Business participation in demand side response: a review of potential barriers

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Abstract

Demand side response (DSR) is widely seen as the main intervention tool to address issues of peaks and troughs in electricity demand. Businesses can provide DSR through a variety of measures, such as using on-site generators or reducing their electricity consumption in response to external signals. To date, energy intensive firms have been the main providers of demand side response. However, the realization of the technical potential of DSR requires that other electricity end-users also alter their consumption patterns in response to system needs and there is little research on what influences their capacity and willingness to do so. This paper contributes to filling this gap by examining DSR participation of large energy consumers in the commercial and public-sector. In this sector, energy costs typically represent a smaller proportion of overall costs than in energy-intensive industries and partly because of this, energy initiatives tend be perceived as marginal to the core business. These differences suggest that the drivers that have encouraged energy intensive industries to participate in DSR may be insufficient to unlock the technical flexibility of the commercial and public sector. Using concepts from neo-classical and behavioural economics and insights from organizational theory and social practice theory, we explore impediments to the uptake of DSR by large commercial firms and public-sector organizations. We argue that to encourage their participation it would be important to investigate what electricity loads are used for in different firms, how energy initiatives are approached within these organizations, and what role barriers such as hidden costs and status-quo-bias may have in inhibiting engagement in demand side response.

Keywords:

Demand Side Response (DSR)
Non-domestic sector
Commercial firms
Commercial and Industrial (C&I)
Barriers to DSR
Electricity demand

Note:

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1. Introduction

A key challenge to demand side response (DSR) deployment is the engagement of electricity consumers [1,2]. DSR can help smooth peak demand, reduce the cost of balancing the system and facilitate the integration of variable generation sources like wind and solar [3,4]. The realisation of these benefits depends on energy users in the industrial, commercial and residential sectors possibility and willingness to alter their consumption patterns in response to the flexibility needs of the grid. However, there is considerable uncertainty as to how much end-user participation can be expected [5–7] and what are the factors influencing it.

To date, the main provider of DSR has been the industrial sector [8]. In the UK, in 2017, 54% of all demand side flexibility[1] was provided by energy-intensive manufacturing industries, whilst the commercial and public sector together contributed 29% [2] [9]. However, commercial firms have considerable technical potential [10,11] and the expectation is that, in the next decade, large industrial and commercial (I&C) firms will be the main source of DSR [12]. The majority of the work on DSR has been from a system perspective [13–15] and there is limited research investigating business participation. This paper aims to contribute to filling this gap by examining the uptake of DSR by large commercial firms and public-sector organisations[3].

Commercial firms' use of and approach to energy is different from that of industry. Electricity consumption is mostly related to building occupancy – the main loads are for lighting, heating, ventilating and cooling working premises - rather than for manufacturing process [16]. Their energy costs represent a small proportion of total costs and, typically, energy is not a strategic consideration [17]. These differences suggest that the participation of the commercial sector in DSR may be driven by different factors than those that have encouraged industry to flex their consumption.

To examine large commercial firms' participation in DSR, we use concepts and insights from the literature on energy efficiency (EE). EE and DSR have sufficient in common to indicate that barriers to EE may also affect DSR. They are both forms of Demand Side Management (Warren, 2014) and within organisations those responsible for EE, such as energy managers are typically the ones managing DSR initiatives. However, there are also key differences between EE and DSR, which indicate that although we can use a similar framework to examine them, the relevance of individual barriers and the way in which they impact on DSR and EE is different [18]. Whilst EE requires lowering the amount of power used to achieve a specific output, DSR focuses on load shifting aspects of energy consumption [19]. Financial returns for DSR are also highly dependent on several external factors, such as meteorological conditions affecting both electricity generation and electricity demand, developments regarding available capacity in ancillary and other energy markets, and investments in the grid network [20]. EE is a well-known concept whereas DSR and the smart grid is a fairly abstract concept, difficult to understand for those without knowledge of the functioning of the energy system and energy markets [21,22].

Our analysis draws on the typology of economic, behavioural and organisational barriers developed by Sorrell et al [23,24], as well as on findings from social practice theory in non-domestic settings [25,26]. Sorrell's typology is widely accepted in the EE literature and has informed previous studies on DSR barriers [18,27]. It focuses on factors internal to the firm and it takes external factors such as energy markets as given [28], which is also the approach taken in this study. The literature on social practice theory also helps explain energy related choices within firms by examining how material arrangements, social settings and temporal rhythms shape energy demand [26].

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[1] DSR accounts for 95% of total demand side flexibility. The remainder 5% refers to generation for export only and energy storage. BEIS, 2017; page 22.

[2] 17% of demand side flexibility is provided by 'other - Water Treatment, etc'. BEIS, 2017; page 23.

[3] In this paper, we use the terms 'commercial firms and public-sector organisations', 'commercial firms', and 'the non-domestic sector' interchangeably.

