Sustainability *First*

GB Electricity Demand – *realising the resource*

Paper 3

What Demand Side Services Could Customers Offer?

Industry Electricity Demand

By Maria Pooley, Judith Ward and Gill Owen.
Sustainability First

September 2012

Published by Sustainability First

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Sponsored by: BEAMA ; British Gas ; Cable & Wireless ; Consumer Focus ; EdF Energy ; Elexon ; E-Meter Strategic Consulting; E.ON UK ; National Grid ; Northern Powergrid ; Ofgem ; ScottishPower Networks ; UK Power Networks.

Smart Demand Forum Participants: Sponsor Group members ; Energy Intensive Users' Group ; Which? ; National Energy Action ; Brattle Group ; Lower Watts Consulting; DECC; Sustainability First.

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Preface

Sustainability First

Sustainability First is a UK environmental think-tank with a focus on practical policy development in the areas of sustainable energy, waste and water. Sustainability First undertakes research, publishes papers and organises policy seminars. It is a registered charity with independent trustees – www.sustainabilityfirst.org.uk.

Since 2006, Sustainability First has produced a series of major multi-sponsor studies on GB household smart energy meters and brings significant knowledge and insight in the fields of energy efficiency, smart metering, smart energy tariffs and demand response[1].

The Sustainability First project on **GB Electricity Demand** began in April 2011. It is supported in its first year under the Northern Powergrid Low Carbon Network Fund project - and thereafter for a further two years to April 2014 via a multi-sponsor group.

Sponsors include : BEAMA; British Gas; Cable & Wireless; Consumer Focus; EdF Energy; Elexon; E-Meter Strategic Consulting; E.ON UK ; National Grid; Northern Powergrid; Ofgem ; ScottishPower Networks; UK Power Networks.

Work is coordinated through a **Smart Demand Forum** whose participants also include a number of key consumer bodies: Energy Intensive Users Group, Which? and National Energy Action; plus DECC and the sponsor group members.

The project aims to identify the potential resource which the electricity demand side could offer into the GB electricity market through demand response and through demand reduction. The project aims to:

- Evaluate and understand the potential GB electricity demand-side resource across all economic sectors (including the role of distributed and micro-generation).
- Develop a clearer understanding of the economic value of this resource to different market actors and to different customers over the next 10-15 years.
- Evaluate the key customer, commercial, regulatory and policy issues and interactions.

[1] Sustainability First published smart meter papers are available on the website – www.sustainabilityfirst.org.uk

The project will develop a substantive knowledge-base, and provide visibility and thought-leadership for GB electricity demand-side issues. The project is undertaking work relevant to:

- GB smart meter deployment.
- Low Carbon Network Fund projects – emerging lessons and insights from the LCNF projects will be fed into the project.
- Proposals for Electricity Market Reform.

The work programme is being delivered through the Smart Demand Forum, through annual wider stakeholder events, and through a series of published papers and other materials. The project is run by Sustainability First. The Sustainability First team is Gill Owen, Judith Ward and Maria Pooley.

Additional expertise and inputs are provided by Serena Hesmondhalgh of Brattle Group who is developing a quantitative all-sector demand model. Stephen Andrews is supporting the project on Distributed Generation and Micro-Generation.

Key themes for the project include:

- **Customer Response and Consumer Issues –** A key focus for the project is to understand successful and cost-efficient demand-side participation from a customer and consumer perspective (household, industry, commercial and public sectors). This will include experience provided through the LCNF trials (e.g. tariffs, remote control of appliances, technologies such as micro-generation, electric vehicles etc.) and other similar initiatives in the UK and elsewhere. For households, this will include any particular issues for the fuel poor and potential distributional impacts.
- **Commercial** - Practical realisation of demand-side services - given different roles and requirements in the value chain. Issues likely to include: the nature of commercial agreements, the role of third parties (DNOs, ESCOs, aggregators), the kind of information-sharing likely to be necessary between parties etc. – drawing from practical experiences of the LCNF Trials and other experience in the UK and elsewhere.
- **Regulatory –** near and longer term regulatory factors that impact upon development of an active electricity demand-side for Great Britain – including current agreements between market actors, statutory codes, incentives in price controls, settlement, and third-party requirements. This will include experiences within the LCNF trials, and also feed into future considerations for price controls, RIIO and other thinking on innovation incentives.
- **Public Policy Issues –** likely economic value and potential contribution of the demand side to: cost-efficiency across the electricity sector; security of supply; carbon-emission reductions. Business models, approaches and incentives for integrating the demand side into the electricity market, including its interactions with Electricity Market Reform, smart meter roll-out and energy efficiency schemes such as the CRC Energy Efficiency Mechanism, Green Deal and Energy Company Obligation.

