LESSONS LEARNED FROM EUROPEAN PILOT PROJECTS: RECOMMENDATIONS ON MARKET ACCESS REQUIREMENTS FOR ELECTRICITY CONSUMERS

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Kurzfassung: In this conference paper market access requirements that need to be provided to electricity consumers in order to attract them accessing the energy market are briefly discussed. Consequently the results of a comparative analysis of four pilot projects in the residential area and further recommendations are presented. In a next step 'good practice' examples of DSM operator models (e.g. pooling, aggregators, virtual power plant etc.) are discussed and their applicability to the Austrian market assessed.

Keywords: Demand Response, energy market, residential sector

1 Introduction

As more and more European citizens will move to cities over the next decades, the dynamics of urbanisation will result in an increase of energy demand and CO_2 emissions. The utilisation of renewable energy technologies will support to reduce the impacts of climate change and lead to a paradigm shift of the energy system. But only additional efforts will ensure security of energy supply. The concepts of Demand Side Management (DSM) and Demand Response (DR) offer new opportunities to face these challenges. DSM can be understood as a portfolio of measures aiming at the direct influence of electricity consumption, e.g. energy demand shifting from peak to off-peak times, energy efficiency measures etc. On the other hand, the consumer's reaction can be summarised as DR. This means that incentivising the consumer monetarily – by changing the electricity price - leads to a change in energy demand.

Major infrastructure investments in the European electricity grid are needed to keep up stability of energy supply. DSM has the potential to ease this pressure that the electricity market is technically and economically experiencing. But to fully tap the potential of DSM, European member states need to overcome current regulatory barriers and appropriate DR programs need to be implemented.

2 Methodological approach

In the further progress of this conference paper[1] market access requirements that need to be provided to electricity consumers in order to attract them accessing the energy market are discussed. Electricity consumers can generally be distinguished in two groups: residential consumers (households) and non-residential consumers (large energy-intensive industries, small and medium commercial consumers, and service companies). Although it has been proven that all consumer groups offer a certain potential for DSM (e.g. Klobasa, 2007; Paulus and Borggrefe, 2011; Torriti et al., 2010 etc.), the applicability in the residential sector is still most controversial as only small electrical loads are available (e.g. dishwasher, washing machine, freezer etc.).

In recent years many co-funded pilot projects has been carried out to further research the potential of DSM in the residential area and to prove its applicability in real-life conditions. In particular the concept of load aggregation seems promising as small electrical loads are aggregated which enables the trading of electricity at the energy market. These projects mostly focus on approaches that integrate energy and ICT concepts and not only address the technical implementation of these solutions but also consider user engagement and the definition of use cases and their economic impacts reflecting national market regulations.

The project results build the cornerstone for further learning and recommendations how to adapt access requirements for entering the energy market which is still limited to large industrial consumers in many European countries. Industrial companies are used to measure their energy consumption and are equipped with a smart meter which enables them to be accurately informed about their energy data and easily discloses DSM potentials. Residential consumers are lacking this kind of information as electricity billing is done on a yearly basis and does not give any hints on consumption patterns and potentials for energy savings as well as shifting of demand. In addition to the measurement and visualisation of consumption data other factors do also influence consumers accessing the energy market.

Currently, practical approaches are on the way from piloting to commercialisation and further knowledge exchange based on actual experiences under real-life conditions facilitates this process. Thus, four pilot projects in the residential area are analysed based on the market access requirements that have earlier identified. In a next step ‘good practice’ examples of DSM operator models (e.g. pooling, aggregators, virtual power plant etc.) are discussed and their applicability to the Austrian market assessed.