We use the concept of 'barriers' in the same way as Banks and Redgrove [29], so factors that impact on investment decisions but that cannot be perceived in isolation, as they interact with each other and are dependent on the context of the individual organisations. Based on the available evidence and on the characteristics of the commercial sector, we have chosen to structure our analysis using the concepts of hidden costs, risk, bounded rationality, loss aversion and status-quo-bias; insights from organisational theories are used throughout the paper, in particular regarding decision-making processes within complex organisations. However, the objective of this paper is not to provide a comprehensive review of what can impede the uptake of DSR, but to offer a deeper understanding of DSR implementation by large non-domestic organisations, that what we have been able to find in the existing literature. The findings can inform some of the assumptions used in modelling DSR potential and also policies aimed at encouraging business participation in DSR.

This paper is structured as follows: Section 2 provides background information on DSR and reviews the literature on business participation. Section 3, summarises the different theoretical approaches to the EE 'gap'. Sections 4, 5 and 6 examine how economic barriers, behavioural considerations and contextual factors can hinder the uptake of DSR. Section 7 concludes with a discussion of policy implications.

2. Background

Businesses can provide DSR through the use of on-site generators (generator-led DSR) or by temporarily increasing or decreasing their electricity consumption (demand-led DSR) in response to specific conditions within the electricity system [30]. They are encouraged to participate through price or incentive signals. Incentive-based programmes, which are the focus of this paper, typically require participants to commit to provide pre-specified load reductions (or increases) to help balance the system at times of stress [19] If providing demand-led DS, electricity loads can be adjusted manually or through direct load control, in which case third parties remotely turn off equipment within previously agreed parameters[14]. Incentive based schemes involve contracts between electricity consumers and a DSR buyer, such as the system operator or a distribution network operator; in the commercial and public-sector contracts are frequently between the DSR provider and an aggregator, who buys DSR capacity from several individual energy demand sites and then sells the aggregated load to the system or distribution network operators. Contracts specify the required response time, response duration, quantity and regularity of the service, as well as the financial rewards for being on standby and for actually providing DSR in case of an event, and the penalties for non-compliance [31].

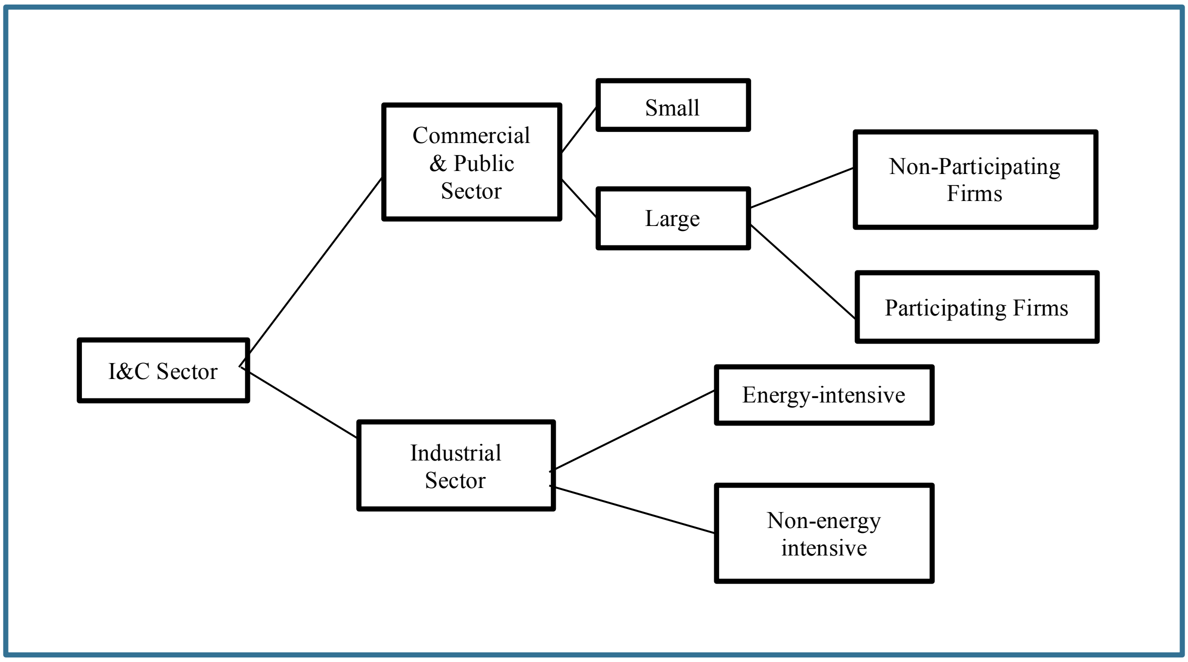
The National Grid (NG) estimates that in 2016, 2.7 GW of DSR, equivalent to two large power stations and corresponding to 4.5% of peak demand, participated across their portfolio of balancing products [32,33]. This was provided by large I&C consumers using a combination of generation and demand-led DSR [9]. DSR potential, however, is higher; the International Energy Agency estimates that the average is 15% of peak demand [8]. In the UK, research by ADE (2016b) concluded that businesses could provide 16% of peak demand, or 9.8 GW of DSR, 4.5 GW of which being demand-led and the rest diesel-based on-site generation and CHP [35]. This figure is in line with the findings of another study that estimated the economic potential of DSR by evaluating how much of it would be competitive against dispatched generation, concluding that the I&C sector could provide 5 GW of turn-down DSR [12].

