search costs, slow penetration of the technology and its costs, response fatigue among the customers, moderate saving potential, and prefer of simplicity in daily routines. Similarly in [9], it has been illustrated that the saving expectations of the customers from DR are quite high, and large part of the loads of the households are considered to be unshiftable.

Monopoly sector regulation has strong impacts on the behaviour of the DSOs and TSOs, and thus, also on the implementation of the DR. Typically, regulation provide incentives to decrease operational expenses, and spend more capital expenses. For instance, in [10], it has been illustrated that although DSOs and TSOs could gain benefits from DR, as they could utilize it to congestion management, such actions may not be incentivized by regulation, as more regulatory incentives are given for network investments than for innovative solutions, which increase rather operational than capital expenses. This has been recognized also in [11], as it has been presented that the regulation of the DSOs should be reconsidered, so that it incentivize DSOs to deploy innovative solutions and pursue those investments, both in network and ICT systems, which are needed to integrate DER (Distributed Energy Resources) in markets, and also use them in daily grid operations.

Besides of the monopoly sector regulation, also other regulations and guidelines has to be designed so that they support the efficient utilization of the DR. It has been illustrated in [12], that standardization of the smart metering interfaces are needed, to avoid the obsolescence of the installed meters. Furthermore, as presented in [11], the roles, boundaries and responsibilities of the DSOs, and the differentiation of the tasks between DSOs and TSOs have to be defined. In addition, DR should also be taken into account in legislation and recommendations concerning the building codes and the electrical installations of the buildings.

DR IMPLEMENTATION IN FINLAND

Key requirements for DR implementation are attracting market places for flexible demand, existing controllable resources and appropriate ICT infrastructure. In this chapter, we will cast a view on the existing market places and load control potential in Finland.

Market places for flexible resources

As presented above, all the stakeholders can gain benefits from DR. This is also illustrated in figure below, where the benefits for different stakeholders and market places of the DSM are presented. Besides of the peak power limitation of the DSO and the energy cost minimization of the customer, demand side resources can be utilized in day-ahead (Elspot) or intra-day (Elbas) energy markets, or retailers can use them in balance management. Furthermore, these resources can also be utilized in balancing or reserve power markets, in which different market places exist.

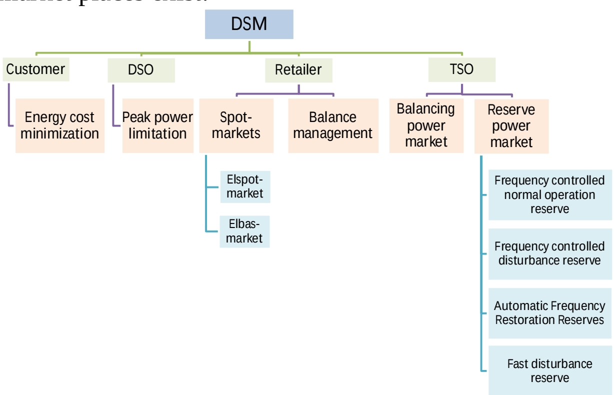

Figure 1. The benefits and market places of the DSM from the viewpoint of different stakeholders

To utilize demand response resources in different market places, retailer or aggregator needs to gather the loads of the end-users to larger entities, as the minimum amount of the bids are typically 0.1 – 10 MW, depending on the market places. More information about the requirements of the market places can be found for instance in [13].

We have simulated the economic benefits of the load control in different market places, based on the historical market data and customers' hourly consumption data. We have found out that benefits can be achieved in all the market places, but balancing and reserve power markets offer greater economic potential than day-ahead markets. However, also more financial risks and technical challenges are related to these balance and reserve markets. More detailed analysis of the load control in balancing power market will be provided in [14].

Controllable loads

Load control possibilities vary a lot between different customers and load types. Typically, if there is possibility to shift the demand by storing energy (e.g. heat or cold), or decrease or increase load without instant customer notice (e.g. ventilation), it is possible to control loads without loss of comfortable. Furthermore, load control should be automatic, so that the actions of the customers are not needed. Besides of the easiness for customers, this will also reduce the uncertainty in load control, caused by unpredicted customer behaviour.

The electric heating of the detached houses have been controlled based on ToU pricing in Finland for several decades. Typically, there have been two types of load control options; time-based control, which shifts storage heating loads to night-time and load reduction control, which can be used to decrease the heating loads of the customer on demand. However, some of the control possibilities may have vanished during the installation of new meters.

