USER CENTRIC DESIGN OF SMART GRID A SOCIAL AND ECONOMICAL APPROACH

Charlotte KOBUS
Enexis – the Netherlands
Charlotte.cba.Kobus@enexis.nl

Bas DE JONGE
Alliander – the Netherlands
Bas.de.Jonge@alliander.com

Joris KNIGGE
Enexis – the Netherlands
Joris.Knigge@enexis.nl

J.G. (Han) SLOOTWEG
Eindhoven University of Technology
Enexis – the Netherlands
Han.Slootweg@enexis.nl

ABSTRACT

The energy transition poses challenges for maintaining the energy balance between demand and supply in the future. One of the solutions is Demand Side Management (DSM) where mobilizing flexibility in demand is the main objective. This paper summarizes two research projects on the economical and social aspects of DSM. These projects aim at the development of DSM instruments that are to be tested in a pilot project with over 300 residences. It is argued that objectives are to be interpreted in desired behaviour and desired behaviour should be translated into adequate DSM instruments. Four fields of attention were identified as relevant for instrument development; technology, incentives, interaction and communication.

INTRODUCTION

The transition towards a more sustainable energy supply system causes changes in the supply and demand of energy. It will cause the energy system to change from a system with a central and continuous character, to a system with a decentral and intermitting character by the increased use of generation capacity connected to the distribution grid and the integration of large scale intermittent sustainable energy sources. Moreover, the substitution of appliances that use fossil fuels by appliances that use electricity (particularly for heating and transportation) will cause electricity to become a more important energy carrier.
The Dutch Distribution System Operator (DSO)[1] Enexis facilitates the energy market within its supply area. Enexis has the ambition to play a leading role in facilitating the energy transition. To incorporate sustainable energy technologies into new and existing grids, Enexis will have to increase the flexibility of its networks.

In order to increase the flexibility of operation and the efficiency, one can look for the mobilisation of "hidden" flexibility at the demand side of the electricity value chain. It calls for smart grids with embedded intelligent control to incorporate electricity storage and controllable demand. To unlock the hidden potential of flexibility at the demand side of the energy value chain, Demand Side Management (DSM) is considered to be promising. DSM is defined in this paper as the mechanism to control non-time-critical demand or control demand with a long time constant [1]. Consumers become involved and are able to make informed decisions about their energy consumption [2]. As follows, it requires that the consumer offers flexibility by changing its current consumption patterns.
Insight in the effects of DSM on behavioural change for flexibility is needed. In order to set up pilot projects to increase this needed insight, two studies were conducted into the social and economical aspects of DSM. These aspects will bear consequences for designing DSM instruments and these findings are presented. Last, the steps taken and to undertake are presented and conclusions and recommendations are formulated.

ECONOMICAL ASPECTS

The trends brought about by the energy transition result in several infrastructural and market challenges [3] The infrastructural challenges are related to voltage control, power quality, short circuit power, requirements to protect the system and therefore the reliability of supply. On the other hand, the expected increase of (peak) demand creates the necessity to upgrade the already ageing infrastructure.
Market challenges are caused by the fact that supply and demand of electricity always have to be in balance as a result of the inability to store electricity on a large scale. The non-controllability and uncertainty of electricity generation by intermitting sources causes difficulties with maintaining the balance between supply and demand. Also the implementation of distributed generation owned by consumers causes more unbalance on the network.

In the liberalized electricity market of today different actors have different interests in DSM. An electricity producer who is responsible to predict the day to day electricity production and possess a large wind park is interested in DSM to act on their predictions. Also an aggregator or retailer that purchases electricity on national spot markets can use DSM to act on price fluctuations on the spot market. A DSO is interested in DSM to decrease peak demand

1 After the implementation of the European electricity directive 96/92/EC in 1998 in the Netherlands the electricity production and retail part and the utility part are unbundled. The new legal independent entities, called Distribution System Operators (DSOs), are responsible for the maintenance, operation and development of the distribution grid in a certain region and the interconnection with other regions. Electricity producers and retailers are responsible for the production and availability of electricity; they perform their activities in the free market environment.

which results in more efficient use of the grid and delay grid investments.
At times, these individual interests could be in opposite direction [3]. The result will be that the cost and benefits from DSM and smart grids in general are not the same for every actor. The value of DSM will increase if the objectives of DSM are combined. For the adoption and development of DSM instruments, cooperation between the different actors is important [3]. It is therefore recommended to bring actors together during smart grid pilots and use DSM for shared objectives.

The objectives of DSM for the pilot projects are formulated as follows:

- to use the locally sustainable production of electricity as efficient and local as possible
- to use the local grid capacity as efficient as possible
- to transfer price fluctuations of electricity during the day to the consumers.