To assess how much of DSR's economic potential can be realized it is necessary to consider the barriers to the diffusion of DSR [10], including those preventing business participation. Most work in this area has considered barriers from a system perspective, such as the difficulties of modelling, valuing and incorporating DSR into energy markets [36,37]. Regarding consumer barriers, several authors discuss the challenges faced by households [38,39] but relatively little has been written about the I&C sector [40–42].

Businesses' participation in DSR schemes can be inhibited by several factors. A frequently mentioned impediment is firms' lack of knowledge of the opportunities of demand side response, noted for example in a statement by Ofgem [43] p.26) "many [I&C], including commercial customers, are prevented from participating more fully because they are unclear about the monetary benefits of providing flexibility, as well as of the programmes available to them". Current market structure and regulatory environment, having been originally designed for centralized generation, also fails to cater for the characteristics of DSR providers [44–46]. A study of non-domestic consumers found that some of the regulatory conditions of the National Grid (NG) balancing services for example, prevent higher penetration of demand-led DSR [47]. In their review of DSR barriers, Good et al [27] include many that can impede electricity end-users, including business consumers, from providing demand side response, such as difficulties accessing capital, uncertainty about future revenues, hidden costs and bounded rationality. A study of barriers to load shift adoption by German non-energy intensive manufacturing companies found that risk of disruption of operations, impact on product quality and uncertainty about costs savings were the most relevant barriers [18].

As it can be seen in Figure 1., the I&C sector includes two very different types of businesses – industrial firms, which consume electricity mostly for productive processes and, commercial enterprises, which require electricity for building-related purposes, namely lighting; heating, cooling and ventilation (HVAC); catering and refrigeration, and computing. Given the different types of electricity loads, industrial and commercial consumers face different types of barriers [2]. For industrial firms some of the main constraints are the criticality of production processes, the number of available production lines and inventory restrictions; for non-domestic organisations key barriers are loss of comfort, perceptions of business risk and prohibitive capital costs [2]. Previous studies have also noted that in non-domestic firms, regulatory constraints [47] and the context and the purpose of electricity use also has implications for DSR provision [26].

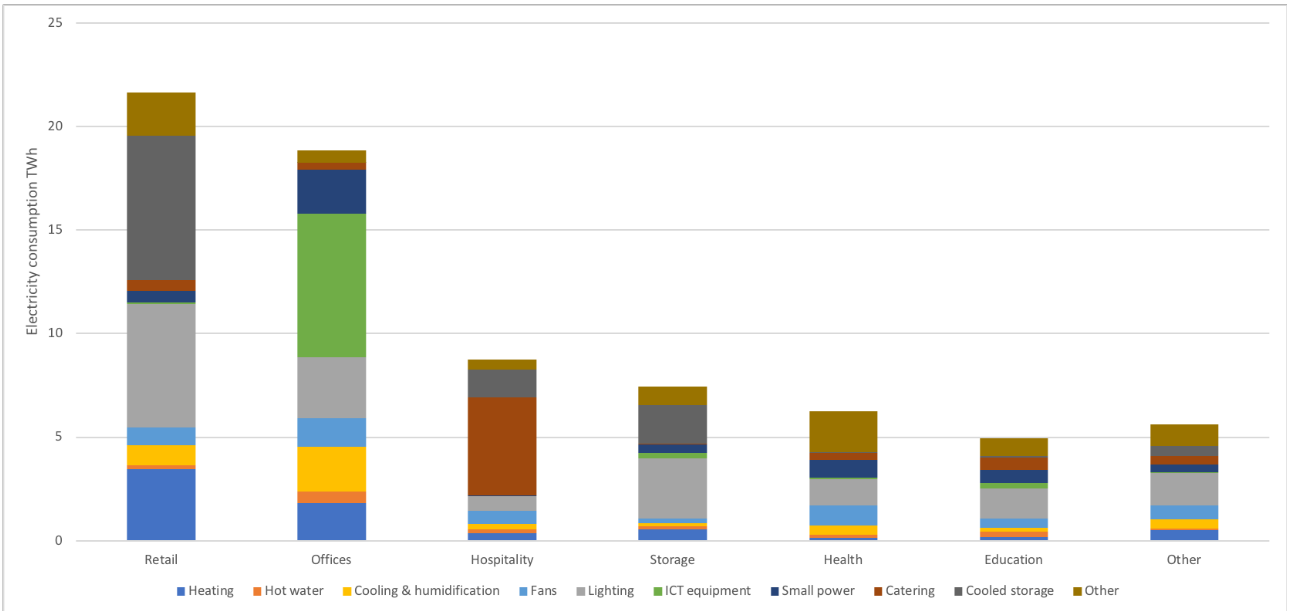
Figure 1. Categorisation of the I&C sector



