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A review of the costs and benefits of demand response for electricity in the UK

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HIGHLIGHTS

- ► The paper clearly articulates the range of benefits and costs from demand response.
- ► Estimates for benefits and costs are converted into a broadly comparable basis.
- ► It is found that a positive case exists for demand response in the UK.
- ► New quantitative modelling is provided for one UK benefit not found in the literature.
- ► Economic welfare gain is considered in assessment; other UK papers do not consider such effects.

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ABSTRACT

The recent policy discussion in the UK on the economic case for demand response (DR) calls for a reflection on available evidence regarding its costs and benefits. Existing studies tend to consider the size of investments and returns of certain forms of DR in isolation and do not consider economic welfare effects. From review of existing studies, policy documents, and some simple modelling of benefits of DR in providing reserve for unforeseen events, we demonstrate that the economic case for DR in UK electricity markets is positive. Consideration of economic welfare gains is provided.

1. Introduction

For decades the assessment of the costs and benefits of Demand Response (DR) has been one of the focal points of energy economists' research. Recently UK policy-makers opened a discussion about the UK-specific costs and benefits of DR as part of the Electricity Market Reform (EMR). It has been pointed out that an appropriate regulatory framework is essential in order to optimise the benefits of storage and demand side management within the UK liberalised market (Strbac, 2008). For policy-makers to undertake the necessary regulatory changes required to accommodate DR in electricity markets, they must be confident about the economic case for DR.

This paper sets out to review the costs and benefits of DR for the UK electricity market. For this study, five of the most relevant papers and reports assessing potential current and future costs and benefits of DR in the UK are brought together and estimates converted to a broadly comparable form in order to investigate the economic case for DR.

The main studies reviewed are as follows: DECC and Ofgem (2011a, 2011b), Ofgem (2010), Strbac et al. (2010), Strbac (2008) and Seebach et al. (2009). These illustrative analyses inform our survey of costs and benefits. Where possible, the concept of net welfare gain is used to distinguish between investment costs (e.g. installing smart meters) and DR programme returns (e.g. electricity aggregators' profits or consumer savings etc.) on the one hand, and societal costs (e.g. system level upgrades) and benefits (e.g. reductions in interruptions) on the other hand.

The paper aims to both classify the range of benefits and costs that can occur from DR and, where possible, to provide quantitative estimates of costs and benefits. The study then attempts to draw some broad insights and comparison of the order of magnitude differences in various costs and benefits for different forms of DR. Assumed customer participation and customer response rates of the studies are compared with various estimates in the literature in order to provide 'a reality check' to estimates.

The paper firstly provides background information about the implementation of DR in the UK electricity market and reviews the core benefits categories for DR (Section 2) identifies the main

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cost types relating to DR (Section 3); quantifies costs and benefits and CO_2 reductions (Section 4); Section 5 concludes with a discussion of policy implications.

2. Background

Demand side management (DSM) has evolved over the last three decades. Traditionally DSM has been applied and generally restricted to efficiency and conservation programmes.[1] When developing such programmes electricity prices were taken as a given; this is said to have hampered such programmes. More recently however, programmes that emphasise price responsiveness have arisen (Charles River Associates, 2005), The International Energy Agency (2003) seem to follow this line when defining DSM. They define demand side management as including wide ranging actions to reduce demand for electricity (or gas) and/or to shift demand from peak to off peak times. Such a definition can encompass programs emphasising price response as well as automated reductions in energy at peak times. When price responsiveness is considered in the literature, many authors refer to the latter as DR.[2]

Various definitions of DR exist.[3] In this study we apply the broad definition of Albadi and El-Saadany (2008, p. 1990) when reviewing the costs and benefits associated with demand side response.[4] The current study does not however, include energy efficiency improvements as a result of improved insulation etc. as a form of DR.

