Utilities Policy 31 (2014) 74–84

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

# Linking meters and markets: Roles and incentives to support a flexible demand side

Jonas Katz*

*Technical University of Denmark, Department of Management Engineering, Energy Systems Analysis, Risø Campus, Frederiksborgvej 399, 4000 Roskilde, Denmark*

ARTICLE INFO

*Article history:*
Received 1 April 2014
Received in revised form
27 August 2014
Accepted 27 August 2014
Available online

*Keywords:*
Demand response
Smart-meter roll-out
Decentralised resources
Electricity market-roles
Product design
Flexibility

ABSTRACT

Present trends in the development of electricity systems are expected to generate a growing need for flexibility in decentralised resources, including demand response. In order to enable decentralised actors to create value, the organisation of markets and incentives should incorporate these new participants. The roll-out of smart metering to electricity consumers is an important precondition to establishing a flexible demand side and will provide essential information flows. On the basis of current incentive structures and related risks, however, the pass-through of information and value from wholesale market participants to the demand side is mostly infeasible, resulting in flexibility tasks being aggregated and delegated to balancing responsible wholesale traders. This analysis focuses on whether current incentives and roles are appropriate and where the design could be improved to establish a flexible demand side with a particular focus on the Danish case. Design-related barriers are identified that affect expected value, associated risks, and the distribution of responsibilities. This serves as a basis to define policy options in the context of Nordic electricity markets.



## 1. Introduction

Policy-makers intend to cure the missing information transfer between the demand side and wholesale markets by rolling out smart metering to all or most customers. Arguments for establishing this kind of infrastructure are based on socio-economic calculations that show substantial benefits induced by flexible demand-side resources (e.g., Danish Energy Agency, 2013; Energinet.dk, 2013, for Denmark). However, such findings also rely on significant adoption rates.

At the moment many barriers, mainly regulatory and institutional, still exclude decentralised resources from the informational flows about flexibility supply and demand (e.g., Greening, 2010).

Currently, with market products generating only weak incentives, combined with their risk profiles it remains an open question whether adoption will take place at expected rates and if economic projections are justified. The present distribution of responsibilities for handling flexibility suggests the need for some adjustment.

Considering the Danish situation, the existing market places for flexibility are reviewed from the perspective of decentralised resources, including both demand response and distributed generation.

The analysis focuses not so much on the economic value of flexibility and the underlying incentive to bring it to the market. Instead, the focus lies on how flexibility trades and whether the form of products and the organisation of markets fit with the characteristics of demand-side flexibility. The reasoning is that while the demand for flexibility and its value can be expected to increase with growing shares of intermittent production, it is of central importance that information about the rise in value is in a form that creates demand-side incentives.

The next section lays out the scope and research interest in more detail. It points out trends that suggest a growing importance of flexibility from decentralised resources and describes the approach taken towards barriers to demand-side flexibility. A clear distinction is drawn between barriers caused by the underlying market structure and additional barriers introduced by regulation and design. Hereafter the major design-related barriers as well as options to address them in favour of small-scale demand-side actors are presented and discussed.

* Tel.: +45 2465 8855.
*E-mail address:* jokat@dtu.dk.

http://dx.doi.org/10.1016/j.jup.2014.08.003
0957-1787/

## 2. Drivers for decentralised flexibility

### 2.1. A growing demand for flexible resources

The necessity of providing flexibility to the system originates from reliability requirements. Securing system balance and power quality at all times are basic preconditions to the operation of electricity systems. In a liberalised electricity market these requirements establish the demand side in a market for flexibility.

As reliability is both a long-term and a short-term task, so is the provision of flexibility. In the long-term the reliability or system adequacy requirement traditionally meant providing sufficient production and transmission capacity to serve demand at all times (ENTSO-E, 2004). Here flexibility is seen as the ability to handle fluctuations in demand (see also Nicolosi, 2010). With recent developments in intermittent production, adequacy increasingly must to take into account variability of production.

In the short term reliability translates into security requirements within an otherwise adequate system. In particular, reserve requirements for outages and stochastic deviations are determining factors. Although electricity demand is subject to forecasting errors, these are comparatively small on an aggregated basis. Flexibility in the short term, therefore, is almost completely driven by the supply side of the system (Gül and Stenzel, 2005).