Commercial firms account for approximately the same proportion of total energy demand as the industrial sector [48] and for 30% of peak demand [11]. Their potential to provide demand-led DSR was estimated to be 1.7 GW [34]. Other studies suggest that technically the non-domestic sector could provide between 1.2 GW and 4.4 GW of turn-down DSR [11]. Commercial premises with highly critical electricity loads, such as hospitals, data centres banks and some large commercial offices also have back-up generators to use in case of emergency [11]. Generation-led DSR may provide an additional 1GW – 4 GW between now and 2020 [49].

Commercial firms include both large and small consumers, as it can be seen in Figure 1. The electricity consumption of large energy users in the non-domestic sector has been historically half-metered, which together with the considerable size of their loads can help explain why until now they have been the main provider of DSR after industry [50]. Large surfaces, such as supermarkets and shopping centres with high heating and cooling requirements and significant thermal inertia can have considerable DSR capabilities [44]. However, as shown in Figure 2, individual commercial loads are typically smaller and more dispersed than those in energy intensive sectors. Most large commercial firms also lack the advanced facilities for energy control that energy intensive industries have, which is why participation in DSR may involve considerable capital costs.

Figure 2. Electricity consumption in the non-domestic sector. Based on BEIS, 2016[4] [16]



Whilst previous research has identified a number of barriers that currently inhibit the uptake of DSR by electricity end-users, to our knowledge no study has focused specifically on what determines DSR participation by large commercial and public-sector consumers. This paper contributes to filling this gap by presenting a review of barriers that can prevent large organisations in the commercial and public sector from participating in existing DSR programmes.

Drawing on evidence gathered from the academic DSR literature, and on publicly available reports, surveys, qualitative interviews and trials, we examine how barriers identified in the EE literature can influence business uptake of DSR. The focus is on multi-site commercial firms and public-sector organisations with little or no experience of DSR, which represent the majority of commercial firms.

[4] Based on Table B.3: Energy consumption simplified energy end use by sector and energy type, 2014–15 p.122, BEIS, 2016.

3. Perspectives on the EE 'Gap'

Explanations for the EE 'gap' generally include insights from different methodological approaches [28,29,51]. In this section, we review the four approaches used in this paper.

Neoclassical economics assumes that individuals act rationally and explain the EE gap through the existence of market barriers and market failures [23]. Market barriers are factors that explain why apparently cost-effective technologies are not taken up, whilst market failures describe situations when markets do not function as expected by neoclassical economics. Behavioural economics (BE) relaxes several of orthodox economics' assumptions, including that of perfect rationality [52]. When taking decisions, individuals are unlikely to be able or willing to evaluate all the costs and benefits associated with the options under consideration. Issues of bounded rationality and strong aversion to loss - real, potential or perceived – have also been shown to explain the EE gap [53,54].

Non-economic approaches such as organizational and social practice theory dispute the assumption of both orthodox and neoclassical economists that energy decisions are down to individuals. Organizational theories focus on the way organizations are structured and how internal rules and the way in which individuals interact within a firm influence their decisions. For the purposes of the present analysis, a key contribution of organizational approaches is the understanding that firms do not act as single actors, which is the frequently held assumption of orthodox economic explanations of the EE gap [55]. In large, multi-site commercial firms decisions about energy tend to involve complex decision chains and many different stakeholders – besides the energy manager, other decision-makers with a say on energy decisions include managers from the finance department, engineers from the buildings and maintenance team, senior managers and, in the case of offices, the building occupants [16,55].

Social practice theory argues that decisions about energy use and by extension about energy efficiency occur within a social context [56]. Energy is used for accomplishing social practices, at home but also at work [57]. The patterning of social life is a consequence of routine, collective and conventional nature of consumption [58]. From social practice theory, the timing of energy demand can be defined as the result of the socio-temporal organisation of daily practices. From this it follows that decisions about energy investment are not solely determined by an evaluation of a project's costs and benefits, and by the decision-makers' individual motivations, but also by what is feasible and expected within institutional settings as well as by the necessary energy-using technologies [26].

4. **Economic barriers**

4.1 Hidden costs in the commercial and public sector

Hidden costs, that is, costs that are not conventionally included in engineering-economic studies of energy efficiency, the most important explanation for the EE 'gap' [24]. The reviewed evidence suggest that they may also play a role with regard to the participation of the commercial and public sector in DSR programmes.