3 Guidance to analyse DR pilot projects

As a starting point requirements that are decisive for enabling market access to electricity consumers are analysed. In a thorough work of structuring, comparing and interpreting meta-studies and other assessments of Smart Grid and Demand Response pilot projects four categories were identified. Each category is composed of several indicators which have been

[1] This conference paper is based on the results of the author’s master thesis which was written in the scope of the IEA DSM Task 17 which deals with the integration of demand side management, energy efficiency, distributed generation and renewable energy sources.

selected carefully. Finally, an analytical framework is developed which assesses pilot projects based on the following categories:

- *Participation and acceptance of consumers* aiming at consumer motivation to change their behaviour and accept to participate in the market (e.g. user activation, access to information, data security & privacy):
- *Institutional and regulatory framework* describing the set-up and structure of electricity markets to enable participation (e.g. definition of roles and responsibilities of market players, formalisation of interactions between different parties):
- *Economic and financial aspects* summarizing the financial profitability of DR services (e.g. business models, profitability)
- *Technical aspects* defining the technical conditions in relation to hardware, software and interoperability (e.g. data communication standards, enabling technologies, interoperability)

4 Pilot projects

In order to prove these assumptions the analysis of pilot projects follows. Projects considering the aggregation of demand side resources are specifically addressed as they are interesting in many ways: flexible electricity loads support the control of the distribution network and security of supply in times of highly fluctuating renewable energy sources; the aggregation of small loads enables the trading of these loads at the energy market. Thus, not only the technical implementation of these solutions has to be ensured in pilot projects but also aspects as user engagement, the definition of use cases and their economic impacts reflecting the national regulations in this sector need to be considered.

The publication ‘Smart Grid Projects Outlook 2014’ which lists 459 Smart Grid projects launched from 2002 up until today is screened (Covrig et al., 2014). The list of suitable projects ranges from national projects from EU-28 member states as well as includes projects funded by the EC under FP6 and FP7. Thus, the pool of projects seemed extensive but a closer look at the projects revealed the following barriers for their selection:

- Many national projects of EU-28 countries promised to be interesting after a first brief internet search. Many reports were only available in the national language. Information in English was limited to an abstract or a short summary.
- In other cases general information in English or German were publicly available but they were not detailed enough to allow an intensive analysis. In particular, the assessment of economic and financial aspects was hampered as reports on the development of business models are kept confidential due to the involvement of industrial companies and energy utility companies.
- In many projects research activities focussed on specific questions in the area of DSM and a demonstration and implementation of a pilot case was not intended.

As a consequence, the list of projects to be chosen was even further condensed. Finally, the author decided to analyse the following four pilot projects which offer an interesting concept and approach (see Figure 1).

Figure 1 Map with pilot projects (own graph)

- The *Dutch demonstration project PowerMatching City* was started in the year 2007 as one pilot case of the European FP6 project INTEGRAL. Phase II started in September 2011 as a follow-up project funded by the Netherlands Enterprise Agency. The activities are based on the software solution 'Power Matcher Suite' which acts as a virtual power plant (VPP) with the aim to stabilise and optimise the electricity network through energy trading based on a real-time market approach.
- The *FP7 project ADDRESS* was launched in June 2008 as a R&D project funded by the European Commission. Via the Energy Box and the Aggregation Box loads were controlled and optimised in residential buildings at two pilot sites in Spain and France. As mediator between consumers and other market players the aggregator offered services to its customers enabling them to exploit their flexibilities.
- The *German E-Energy project E-DeMa* addressed the development and demonstration of decentralised energy systems as well as of the market place of the future. Activities started in November 2008 and set a focus on prosumers actively participating in an energy market place via an ICT gateway by shifting loads of household appliances.
- The *E-Energy project RegModHarz* developed technologies and business models tailored to the challenges of future energy systems driven by decentralised and renewable energies. The pilot demonstration took place at the German county Harz starting with November 2008. A VPP coordinated various producers, consumers and storages (mainly electric vehicles).

The four pilot projects were selected as all of them address the aggregation of loads via utilisation of an ICT platform to implement a market-driven approach. Load aggregation is focussed on demand side resources in the residential area and renewable energy generation systems (e.g. wind turbines, PV systems). The pilot projects were implemented in four European countries (Netherlands, France, Spain, and Germany) with different regulatory market conditions for DR and aggregation of electrical loads.

The pilot projects are compared and analysed and their activities and results concluded. This endeavour is based on a comparative analysis. Main findings are structured along the categories of the analytical framework. Finally, seven recommendations are formulated which address the requirements needed in order to enable electricity consumers accessing the energy market.