In order to investigate the costs and benefits of DR a theoretical framework was required to guide our analysis of benefits and costs for this paper and the earlier working paper (Bradley et al., 2011). In this study we draw on the framework used in a robustly developed report by the U.S. Department of Energy (2006). Using this framework requires information and assumptions on the following:

- DR options—e.g. tariff type, programme available or proposed to be used;
- *Customer participation*—the expected extent to which customers participate with programs;
- *Customer Response*—quantifying current structure of electricity usage by participants, and identifying how participants change their consumption patterns in response to price changes or incentives available;
- *Financial benefits*—quantifying (through various methods) the short-and long-term resource savings resulting from DR under varying market structures;
- *Other Benefits*—identifying and quantifying other benefits that can result from a given form of DR (e.g. benefits to functioning of the market or improved reliability); and
- *Cost*—estimating the costs required to attain a level of DR.

When assessing studies that estimate the benefits from DR, U.S. Department of Energy (2006) found a wide variation between illustrative studies and programme performance studies and integrated resource planning studies of DR. Taking these findings on board, this study only looks at one form of study, illustrative studies (within which estimates and methods tend to be more consistent) in one country (the UK) with the same market structure and regulatory environment and often similar years and time frame.

Illustrative studies are said to estimate economic impacts (quantitatively) for DR within a given electricity market.

DR benefits assessment in such studies is based on assuming a level of DR and then estimating consequent benefits, therefore these forms of study are hypothetical and speculative (by U.S. Department for Energy (2006)). Whether these studies benefits estimates materialise, depends on how closely reality and actual circumstance match assumptions used in analysis. From limited analysis U.S. Department of Energy (2006) find that such studies tend to report high benefits, in part due to assuming DR penetration levels to be high, over a large base of participants and also because benefits tend to be assumed to be long term (they assume sustained participation for the period assessed).

Due to the importance of looking at these aspects for illustrative studies, an assessment of the extent to which assumptions on the level of DR compare with the most up to date information on participation and response in DR programs is conducted in Section 4. This study also looks at aspects of the UK context that may increase or decrease participation. This provides a 'reality check' to illustrative study estimates.[5] This study only uses published estimates of benefits and costs from DR as this increases the transparency of reporting (where modelling is conducted by the authors due to unavailable DR estimates, again published data is used).

Beyond attempting to find studies of a similar kind with similar methods, following recommendations by U.S. Department of Energy (2006) this study also attempts to avoid overlap between DR benefits categories. Where this is unavoidable the potential for double counting is identified.

This paper also identifies potential for welfare gains for different types of DR and their quantitative estimates. The latter contribution is important and it is rarely conducted for DR assessments. From all of the main UK studies reviewed, none seemed to identify whether benefits would result in net welfare gains. This is important as different forms of DR can vary in the extent to which they produce actual productivity and efficiency gains for the economy. In welfare economics: welfare is the sum of the producer and consumer surpluses. Welfare gain can be defined as the net increase in consumer and producer surplus without regard to the distribution of the gains (as seen in Boisvert and Neenan, 2003). Wealth transfers do not result in an increase in the sum of the consumer and producer surplus, only a change in distribution of the surplus between producers and consumers. See Boisvert and Neenan (2003) for more information about welfare gains and DR.

In the current study we attempt to identify whether DR benefits are likely to result in a welfare gain, assuming benefits outweigh costs (ABOC).[6] From Section 2.1 onwards the term welfare gain is termed a net welfare benefit in order to keep consistency and fluidity in our use of language.[7]

[1] For efficiency programmes, Spees and Lave (2007) report energy efficiency gains for nine studies, some of which include economic estimates.

[2] E.g. Torriti et al. (2010, p. 1) state that: "*Demand Response* (*DR*) *refers to a wide range of actions which can be taken at the customer side of the electricity meter in response to particular conditions within the electricity system* (*such as peak period network congestion or high prices*)."

[3] See Bradley et al. (2011) for a range of different definitions.

[4] Albadi and El-Saadany (2008, p. 1990) define demand response in a similar but slightly wider way to include energy savings that occur not just in response to network congestion or high prices: "*DR includes all intentional electricity consumption pattern modifications by end-use customers that are intended to alter the timing, level of instantaneous demand, or total electricity consumption*".

[5] The working paper from which the paper stems, also looks in details at methods of each study used. Some important points on methods of the various studies are also brought out in this paper where relevant.

[6] The project stops short of conducting a full welfare analysis due to time and resources required.

[7] A net welfare benefit is different from a net benefit which is any overall benefit that remains once reported costs (related to a demand side response investment e.g. smart metering) are deducted from benefits.