DSR participant costs are typically categorised as initial costs, which refer to the cost of investing in enabling technology and establishing a response plan, and event specific or activation costs, which are the costs incurred when they respond to a DSR request [59]. For energy intensive industries, the activation costs tend to be the most relevant ones, as they normally have the necessary equipment in place, whereas for the typical loads of the commercial and public sector, such as HVAC the initial costs are the most relevant [60]. An estimate of the activation cost for industrial processes indicates that it can range from £80 to £400 per MWh, whereas for ventilation loads in commercial premises, it can be up to £15 MWh [12].

Quantifications of initial participant costs tend to cover the initial capital cost of enabling investment [1,49]. However, there are other costs associated with DSR programmes, which if sufficiently high can reduce firms' interest in participating. Drawing on the available empirical evidence, this section explores the hidden costs associated with the decision of whether or not to participate in DSR, and those that are part of the initial costs of participation. Table 1 provides a summary of these costs.

Market transaction costs (TCs) are the costs of gathering information about products and suppliers, managing contracts and administrative procedures for external transactions; they are largely influenced by the market and therefore by factors outside the businesses' control [23]. To decide whether or not to participate in DSR, firms first need to spend time and resources collecting data on their electricity use, identify the sites that have the potential to turn down or turn up their electricity consumption in response to external signals, assess the suitability of existing generators for participation in DSR programmes, and evaluate the costs and benefits of the various options [61]. Assessing options and comparing their net returns can be time consuming as DSR markets are complex and difficult to understand [22,62]. Although recently simplified, the NG balancing services has 11 different products to choose from, each having specific requirements regarding minimum contribution, notice period, duration, regularity, procurement process and contract duration. Choosing the correct product is key as revenues can vary considerably [12].

If after the initial assessment, a firm chooses to proceed, there are further legal and administrative procedures [35]. A study of non-energy intensive firms, noted that administrative overhead costs could be hard to foresee if companies lacked experience in DSR provision and as a result of complex management requirements [21]. Similar observations were made at stakeholder meetings facilitated by the NG, where business consumers commented that participation in DSR was 'unduly burdensome, with substantial paperwork' [64]. Administrative requirement are particularly onerous for commercial firms – for example, to participate in the Capacity Market (CM), sites need to provide a line diagram showing all the loads connected to the service – the cost of preparing the diagram increases with the number of loads, which in commercial buildings can be very high [65]. For multi-site organizations the non-standardization of contracts adds further complexity [63].

Table 1 DSR Hidden Costs (based on Sorrell et al. 2004[23]**)**

Type of hidden costs	Cost examples
Market transaction costs	• Gather sufficient information on DSR to allow initial decision to participate. • Choosing aggregator and negotiating contract • Managing contracts • Collecting half-hourly electricity usage data from different sites
Organisational transaction costs	• Internally championing DSR • Coordinating contribution from different departments
Hidden production costs (of DSR)	• Production interruptions to allow equipment installation • Overhead costs to allow equipment installation outside business hours • Searching for suitable equipment

Most large I&C businesses, 74%, participate in the balancing and CM through aggregators [50] [i]. Aggregators absorb some of the market TCs: They provide information on DSR options, assess the sites' technical capacity and identify the products that best match the capabilities of the company [66]. Aggregators also cover the administrative requirements of DSR participation and manage the market bidding [67]. However, engaging an aggregator reduces the financial benefits of DSR, as they take a share of the revenue estimated to range from 10% to 50% [68]. There are also TCs involved in choosing an aggregator and in negotiating, managing and monitoring their contracts. The fact that most firms choose to engage aggregators, despite the costs in terms of lost revenue and TCs involved, suggests that market TCs of participating in DSR are high.

Organisational TCs are mostly dependent on the characteristics of the firm [23].They include the time needed for championing DSR within the organization – persuading site engineers of its advantages and assuaging concerns about potential impacts on primary operations. Energy managers coordinate the provision of data from different departments and help negotiate individual site contracts. In large firms, the complexity of decision-making procedures can make organisational TCs particularly onerous, as exemplified by the following quote:

> "The onsite energy manager thinks DSR looks interesting and could provide revenue. They have to speak to the estates team, who will look at the asset register. Then they have to get in touch with the finance guys to ask whether they can go ahead; there might be some invoicing arrangements, there might be funding required. Then they have to consult with the clinicians, who are acutely concerned about any break in supply. … Lastly, somebody from procurement will need to get involved to choose the supplier that is offering the best value" (comment by interviewee [69] (Energyst, 2017, p. 21)

Hidden production costs include the time spent finding suitable equipment for participating in DSR, which have been highlighted as one of the main barriers to participation [70]. Equipment may be unsuitable because it cannot meet DSR performance requirements, such as responding to a DSR signal within a specified timeframe or because it is unable to interact with the businesses existing equipment. Other hidden production costs are the inconvenience of installing new equipment, which may have to be done outside business hours to avoid disruption [71]. For commercial firms, hidden production costs can represent more of a barrier than for companies operating in energy intensive sectors as costs per MW are typically higher for DSR types with relatively low capacity per component i.e. refrigeration and chillers, pumps and building HVAC. The larger industrial DSR types benefit from economies of scale and typically already have the necessary metering and control systems in place as it is needed for process control and routine energy management [60].