5 Results and recommendations

The following results and recommendations are drawn from the analysis and are presented in this conference paper:

Recommendation 1: Community creation supports user activation as the sense of belonging to a community influences the engagement and participation.

As a first step the interest and engagement of consumers need to be activated. The creation of a community supports user activation as the sense of belonging to a community influences the engagement. But this process needs to be well prepared; the following key components in setting-up and initiating this process were identified:

- An in-depth user segmentation and analysis of perceptions, attitudes and behavioural patterns are a cornerstone in developing a communication campaign. A participatory approach proved to be useful in PowerMatching City, but it is not feasible on a larger scale as the process would be too time and resource-intense. Thus, a thorough analysis of user participation motives in DR programs is of high importance.
- Clustering of customer groups need to be based on their motivation to participate (e.g. trying a new technology, environmental consciousness, learning about energy consumption and making changes etc.).
- Although financial incentives seem to play a certain role in attracting users, the findings of the pilot projects show that communication activities need to be tailored to the needs of a specific customer group (e.g. a blog, website, chat program etc.); e.g. early technology adopters interested in the high level of ICT penetration and the interaction of devices, or energy conscious people interested in the effects of DR programs and how to save energy.
- With the support of an experienced testimonial, specific messages can be easily conveyed to the consumers (e.g. contributing to a sustainable future, joint efforts lead to a success etc.)
- A range of different events and open house days, trainings how to use the technologies and the interaction of participants with the technology (user manual) support consumer engagement. Additional trainings for technicians and employees of the customer hotline support ensure a customer service of good quality.

Recommendation 2: Variable tariff models need to offer an added value for an acceptable price to attract consumers.

The measurement of electricity consumption patterns of households provides a solid basis for time variable tariff models. Based on this baseline measurement it is easy to identify the change or shift of electricity consumption during a DR event.

Currently, dynamic pricing programs are only common in a few European member states as France or Italy. Numerous studies have shown that dynamic price signals show good effects to increase DR participation (Faruqui & Sergici, 2010) and they can lead to reductions in electricity consumption (Jessoe & Rapson, 2014). In general, tariff schemes should offer an added value for an acceptable price building upon a communication campaign keeping consumers informed and explaining to them how they can participate. Findings from the pilot projects are summarised in the following:

- The project PowerMatching City offers a good example of an energy service with a variable tariff. Two energy services were developed in a participatory approach; one tariff focussing on cost reductions using energy at cheapest times and the other one driven by motivations of sustainability or even self-sufficiency to use energy when it was locally produced.
- Pilot participants preferred a mixed tariff in the FP7 ADDRESS project combining a fixed and variable remuneration. The variable element was related to the extent of DR provided by the consumer.
- In the E-Energy E-DeMa project a performance-related tariff was tested, but it failed as the concept is for consumers too complicated to understand. The majority of consumers do not have any understanding how much power an electrical device consumes.

Drawing on these lessons learned the tariff structure must not be too complicated. For users an ‘easy to understand’ scheme is important. The tariff should match to their energy behaviour in order to promote user engagement in DR programs. Thus, not only the right services need to be offered to consumers but also a good understanding of the sales person and the customer support is needed to sell the right energy services.

Recommendation 3: Based on the visualised electricity consumption data consumers can be incentivised with premiums and other rewards to participate in DR programs.

In Faruqui & Sergici (2010) and in Stromback et al. (2011) it was confirmed that the utilisation of feedback devices visualising energy consumption data influences user behaviour. In the pilot projects different visualisation means were tested (e.g. in-house display, web portal, smart phone application). Users preferred in-house displays and mobile applications; thus, online web portals were used for more detailed assessments of historical consumption data aggregated on monthly or yearly basis. Additional functionalities, e.g. enabling the comparison with a reference group and offering competitive incentives, support customer engagement to participate in DR programs.

In the cases in which devices were automatically responding to DR signals users expressed the request to be easily able to change the settings via the in-house display, e.g. in the E-Energy RegModHarz project, it was only possible to adjust the schedules of automatically operated devices via the online portal which limited their interest and participation.

Recommendation 4: Data protection, privacy & security aspects need to be considered when ICT infrastructures and systems are designed and participation agreements with consumers concluded.