These objectives are to be translated in the DSM instruments by interpreting them into desired behaviour first.

SOCIAL ASPECTS

The social aspects of the challenges brought by the energy transition lie in the natural resistance to cultural change that is needed for innovation, along with the resistance that may be expected from changes within the value chain that affect the position of different actors. The consumer was made the centre of attention by zooming in on the behavioural change that is seen necessary to reach the objectives above. [4]
Since the behavioural change needed is versatile, user centric design of DSM instruments was seen as an essential factor for success. User centric design is based on upfront user input for the development of instruments. Consumer perceptions were explored by qualitative consumer research and implications for DSM instrument development acquired to facilitate adoption of new behaviour to obtain flexibility in demand.

Current electricity consumption behaviour and the expected difficulties for the change to happen were evaluated. The first difficulty of changing electricity consumption behaviour is that the consumer shows low involvement in the decision process and is therefore frequently made on the basis of price [5]. Thus, it may be that customers will only change if the price differential reaches a certain level. Hence it is presumed that small gains in price will not compensate for the inconvenience of having to change. Big financial gains are difficult, while electricity is very cheap already. Consequently, while consumers are likely to primarily consider price as the key determinant of consumption behaviour of electricity, improved service and environmental issues are easier messages to get across.
The second difficulty of changing electricity consumption behaviour is that consumers are unlikely to know the price of their consumption, or their volume of usage by the lack of communicated data. The traditional meter is hidden in the closet and is hard to interpret. Once a year they get feedback about their behaviour in the form of an ambiguous bill. The lack of feedback disables the consumer to have full control over its consumption behaviour, thus to have full control over the effects of its behaviour. Feedback is the behavioural mechanism responsible for the realisation of the intended effects of behaviour and is therefore seen as one of the essential bricks of behavioural change in electricity consumption.

DESIGN FOR FLEXIBILITY IN DEMAND

Current consumer perceptions and the behavioural change wanted to reach the objectives will be the basis of design. It is assumed that behavioural change needs several instruments to enable the change and offer adequate incentives. These instruments are categorised by technology, incentives, interaction and communication.

Technology

Research showed that automated DSM is most likely to succeed. Though participants were interested in offering flexibility, they were almost all not interested in having an active role themselves [4]. Hardware and decision algorithms to automate flexibility in demand are to be developed. Examples of hardware are controllable storage capacity, a smart meter, controllable appliances and an energy management system. Figure 1 shows an artist impression of a future smart home with several forms of controllable appliances, storage and IT-technology.
Despite the fact that automation was preferred, important worries connected were loosing control, the possibility of technological risks, risking privacy, loosing comfort and incapability of offering flexibility at all. These worries need special attention in the development of the technologies and interactions. [4]

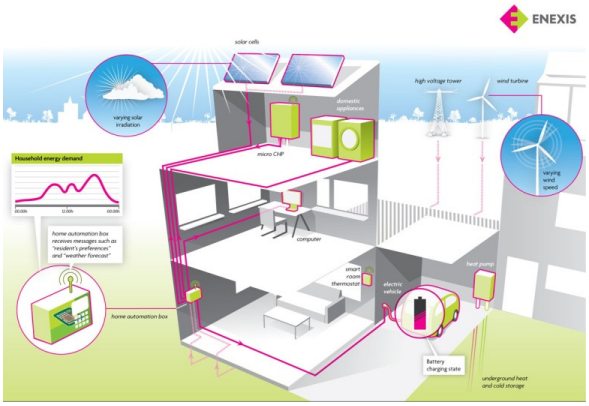

Figure 1 Artist impression of a smart home

Incentives

The adequate incentives to be considered are two sided: to satisfy the emotional gain and the physical gain sought. As became apparent, the emotional gain the participants were looking for, was as important as the physical gain.[4] Until now, the design of incentives for flexibility has mostly remained in the field of physical gain [e.g. 2]. It is very important to put great effort in designing the emotional as well.

Physical gain:

- Financial bonus (reduction on bill, cash rebates)
- Obtain new hardware (e.g. green technologies)
- Obtain new software (new functionalities)

Emotional gain:

- Good feeling (e.g. social proof, assuaging guilt)
- Reduce environmental impact (e.g. collect green points to donate to green energy initiatives or other green causes, showing reduction by CO2 saved)
- Feeling of achievement (e.g. scores, levels, challenges, targets, collections, rewards)

Interaction

"The needs of the users must dominate the design of the human-computer interfaces, and the needs of these interfaces should dominate the design of the rest of the system, because from the point of view of the user, the interface is the system." [6] Besides an appealing 'look and feel' of the user interface the goals the user wants to accomplish with the system must be simple and efficient to carry out. These can be to realize simple tasks or to steer intended effects of behaviour, which need to match the gains sought (see incentives).