4.2 Risk

Rational responses to risk are to require more stringent investment criteria, postpone investment or decide not to invest [23]. Some factors or attributes associated with risks are captured by economic models, such as those that originate from uncertain revenue streams, while others can be more difficult to estimate, like the perceived risks of investing in new technologies. However, whichever the source of risk to DSR participation, if businesses perceive it to be high, this can act as a barrier to participation.

The main risk associated with DSR is that it may have a negative impact on organisations' core business. Interviews with energy managers in the non-domestic sector concluded that the risk of reduced service levels is considered so high that unless there are strong assurances that business would not be disrupted, responders prefer not to participate in DSR [11]. A more recent survey of large businesses noted that the 'risk to the business' was the most frequent barrier to DSR provision mentioned by both respondents participating in DSR and not participating in DSR [50]. In a yearly survey carried out by a DSR specialised publication, ‘disruption and potential impact on business performance’ was once the third and twice the second most frequently mentioned reason for not participating in DSR [65,69].

Firms’ concern that participating in DSR is risky to their core business may be due to DSR being an unfamiliar concept. The smart grid can be a fairly abstract concept operating in the background and difficult to understand without basic knowledge of the energy market [21]. Uncertainty over standardisation and lack of guidelines about technical and safety issues further contributes to heighten perceptions of risk [47]. A frequently mentioned barrier in business surveys and interviews is end-users’ reluctance to cede control of a firms’ internal electricity systems to a third party. Automation is particularly important for the non-domestic sector. It reduces the risks for aggregators and allows businesses to assess a wider and more profitable range of products [26]. In the last Energyst survey (2017), only 13% of respondents mentioned third party control as a reason for not participating in DSR, but most other studies reviewed note that consumers are at best cautious about automation, especially if they lack prior experience with the process [11,22,71]. In the above mentioned survey of large I&C firms, third party control was the most frequently mentioned barrier for not participating in DSR - over 50% of respondents considered it a problem [50].

The second most common risk associated with DSR is the uncertainty of financial returns, which partly results from the characteristics of DSR markets. In the CM, the existence of auctions means that the price is only known once the market clears; financial returns are partly dependent on DSR being needed, which is outside the control of businesses; and contracts are for one year only, which impacts on the possibility of spreading revenue risk over a longer period of time. Potential investors interviewed for an assessment of the CM reported that these uncertainties acted as barriers to participation [68]. Similar observations were made in a study of German firms, that noted that a central drawback of DSR was that prices could not be predicted reliably [21].

Some of this uncertainty, such as those inherent in auctions, may be acceptable in other areas of the business but in the case of DSR initiatives, lack of secure financial returns can hamper energy managers’ efforts to enlist the support of other decision-makers within the firm. Participants in stakeholder meetings with the NG have reported that the risk involved in DSR investments has made it difficult securing internal buy-in and in some cases resulted in companies favouring alternative programmes, such as LED lighting replacement [73]. The combined effect of high market TCs and other hidden costs, together with revenue risk may explain why some surveys have found that businesses require higher financial returns than currently being offered by the market [41,50,69].

5. Behavioural Economics

In reviewing how bounded rationality, loss aversion and the status-quo-bias can influence the choices stakeholders make about DSR, this section aims to demonstrate that decisions about energy are not always and solely based on the economic merits of DSR.

5.1 Bounded rationality

Bounded rationality means that individuals are rational but limited in terms of their attention capacity, their knowledge and their ability to forecast the future [52]. As they lack the time and resources needed to find optimum solutions, they resort instead to rules of thumb and aim for satisfactory rather than optimal outcomes [74]. Bounded rationality is most relevant for issues that are perceived as marginal to the core business, as it is generally the case with energy in the non-domestic sector [29] and during the initial stages of the decision-making process [75].

In the commercial sector energy costs tend to be a relatively small element of expenditure. On average, they make up 0.5% of total costs, whereas for energy intensive industrial firms they can represent 8% or more [76]. This may partly explain why for commercial businesses energy is typically not a strategic priority, even amongst large energy consumers [17,77]. In the UK, 57% of large non-domestic firms have a specialist energy manager but of these, only some are actively engaged in EE initiatives. The proportion of large companies with both the capacity and ambition to reduce energy consumption is 44% [16].