The project will also draw upon relevant information from demand side developments in other countries (notably the EU and US) to inform its work.

Papers published in the first year of the project are:

Paper 1 - GB Electricity Demand in 2010 - baseline data and context. Published October 2011.

Paper 2 - GB Electricity Demand 2010 and 2025 – Initial Brattle Electricity Demand-Side Model: Scope for demand reduction and flexible response
Published February 2012.

Paper 3 -What demand-side services could GB customers offer in 2010?
Industry paper published March 2012 – final paper published September 2012.
Household paper published May 2012.

Paper 4 -What demand-side services can provide value to the electricity sector?
Published June 2012.

All papers are available from on website at:
http://www.sustainabilityfirst.org.uk/gbelec_documents.html

The first two papers in Year 2 will be:

Paper 5 -The electricity demand-side and wider policy developments

Paper 6 –What demand-side services does distributed generation bring to the electricity system?

Future topics are also likely to include:

- Evolution of commercial arrangements, alignment of commercial drivers, regulatory incentives and prospective business models for development of a more active electricity demand-side
- Electricity demand and consumer issues
- Active I&C Customers
- Active Household and Micro-business Customers
- Longer-Term Demand-Side Innovation and Realisation

Sustainability First
September 2012

Paper 3

What demand side services could customers offer?

Industry Electricity Demand

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1. Introduction

This is a paper on Industry Electricity Demand, Electricity Efficiency and Demand Side Response within industry. It is based on a small scale survey of industrial electricity users from a range of industry subsectors.

This paper complements the paper on domestic electricity consumption: **'What demand side services could household customers offer?'** published by Sustainability First[2]. Separately, electricity demand within the **commercial** sector is covered in a recent paper commissioned by Ofgem[3].

In this paper we aim to drill down below top-down models of Industry electricity demand to identify:

- **Technical potential of large electricity customers to provide demand reduction and demand flexibility**. Technical potential has two components –
  - What the key uses of electricity by industry are – i.e. key processes within industry subsectors.
  - How customers use electricity across the day and the seasons.
- **Barriers and drivers for demand reduction and demand response within industry**. What financial incentives will drive industry customers to offer demand reduction or demand response services? At what times of day are services more likely to be available? What barriers are holding back industry customers from realising demand side response?

Focus on 2011 baseline

The main focus of this paper is on Industry demand today (with 2011 taken as the most recent year for which there was most data available), because we strongly believe there is a need to establish a baseline for electricity demand and demand side response, before embarking on any assessment of future potential. In Years 2 and 3 of the project we will assess in more detail how demand is likely to change going forwards to 2020 and 2025.

This paper provides a brief overview of:

- Industry electricity end-use demand[4].
- Description of Industry electricity end-use across different subsectors.
- Results of twenty-three interviews: nineteen industry businesses, three industry associations and the Government Procurement Service (carried out Nov 2011 to July 2012).

[2] See http://www.sustainabilityfirst.org.uk/gbelec_documents.html
[3] 'Demand side response in the non-domestic sector' (July 2012) Element Energy & DeMontfort University. http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=52&refer=Sustainability
[4] Based on DECC and DUKES data.

The qualitative work presented in this paper adds to the Brattle Electricity Demand-Side initial modelling carried out for Paper 2[5] of this project.

1.1 Electricity Demand in 2011 – established data sources

In the DUKES report for 2011, Industry electricity end-use accounts for around one-third of annual consumption: 102TWh out of 318TWh[6].

This Industry grouping includes some but not all of the population of 100kW half-hourly metered and settled customers, the remainder of which are included under 'other final users' within the DUKES commercial customers' classification.

Information on industry electricity customers, and therefore overall industry electricity consumption, is currently collated in two slightly different ways by Elexon and DECC[7]. In this study we have used the definitions and data used by DECC in DUKES.