In the pilot projects no or only minor concerns were expressed about data protection, privacy or security aspects. This can be related to the early addressing of this kind of issues in the beginning of the project execution. Two levels were addressed in the pilot projects:

- ICT infrastructures and systems were analysed in relation to their security demand and risk mitigation. Security and privacy aspects were implemented in the ICT design.
- Participation agreements and contracts were concluded to summarise the rights and obligations of users and information about data utilisation and collection was given in detail.

Recommendation 5: The institutional and regulatory transformation of the energy market requires the introduction of new market players that develop services attractive for consumers.

All pilot projects focussed on load aggregation via different software solutions connected to hardware devices (following the concept of a VPP). Roles and responsibilities of market players were defined in order to ensure a smooth interaction. In this process the need for new roles of market players were identified. In addition to the aggregator, that creates portfolios being composed of small loads (produced and provided by prosumers) and brings them to the market, other market roles, e.g. energy system manager, are needed. These players do not directly interact with the consumers but provide services to enable an energy commercialisation.

Recommendation 6: Detailed cost-benefit-analyses are crucial for defining the added value of business models; financial advantages for consumers are quite low. Thus, aggregators respectively companies, who offer aggregation services, need to concentrate on key messages on a broader level in order to attract consumers.

Business models are understood in this context how market participants can create values based on value adding processes and gain revenues. In the pilot projects (in particular the E-Energy RegModHarz project) requirements for a sustainable development of business models were set-up:

- The development of business models needs to be based on a thorough market analysis and existing access requirements to trade electricity on the energy market.
- The development of business models was bottom-up driven involving all stakeholders, e.g. plant operator, network operator, distributor, trader etc. They were brought together in workshops to discuss requirements, and chances and risks.
- The business models identified were described in detail, while additional aspects as implementation concepts for each market player, economic barriers, and existing framework conditions were addressed.

The economic translation of these business models to the energy market is still very difficult, but the pilot projects give some indications if these developments will be feasible in the future:

- In all pilot projects economic analyses were carried out; some of them were done on a broader system level (PowerMatching City, FP7 ADDRESS), others on the level of the specific business case (E-Energy E-DeMa, E-Energy RegModHarz).
- A cost-benefit analysis is due to various reasons difficult; costs for setting up the ICT infrastructure need to be taken into account which is difficult to assess as ICT solutions and devices needed for the enabling of load shifting are currently not commercialised or show a low level of technology penetration.
- In all cases the economic analysis showed that the commercial deployment of the business cases is not profitable yet.
- Considering national regulatory conditions and assuming increasing market prices for electricity until 2020 as well as decreasing acquisition costs for ICT components business could be viable.

Recommendation 7: Standardisation and interoperability of technologies proved to be a basic condition for interaction of technical appliances and enabling technologies.

The findings of the pilot projects revealed that the harmonisation of communication of technical devices was very time consuming and cost intense; technical standardisation and interoperability proved to be a basic condition for interaction of technical appliances and enabling technologies in order to take advantage of flexibility. User acceptance can only be achieved if standards take into account technical solutions that consider the current technology's service life.

Different technologies needed to be integrated that were used for the interconnectivity of the in-house devices; several of them even competed with each other (e.g. smart meters and the metering gateway). The involvement of manufacturers to build interfaces is crucial. The current situation is that devices as washing machines and dish washers are not able to switch on and off when a price signal is received; thus, an additional plug-in is needed. Despite technical problems with hardware devices software and communication issues of components need to be considered (e.g. firmware updates of components, WIFI connection of component to router etc.). It became apparent that pragmatic approaches to interlink and connect devices are not feasible for a large-scale rollout in future scenarios. Thus, the need and utilisation of a dedicated smart home network based on an interoperable ICT architecture ensuring interconnectivity seems a feasible solution.

6 Good practice examples of DSM operator models

In the pilot projects DSM operator models were developed supported by different software solutions connected to hardware devices following the concept of a virtual power plant (VPP). VPPs have the advantage to balance fluctuations of distributed producers by pooling energy producers and consumers and enabling them to access the energy market (Krautzberger, 2014). Currently, this approach is gaining momentum in Europe as legislation and market regulation is changing. Thus, the transformation of the energy market is still ongoing and competition in retailer markets is needed to make this operator models attractive for consumers.