Empirical studies looking at DSR in the USA, Germany and Great Britain link the lack of interest in DSR solutions and the low importance of energy in sectors such as the commercial sector, where energy costs represent a small percentage of operating costs [11,21,22]. As resources for investing in energy decision-making processes are limited, firms tend to concentrate on the primary business and use ‘rules of thumb’ to make ‘satisfactory’ choices about energy [78,79].

A qualitative study of barriers to participation in DSR programmes by mostly commercial firms in London, found that one of the key differences between firms participating or not participating in DSR programmes was energy managers’ time and technical capacity [41]. Whilst energy managers in participating firms worked full-time on energy matters, in non-participating firms, the person responsible for energy had also other duties. Most interviewees in non-participating firms knew about the benefits of different DSR options, but felt that introducing DSR was not part of their role.

Decisions about energy and EE initiatives are part of a decision-making process, which can be described as including three stages: identification, development and selection [75]. Although formal economic methods of assessment are frequently used in the selection phase, during the identification phase bounded rationality and the use of heuristics such as shortcuts and routines, and unconsciously searching for information to support their existing views, play a larger role and can distort decisions.

If time and resource constraints lead to using heuristics in decisions about EE it can be argued that the same may happen regarding DSR. There is some evidence to support this argument. In the aforementioned survey of London firms, the authors note that the main barriers to participation were negative perceptions of DSR including the notion that participation is time consuming, risky and costly without looking into the specific costs and benefits of different options [41]. A study of aggregators’ acquisition process found that a primary reason for sites not taking up DSR during the first two stages of the selling process was lack of interest, whilst during the last third and last phase, more specific reasons were given, such as technical unsuitability of assets [66]. A possible interpretation for these results is that during the initial phases, decisions about DSR were taken without carrying out a detailed assessment of the aggregators’ proposals.

5.2 Loss aversion and the status-quo-bias

A central tenet of BE is that individuals estimate costs and benefits in relation to a neutral reference point. As people value costs more highly than benefits - they are ‘loss averse’ – if the costs and benefits of an action are the same in absolute terms, they will fear the costs more than they will value the gains and therefore will choose not to act [80]. Organisations’ loss aversion can be described as a conservative bias - people are unlikely to get blamed for doing things in the traditional ways, but doing something new may carry a high personal risk of being blamed if it goes wrong [81]. Loss aversion can thus stop a firm from providing DSR, as even if the potential benefits are high, the risks involved carry more weight with the decision maker.

The reference point in relation to which costs and gains are assessed is often the status-quo. Individuals tend to show a preference for the status quo because the disadvantages of leaving "loom larger than the advantages [82]. Interviews with DSR stakeholders about business provision of flexibility services, mention inertia as a reason for preventing DSR projects from happening [41,65,69,83]. The term 'inertia' describes the inaction of companies for no identified reason but it can also be understood as a strong preference for the status-quo.

The 'status-quo-bias' can hinder the uptake of DSR for two reasons. First, DSR represents a radical departure from how consumers perceive energy use. Access to energy on a continuous basis is taken as a given and flexing consumption in response to external signals can be seen as a deviation from what, from the organisation's perspective, is a well-functioning system [21,84]. This is most likely to be the case with decision-makers other than energy managers. A comment by the person in charge of DSR for an international hotel chain illustrates this issue: the biggest challenge of implementing DSR is 'getting our internal audience to understand the concept of 'turning down' at their peak operating times" [83]p22).

Second, uncertainty enhances the attraction of the status quo, which, whatever its limitations, has the value of being known [85]. As aforementioned in section 4.2, there are considerable levels of uncertainty inherent in the design of the CM and in some products in the balancing market. Changes in legislation which are perceived as piecemeal also add to feelings of uncertainty [86]. A survey of potential investors in the CM reported that lack of certainty about the future policy environment was one of the issues that needed to be addressed [68]. These comments were made by businesses already engaged in DSR discussions. However, they also indicate that DSR is associated with many uncertainties and unknowns – auction prices, number of DSR events, complexity of regulation, changes in policy and market regulations, access to electricity supply – which if taken together might result in perceptions of DSR being risky and reinforce the status-quo-bias.

In summary, whilst projects which are central to the business are generally assessed using robust decision-making approaches, peripheral projects such as energy related initiatives in non-energy intensive sectors, are often evaluated using heuristics. Issues of bounded rationality, loss aversion and the status-quo-bias may thus be significant for initial decisions on whether or not to participate in DSR.

6. Social practice perspectives

Socio-technical perspectives on energy demand point out that decisions about energy are 'an outcome of what energy is for' [87]. What people and organisations do – and what they use energy for - are seen as social practices; for example, in the case of a hotel, energy is part of social practices such as cooking, washing dishes, washing clothes and cleaning [26]. These practices are embedded in social settings and temporal rhythms of everyday life, and influenced by material arrangements [25,56,57]. For social practice theory, the central topic of enquiry is the social practice itself [57] rather than the individual, as it is the case in orthodox and behavioural economics, or the organisation, as it is the case with organisational theories. In this paper, however, and in line with other energy researchers [88] we take the insights of social practice to gain a better understanding of individuals and organisations behaviour. In the remainder of the section, we briefly discuss some ways in which social settings, temporal rhythms and material arrangements can influence the uptake or otherwise of DSR programmes in the non-domestic sector.