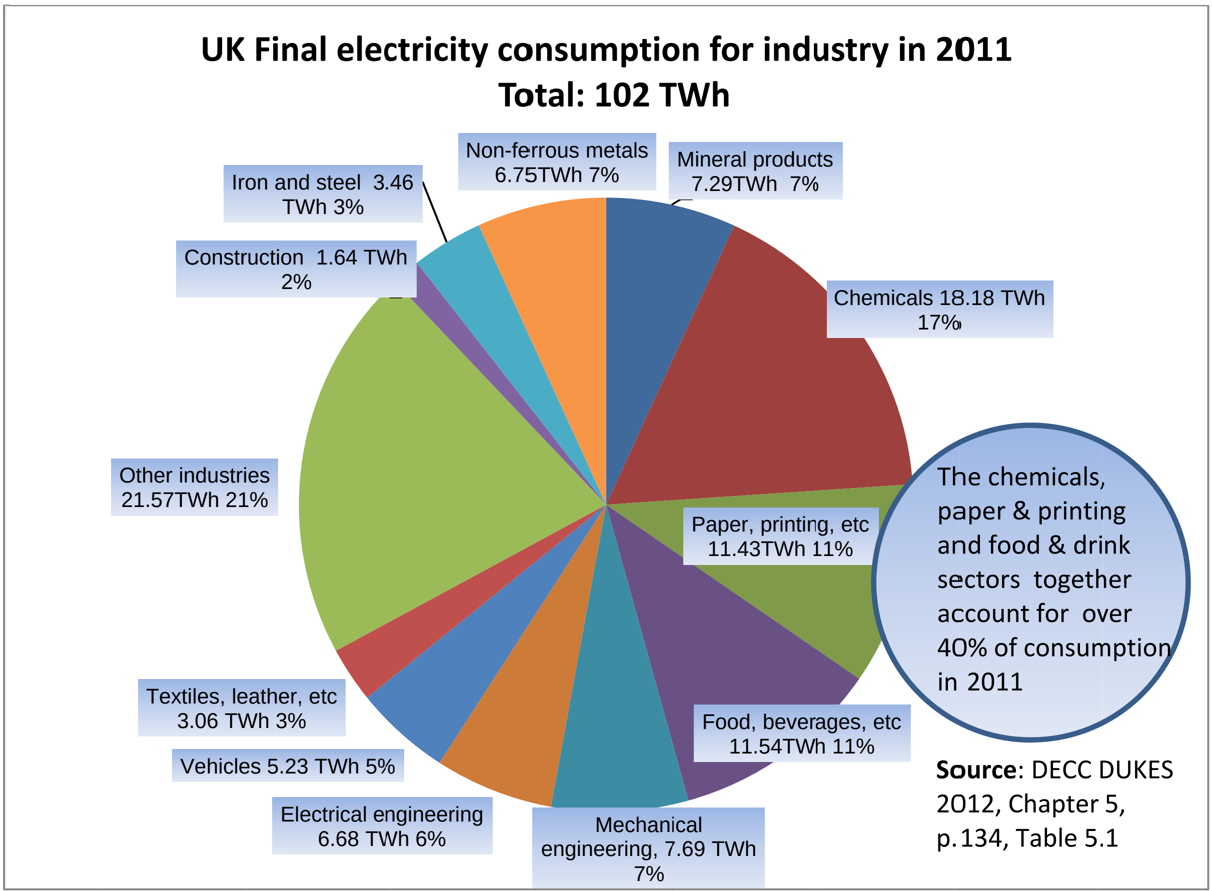
Electricity use in the industry sector is classified in DUKES by industry subsector as follows.

Breakdown of industrial electricity consumption in 2011	
Standard Industry Classification	**Percent Estimated End-Use**
Iron & steel	4%
Non-ferrous metals	7%
Mineral products	7%
Chemicals	17%
Mechanical engineering, etc.	7%
Electrical engineering, etc.	6%
Vehicles	5%
Food, beverages, etc.	11%
Textiles, leather	3%
Paper, printing, etc.	11%
Other industries	21%
Construction	2%

Table 1 Breakdown of industrial electricity consumption. Source: DECC DUKES 2012

[5] 'GB Electricity Demand – 2010 and 2025, Initial Brattle Electricity Demand-Side model – Scope for Demand Reduction and Flexible Response'(2012), published http://www.sustainabilityfirst.org.uk/gbelec_documents.html
[6] DECC – DUKES. July 2012. Table 5.2 Electricity supply and consumption.
[7] For further detail see 'GB Electricity Demand – 2010 and 2025, Initial Brattle Electricity Demand-Side model – Scope for Demand Reduction and Flexible Response' (2012), p.37, published on our website as above.