As a part of our DSO questionnaire, we surveyed the amount of the loads, which are ready to be controlled by the smart meters at the moment. It was asked from DSOs, how much load is connected to time-based control relay, and how much in load reduction control relay. In total, respondent companies have answered that their customers have 750 MW of loads that can be controlled by time-based control relay, and 570 MW of loads are in the control of the load reduction control relay. However, most of the loads that are connected to load reduction control relay are actually controlled by time based control. As the number of customers of respondent DSOs is 75 % of all end-customers, it can be estimated that the total loads connected to time-based and load reduction control relays are 1 000 MW and 800 MW, respectively. In these figures, it is assumed that controllable loads are equally distributed among all the DSOs. Moreover, there may be some errors in the answers of the DSOs, as actual loads are in the premises of the end-users, and thus, companies may not have accurate information about those loads. Nevertheless, we can estimate that at the moment, based on the viewpoints of the DSO staff, there are in total 1 800 MW of loads ready to be controlled via smart meters in Finland. This is significant amount, as for instance highest nation level peak load in Finland in year 2014 was 14 200 MW.

OBSTACLES IN DR IMPLEMENTATION

Although there exists controllable loads and market places, in which these flexibility resources can be traded, there are still some obstacles that hinder the full-scale implementation of the DR resources. In our DSO and retailer questionnaires, we asked respondents to name three most important obstacles, which should be removed, to facilitate the DR implementation. The results of this question are presented in Fig. 2.

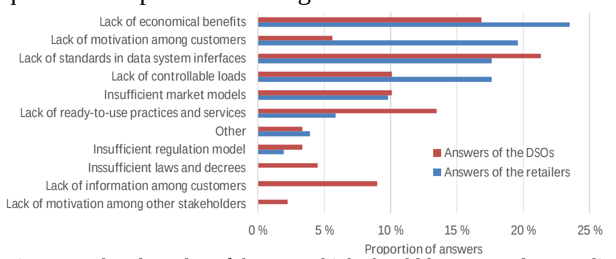

Figure 2. The obstacles of the DR, which should be removed, according to DSO and retailer questionnaires.

Based on the answers illustrated in figure above, it can be seen that two issues, which came up in both retailers' and DSOs' answers, are the lack of economic benefits and the lack of standards in data system interfaces. Furthermore, retailers have highlighted the lack of motivation among the customers, and the lack of controllable loads, while DSOs have casted some votes for the lack of ready-to-use practices and services.

Most of the listed issues are related to each other; demand response call for controllable loads, and if economic benefits are missing, also motivation is missing. Moreover, these answers may also reflect, not solely the harsh reality, but also the present attitudes of the respondents. That is, there may be also the lack of exact information about the controllable loads and economic benefits. However, there are certain obstacles, and in next, we will study couple of them further.

ICT systems' interfaces

As DSOs own and operate smart meters, and again retailers (and aggregators) operate in energy and power markets, the market based demand response requires that retailers are able to control the customers' loads, either via smart meters, or by some other control technology, such as HEMS (Home Energy Management System) or BACS (Building Automation and Control System). Since smart meters are already installed for customers, and there is a significant amount of the controllable loads connected to those meters, as illustrated above, we are interested how to integrate these loads in electricity markets. Hence, we asked in our questionnaires from DSOs, whether retailers could control loads connected to their meters, and similarly from retailers, whether they are able to control their customers' loads via smart meters of the DSOs.

Based on the answers, generally retailers are unable to control the loads of their customers, or DSOs need to do some manual work to transmit the control signal from a retailer to a customer. Furthermore, estimations concerning the time delay that is needed to carry the load control request, varied between couple of minutes to couple of days. On the other hand, the requirements of the markets for maximum time delay vary from couple of seconds to 12 hours, depending on the market place. Hence, it seems that although controllable loads exists, the control requests from retailers to customers' meters cannot be transmitted within desired time limits. The major problem is that the ICT systems and solutions are heterogenic, they are not designed for demand response operations, and interfaces between them are not standardized.

Roles and responsibilities of the stakeholders

One issue that hinders the implementation of the DR seems to be unclear roles and responsibilities between stakeholders. This came up in our questionnaires, where we asked "Who should be the most active stakeholder that develops DR services / technical infrastructure?" Besides above mentioned retailer and DSO questionnaire, this question was also addressed to the participants of first workshop, as these participants represented different stakeholders. In Fig. 3, answers regarding to stakeholder that develops services are presented, and answers concerning the infrastructure development are illustrated in Fig. 4.