In the following section the findings of good practice examples of DSM operator models are presented. The DSM operator models are based on software solutions that were developed within the pilot projects and tested in a real life environment. Finally, conclusions for the further utilisation of these operator models are drawn.

PowerMatcher

In the project PowerMatching City the software solution PowerMatcher Suite was utilised which development has started back in the year 2006. Devices producing or consuming electricity are intelligently clustered and aggregated with the PowerMatcher Suite. Their operation is automatically optimised with the aim to achieve an optimal match between electricity generation and consumption. The PowerMatcher Suite has been commercialised as an open source technology and designed for various business areas that are based on utilising flexibility. For example, service providers can aggregate electrical loads of individual households and businesses and offer this flexibility to consumers. Energy service companies utilised the flexibility of businesses in order to reduce their connection capacity. Another business area is the intelligent energy management of consumption and production in the residential area. (Power Matcher Suite, 2015)

E-DeMa market place

The operator of the E-DeMa market place acts as an intermediary bringing together supplier and consumer; prosumers are interacting with energy traders, DSOs and other market players. The creation of the E-DeMa market place enables electronic business and legal relations between market players and triggers positive effects as data consolidation, the shortening of clearing and business processes and the reduction of transaction costs through efficient communication. It offers business opportunities for various market players as energy suppliers, meter reading and energy service companies, aggregators as well as DSOs. (Laskowski, 2015)

E-Energy RegModHarz

In the pilot project E-Energy RegModHarz various producers, consumers and storages (mainly electric vehicles) were coordinated via a VPP aiming at a full exploitation of renewable energies. The household's devices were connected to a bi-directional energy management interface, the BEMI. Two appliances in each household were automatically controlled via the BEMI (e.g. washing machines, dryers, dishwasher, refrigerator, and freezer) and participants could fix time windows when consumption should be optimised. The BEMI visualised the actual tariff and the next day's one via a display as well as the optimisation plans for the appliances automatically controlled. It also gave detailed information on power and energy demand of appliances controlled as well as of the entire household on a yearly, monthly and weekly basis. The market platform acted as an add-on to the BEMI web portal and enabled the participants to analyse their consumption and virtual account balance. (Speckmann et al., 2012)

Several business cases were developed and analysed in the project. One of them is the direct marketing of VPP's energy volumes via a pool coordinator. The pool coordinator is responsible for the energy commercialisation and acts as a trader who aggregates electricity of decentralised energy producers (Speckmann et al., 2012).

7 Conclusions

Based on the findings of the pilot project it can be concluded that the market access barriers for residential consumers are high as a lot of preconditions need to be fulfilled. These requirements start with the long-term activation of residents by intensive planning, structuring and implementing of community building measures. Attractive tariff schemes are needed that convey a key message with which the consumer identifies him- or herself. Tariff options as an economic (cost-optimal) and a sustainable (self-sufficient) one are in particular interesting for regions that have a high amount of customers with distributed renewable energy technologies. The visualisation of energy consumption is inevitable as relevant information about consumption data, price signals and even data of a reference group gives the consumer the chance to adapt his/her behaviour. Data protection is a prerequisite for residential consumers accessing the energy market. In all pilot projects analysed privacy and security concerns were early addressed by considering the protection of personal data via participation agreements as well as security demand and risk mitigation in the ICT design.

In the pilot projects DSM operator models were developed supported by different software solutions connected to hardware devices following the concept of a virtual power plant (VPP). In Austria a few VPP operators are currently active but which only commercialise flexibilities of industrial and commercial companies. The sector of residential consumers is still untapped. Although Austria has advanced its regulatory conditions the economic analyses in the pilot projects have proved that load aggregation in the residential sector does not offer a viable business model. Economic advantages for residential consumers are limited as well. Thus, other aspects as saving money or financial rewards need to attract or convince users to participate in DR programs. Nevertheless, it can be expected that the market for DR in the residential sector will develop in the upcoming years (under the condition that technical requirements as a smart meter roll-out has been carried out and the interoperability of home energy management systems improved).

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