Figure 1 Final electricity consumption for industry in 2011



Industry electricity end-use is estimated to break down by key applications as shown in **Table 2** below:

End use	Percentage of total use
Heat processes	
High temperature processes	13%
Low temperature processes	17%
Drying	6%
Space Heating	8%
Non-heat processes	
Motors	33%
Compressed Air	9%
Lighting	3%
Refrigeration	6%
Other	5%

Table 2 End-use breakdown of electricity consumption in the industrial sector in 2011

Source: DECC Energy Consumption in the UK 2012. Table 4.6d(ii) 'Industrial energy consumption by end use (different process) 2011'.

The Energy Consumption in the UK data on electricity end-use by process type are modelled data, based on end use originating from historic survey information. DECC state that 'end use information should therefore be considered approximate'[8].

There is no published data which details industry electricity end-use, either by time-of-day or across the year. The modelling carried out by Brattle and presented in Paper 2[9] of this project suggests that industry electricity demand by **time-of-day** is characterised as follows:

- Demand is broadly flat/ gently rising from 08.00 to 17.00.
- A prolonged evening plateau between 17.00-20.00 both in summer and winter, though most marked in winter.
- A sharp morning winter peak at around 08.00 of 14GW (may be attributable to data shortcomings).
- Steady overnight consumption.

The lack of disaggregated actual data on electricity consumption by industrial sector, process and time-of-use make it hard to estimate in a top-down way what part of the electricity load could potentially be shiftable when considering Demand Side Response services.

The Brattle modelling (Paper 2) makes an initial estimate of the potential for different sectors of the economy to contribute to shifting electricity demand away from peak. This finds that the largest contribution to evening peak-shifting (either winter or summer) could be from the domestic sector, followed by the commercial sector, with the industry sector likely to provide the smallest fraction of potentially shiftable load at peak. However, in *future* scenarios of high-wind in the generation mix, the highest cost periods may not necessarily be the traditional evening peak. For example, if winter mornings were to be high demand / low wind times of day, this may coincide with a time when (from the modelling), industry would also appear to have some potential for flexibility.

The key question addressed in this paper is whether there is unexploited potential *today* in industry electricity end-use for:

- Demand reduction,
- Demand response.

This paper does not look in detail at longer term potential for DSR from the industry sector involving the use of new DSR technologies. It looks at the potential for DSR *today*, seeking to identify any unexploited DSR potential and barriers to that exploitation.

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[8] For further information on data sources used by DECC, see the paper produced for Sustainability First by Richard Hoggett, Associate Research Fellow, Energy Policy Group, University of Exeter : 'DECC Electricity Demand Data Sources – Summary Note' (February 2012) available on our website: http://www.sustainabilityfirst.org.uk/gbelec_documents.html

[9] 'GB Electricity Demand – 2010 and 2025, Initial Brattle Electricity Demand-Side model – Scope for Demand Reduction and Flexible Response' (2012), see: http://www.sustainabilityfirst.org.uk/gbelec_documents.html

2. Methodology

Given the limited availability of empirical data on industry electricity end-use – particularly detailed data on electricity demand breakdown by process use, and by time of use – Sustainability First carried out a number of interviews with key industrial electricity users.

The selective interviews targeted a small but broadly representative group of large industrial electricity users across key subsectors, including the food & drink, paper, chemicals, steel, cement, industrial gases, ceramics, water and retail industries. These were chosen to represent sectors accounting for significant electricity consumption within UK industry[10] .

The interviews were mainly qualitative, focusing on the following topics:

1. **Electricity demand at present –** electricity demand distribution by processes, time of use (daily, weekly and seasonal distribution).
2. **Energy management and electricity purchasing –** role of suppliers, electricity tariffs, involvement of aggregators.
3. **Potential for further demand reduction**.
4. **Demand side response today** – participation in DSR schemes at present, experience of these, barriers to participation.
5. **Demand side response: unexploited potential –** potential for DSR not presently exploited, barriers, financial incentives required, technical issues, notice periods, etc.

The full questionnaire used is available in **Annex 4**.