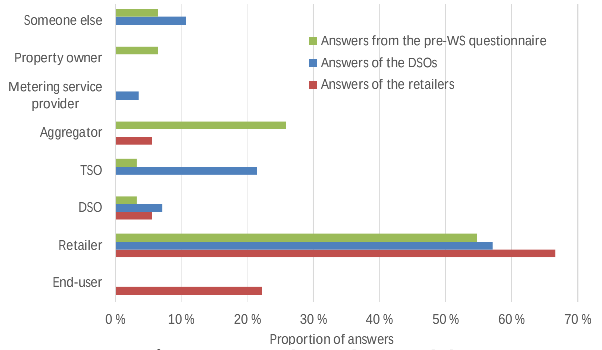

Figure 3. Answers from DSO, retailer, and pre-workshop questionnaires to question "Who should be the most active stakeholder that develops DR services".

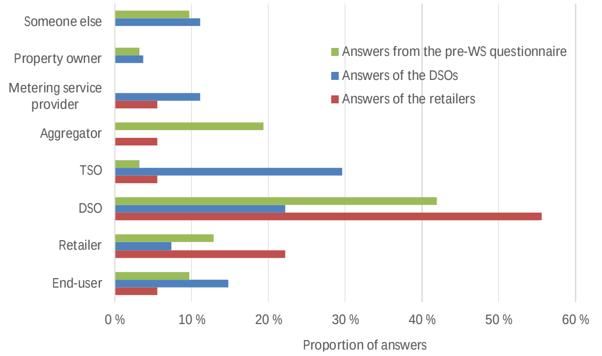

Figure 4. Answers from DSO, retailer, and pre-workshop questionnaires to question "Who should be the most active stakeholder that develops DR infrastructure".

There is quite good consensus about the stakeholder that develops DR services; over 50 % of respondents of all questionnaires have said that it should be retailer who develops DR services. However, there are more variations in the answers of different questionnaires, when the question is concerning the stakeholder that should build the infrastructure for DR. Most popular choice among the retailers and workshop respondents was DSO. But when the same question was asked from DSOs, there was more variation in the answers, and most votes was given for TSO. Hence, it seems that DSOs are not willing to take that infrastructure builder role, which other stakeholders would like to give them. Reason for this is that DSOs do not typically need DR for their own purposes at the moment (which was also revealed in questionnaire), due to strong distribution network, caused by traditionally high power demand. Moreover, monopoly sector regulation do not provide the incentives to spend costs for DR infrastructure, especially if this increase operational expenses.

Conflict of interests

Conflicting interests were also revealed in questionnaires; 45 % of DSOs and 59 % of retailers said that conflict of interest between stakeholders exist in DR. Typically, different load control needs and unequal sharing of costs, benefits, and risks between stakeholders seem to cause the conflicts. Moreover, 71 % of retailers said that it is problematic, if someone else controls the loads of their customers, as it would increase their imbalance costs.

Conflicting interests have been revealed also in network simulations, where it has been studied how the hourly loads in real-life network would change, if the electric heating of the households are controlled based on the market price of the electricity, so that heating is shifted to low-price hours. Based on the simulation results, it can be concluded that the peak loads of the distribution network increase in this case area, if the loads are controlled based on the market prices. This is a consequence of the fact that alternation between the loads of the different customers decrease, if the loads are controlled based on the uniform market prices. However, it seems that power-based element in the distribution tariff could provide customers with incentives to control also their peak powers, and thus, it could help to prevent such increase of the peak powers in network. More detailed information about these network analyses will be provided in [15] and [16].

CONCULSIONS

In our analyses, we have found out that there already exist remarkable amount of controllable loads, which can be controlled via smart meters. In addition, market places for flexible resources are already in place in Finland. Moreover, there seem to be economic potential for demand response, especially in balancing and reserve power markets.

However, the roles and responsibilities of the different stakeholders in the practical implementation of the DR are unclear, and heterogeneity in ICT systems and solutions hinder the actualization of the load controls. Furthermore, there may appear conflicting interests, as the sharing of the costs and benefits seem to be unequal in some cases, and contradicting needs for load controls between stakeholders may occur. This may lead to increasing network loads, as a consequence of the market based load control.

Based on above presented research results, we see that more standardization to interfaces between stakeholders' ICT systems are needed, to facilitate the efficient implementation of the DR. In addition, stakeholders' roles and responsibilities in the demand response process need to be clarified. Furthermore, power based distribution pricing could be a mechanism, by which also DSOs could gain benefits from DR and avoid possible harmful impacts of the market based DR. Moreover, modifications in the monopoly sector regulation are needed, to ensure that DSOs are provided with incentives to develop their ICT and other systems, so that DR resources can be efficiently integrated in electricity markets. In addition, need to improve, not only energy efficiency, but also capacity and power efficiency, and the role of DR in that process, has to be emphasised in legislations, regulations and recommendations, concerning energy sector, building codes and electrical installations.

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