The demand for flexibility due to adequacy and security requirements thus depends very much on supply-side developments. In a broader sense, therefore, flexibility can be defined as changes in the behaviour of connected parties to accommodate system needs (Dansk Energi and Energinet.dk, 2012). As the supply side of electricity changes, so will the value of and the demand for flexibility. The development of variable renewable electricity production, accordingly, is expected to increase the demand for flexible capacity (Grohnheit et al., 2011).

### 2.2. Declining availability of traditional flexibility providers

Centralised thermal power plants are the most common providers of operational flexibility to the system at present. Due to low marginal costs of most renewable energies, conventional production technologies may experience lower utilisation rates. Combined with the overall price depressing effect (cp. Munksgaard and Morthorst, 2008), this reduces the feasibility of these traditional suppliers of flexibility.

Therefore, it can be expected that conventional sources of flexibility will become less available or, at least, more costly (cp. e.g., Droste-Franke et al., 2012, p. 63ff., for an analysis of German scenarios). Although there is an option of keeping them on-line to provide reliability services, this may result in substantial costs. Adding new flexibility resources should be considered.

Several flexibility options have been identified, ranging from grid extension to establishing storage and demand response (cp. BMU, 2012; Energinet.dk and Dansk Energi, 2012; Gül and Stenzel, 2005). Some of those are centralised options and others are more decentralised, that is, smaller in size and typically connected to lower voltage grids. A cost-efficient system should take advantage of and optimise among all available resources.

### 2.3. Decentralisation of reliability management

Building an electricity system with large shares of intermittent renewable production typically implies that the supply structure becomes more decentralised. Therefore regional and local grids may become challenged. As a result, reliability management requires either more grid capacity or more decentralised solutions (CIRED, 2013).

Currently, flexibility services are primarily managed by transmission-system operators. At the distribution level, reliability requirements traditionally have been covered by investments in new grid capacity. In a future system with increasing variable activity at the distribution level, building sufficient grid capacity may come at a significant cost and distribution-system operators may instead ask for flexibility services and seek to establish a more active management of such resources (Energinet.dk and Dansk Energi, 2012).

In addition to the specific challenges in distribution grids, various benefits have been identified and are expected to become effective when activating the flexibility of the demand side (see e.g., Albadi and El-Saadany, 2008; Andersen et al., 2006). Active demand response is expected to improve general market performance by reducing variability of prices and preventing market power (Kirschen, 2003; Hirst, 2001). It reduces the usage and investments in peak capacity and supports reliability (Strbac, 2008; Earle and Faruqui, 2006). At the same time, improved monitoring may lead to operational benefits to suppliers and grid companies (Faruqui et al., 2010).

Although developing a smart and flexible demand side is supported by research and acknowledged by policy-makers in countries with growing shares of renewable resources, including Denmark and Germany, the scale is an ongoing debate (see Lund et al., 2012). In particular the demand-response potential from most household appliances may be limited. If individual transport and heating systems become electrified, however, the flexibility of such devices should be utilised actively in order to prevent severe reliability issues (Slootweg et al., 2011).

### 2.4. Market structure and impacts of market design

Many options already exist to activate flexible capacities on the demand side. In principle demand response and other decentralised resources also are able to participate in most if not all of the relevant markets (Hirst, 2002). The lack of smart metering installations is sometimes considered a major barrier to the utilisation of demand response (e.g., Kim and Shcherbakova, 2011). While this clearly is an important technical precondition, metering by itself is not sufficient to induce flexible demand.

In order to enable decentralised actors to create value, informational links between markets and customer meters should be established. The current information asymmetry in electricity markets to a great extent explains the inelasticity of demand (Stoft, 2002). It has been shown that customers respond to dynamic price information (Faruqui and Sergici, 2010), but even in the case of large-volume market participants (such as industrial customers) with advanced metering already installed, timely information about market conditions is only rarely passed-through.

Customers often prefer fixed rates to variable ones (for a survey amongst large Danish consumers, see Dansk Energi Analyse and Norenergi, 2005), and household customers may prefer stable prices as well (Costello, 2004). An astonishing finding is that only a small number of customers with real-time metering is actually bringing flexibility to the market (see Faruqui et al., 2014).

From a commercial point of view, three major reasons contribute to this situation. First, the expected value from response actions on existing markets is low. Second, even though studies claim to identify value created from demand response, it will always be subject to substantial risks. Third, demand-side actors are mostly not held responsible for their behaviour toward the system.

All of these three barriers may be perfectly good reasons, economically speaking, to refrain from implementing demand response in spite of smart metering installations. It would be clearly inefficient to employ demand response if the related costs for