Communication

It is argued that while obliged roll-outs are very effective for spreading behavioural change, they are often not appreciated and will cause resistance [7]. Subsidies are of course appreciated, but do not always lead to the desired behaviour. A communication persuasion strategy is needed to make the product familiar, acceptable, and even desirable to the audience. This means that the strategy needs to adapt to the appeals of the segment that is to be attracted. It is advised to match this strategy with the expected developments in the sector [4]. That is shifting the focus from:

- doing the good thing for the environment, by making use of green electricity now,
- to using own generated electricity as efficiently as possible, when residential distributed generation becomes more popular,
- to saving serious money, when electricity or at least time critical electricity becomes very expensive.

IMPLEMENTATION

In order to increase insight in DSM in the Netherlands, sense of urgency [8] is felt amongst stakeholders to demonstrate and research the effects of DSM for flexibility. Enexis has launched a strategic research project in its supply area to demonstrate the possibilities and research the effectiveness of the DSM instruments within a pilot project setting with a substantial number of consumers. The first step was to find building development projects within the supply area of Enexis. Potential partners had to be willing to incorporate the demonstration of DSM within their existing building or renovation plans and to facilitate the contact with the inhabitants of the buildings, flats and houses. Consequently, contacts and meetings were sought with commercial project developers, housing corporations and municipalities.

After this was consolidated and mutual intentions were agreed upon, contacts with energy retailers were sought in order to have secure expertise on customer relations management, billing and consumer interaction for the project. A "lean and mean" energy retailer[2] was contacted as the interests of the energy retailer and the DSO were considered to be mutual complementary.

This proved to be the case. On November 26th, 2010, a consortium has been set up to realise a smart grid demonstration project within two newly developed districts: 250 apartments and 60 semi detached houses within the city of Breda. The consortium consists of a project developer (Heja), a Dutch energy retailer (Greenchoice) and the DSO Enexis. Together the organisations will combine their efforts to develop and build the necessary instruments to mobilise flexible electricity use of customers living in the houses and apartments. The development of the instruments to mobilise flexibility have began as of December 2010 and will be be finalised when the houses and apartments are delivered by the summer of 2012.

CONCLUSIONS & RECOMMEDATIONS

Flexibility in demand is expected to be of great importance for the affordability, reliability and sustainability of our energy system of the future. Many actors have different interests in the application of DSM and the cost and benefits are not the same for all. Clear understanding amongst involved actors of their interests in DSM and their different objectives should be openly discussed, in order to truly be able to serve the public goals.

DSM instrument development efforts of many disciplines are required, since there is no one instrument that can accomplish the behavioural change to achieve flexibility in demand. Various instruments have to be developed that will make partial contributions to the objectives. Software, and hardware are just some of these; a public education media campaign providing tips on flexibility is another; the

2 "lean and mean" refers to an energy retailer being sought which has the focus on retail of sustainable energy to customers and not on production.

creation of contracts which reduce electricity prices for more flexible users is still another. A holistic approach is crucial for the successfulness of DSM for flexibility.

REFERENCES

[1] Strbac, G., 2008 "Demand side management: Benefits and challenges"Energy Policy 36, 4419-4426

[2] McKinsey&Company, 2010, "Mckinsey on smart grids" McKinsey&Company Electric Power and Natural Gas practice and Business Technology Office

[3] Jonge, S.F. de, 2010, "Business models for demand side management, Cost and benefits for actors in the future electricity regime" Master thesis, Eindhoven University of Technology.

[4] Kobus. C.B.A. (2010) *Smart Grids: Changing consumer interaction.* Master thesis, Delft University of Technology.

[5] Assael, H. (1987). *Consumer Behavior and Marketing Action*, 3rd ed., PWSKent Publishing, Boston.

[6] Norman, D.A. (1986) *Cognitive engineering. User Centred System Design: New Perspectives on Human Computer Interaction*, Lawrence Erlbaum, p. 31-61.

[7] TNS NIPO (2003) *Hoe kan Maatschappelijk Verantwoord Consumeren worden bevorderd?* Onderzoek en advies voor de DuProCo-strategie. Z1419, Ministerie van VROM *(in Dutch)*

[8] Taskforce Intelligente Netten, 2010, "*Op weg naar Intelligente Netten*" Ministerie van Economische Zaken, 's Gravenshage, the Neterlands Publicatienummer: 13PD2010G292 *(in Dutch)*