The setting for DSR, that is, whether energy consumption is taking place in a hotel for example, or in a school, can be used to show how feasible it is in practice to change energy use in response to signals coming from the energy supply system [89] . Two identical office buildings (in terms of physical characteristics) can experience different levels of electricity demand at different times of the day depending on the commercial activities taking place. Whether or not a building can participate in DSR depends thus not only on the technical characteristics of its loads but also on the sector it operates in and on the purpose of the electricity use. The practices taking place in the workplace are associated with different rhythms. Similar buildings will have different daily or yearly rhythms if they operate in different settings, which in turn will impact on when and how they can flex their consumption [11]. For instance, offices used in the education sector tend to have a typical nine-to-five routine while in the healthcare sector diurnal variations are lower. Schools are more likely to have yearly variations with higher occupancy during term time and less during the summer months than offices in banking. In hospital buildings, energy used is determined by medical practices, rhythms of sequencing for treatment scheduling and provision of care [89].

A study of the DSR potential of individual loads in a hotel site demonstrates the relevance of material arrangements and of every day social practices for determining the provision of DSR in commercial organisations [26]. There are four different loads: lighting, HVAC, computing and catering. From a technical perspective, all four loads can contribute to DSR, however, what the loads are used for, the regulations affecting their use, and the time constraints of their usage, limit the flexibility that they can offer. Flexing lighting in rooms is not possible as it would affect hotel customers; flexing refrigeration can be done without impacting on users, but health and safety regulations about food conservation make this option unfeasible. HVAC does not share the limitations of the other two loads but whether it can participate in the most profitable forms of DSR depends on the business's acceptance of automatic remote control.

The purpose for what the electricity is being used and the social context for those activities impacts on the economic and behavioural barriers discussed in sections 3 and 4. This can be exemplified by firms' perceptions of risk. Organisations may be more or less risk averse depending on what the energy is being used for. Hospitals are often weary of using their generators for DSR as for them reliability is paramount [49]. For data centres, the issue is one of security and privacy and their main concern is granting third party access to their equipment [69]. Firms' willingness to consider energy issues is therefore related to their core business. With regard to EE, it has been observed that offices working in environmentally sensitive areas such as oil, tend to use EE projects to offset negative reputation effects. Energy consumption is also more salient in sectors that trade directly with the public such as retailers [29]. Similar patterns can occur with regard to DSR.

7. **Conclusion**

This paper has examined barriers to the engagement of large energy consumers in the commercial and public-sector organisations, in DSR progammes. Market transaction costs, perceptions of risk to primary business and to DSR revenue, bounded rationality, status-quo bias and what energy is used for in different firms, are important factors influencing the uptake of DSR. Given that information on DSR in the commercial and public sector is limited, this analysis has not intended to determine the materiality of these barriers. However, the results from this exploratory review would suggest that further research is warranted to assess the impact of these barriers on the commercial and public sector as a whole and also on specific subsectors.

Initial decisions about new energy investments and, by extension, about DSR initiatives, are not always taken by energy experts after careful consideration of the investments' pros and cons. Many of those responsible for energy decisions are unlikely to have the time and resources to explore new opportunities and thus decisions about DSR might be based on quick assessments of perceived risks and other heuristics rather than on formal procedures. In large commercial firms, decisions about DSR require the approval of a range of stakeholders; for many of them, energy projects are unlikely to be a priority and they may have little to gain from participating in DSR. Furthermore, the concept of flexing energy consumption and of allowing third parties to switch off their appliances might represent a considerable departure from the status-quo and thus may object to DSR initiatives without much consideration of individual benefits. For more engaged and informed decision-makers, the level of market and organisational transactions costs involved in DSR programmes, combined with the risk of participation, may also prevent them from engaging.

Participation in DSR is also constrained by the purposes for which electricity is for. A specific load such as HVAC, has considerable technical potential but whether it is used in a hospital setting or an office building setting will influence how much DSR it can actually provide. Perceived risks of providing DSR and the type of DSR products that organisations can access will also vary with the setting in which the electricity load is being used, therefore the profitability of DSR products may differ considerably between sectors.

There is a strong expectation of DSR policies making demand flexible, but the extent to which the technical and economic potential will be realised through market routes will depend on how individual firms take up DSR. The finding of the present study would suggest that if we are to encourage the commercial and public sector to participate in DSR, it may be necessary to develop and support DSR opportunities that are easy to understand by non-energy specialists and that involve reduced levels of risk.

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