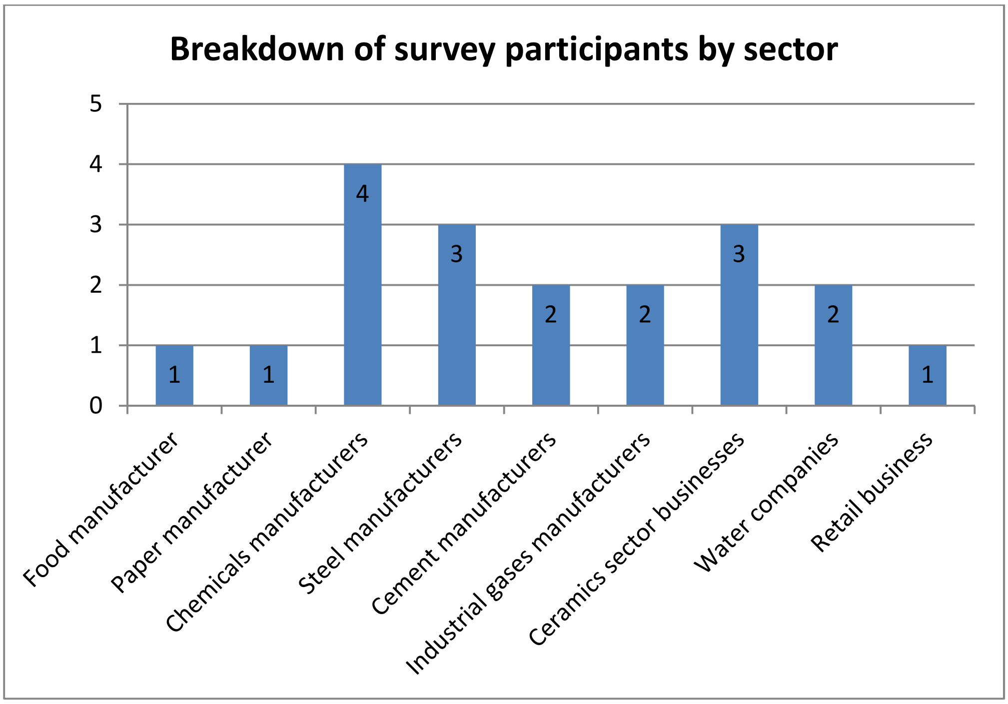
We carried out most interviews face-to-face at the premises of the businesses, and a number by phone. The following were interviewed:

- 1 food manufacturer
- 1 business in the paper industry
- 4 chemicals manufacturers
- 3 steel manufacturers
- 2 cement and aggregates manufacturers
- 2 manufacturers of industrial gases
- 3 businesses in the ceramics sector (of which 2 brick manufacturers)
- 2 water companies
- 1 retail business
- The Government Procurement Service, a trading fund of the Cabinet Office.

[10] According to DUKES 2011 data

Figure 2 below shows the breakdown of participants by sector[11].

Figure 2 Breakdown of survey participants by sector



In addition to the nineteen industry businesses, and the Government Procurement Service, we spoke with three industry associations: the Chemical Industries Association, the British Ceramic Confederation and the Confederation of Paper Industries.

The sections that follow draw from our conversations with the industry businesses detailed above. When presenting quantitative data we have excluded our interview with the Government Procurement Service, as GPS procures electricity on behalf of many individual public sector entities and is hence not directly comparable to the individual industry businesses in our survey.

[11] Excluding the Government Procurement Service.

3. Results of industry interviews

A key reason for carrying out these interviews was the understanding that the diversity of subsectors within the industry sector, and the specific processes within those subsectors, is such that it is **difficult or impossible** to successfully generalise on what the potential for DSR might be.

Bearing this in mind, and given the small number of industry users we have spoken to as part of this work, it is not our aim at this point to go beyond the Brattle modelling to attempt additional quantitative estimates of future DSR potential.

Instead it is our aim to highlight some of the key barriers and issues to mobilising potential DSR within industry, as well as to gather feedback on existing DSR schemes from those who participate in them.

We have provided a description of key terms in **section 3.3 (Demand side response today)** on page 22 below.

3.1. Current Electricity Usage

How is electricity used?

In asking this question, we aimed to explore to what processes electricity consumption is attributable in industry. Unsurprisingly we found that the main production processes are very specific to individual industry subsectors. For example, in the industrial gases sector[12], the key electricity consumption arises from compression and refrigeration in air separation units (ASU), and also from gas liquefaction; in the steel sector, electricity consumption by Electric Arc Furnaces significantly exceeds all other electricity consumption; and in cement manufacture the grinding of raw materials and of cement are the most electricity-intensive steps in the manufacture process.

There are however some processes which are common across all industries: the running of motors, pumps and fans. These are found across all the industries we spoke to: motors and fans are used in food manufacture (on the production line, and in refrigeration), in chemicals manufacturing (moving materials and solutions through the production process), in cement production (motors used to convey materials, grind materials), in brick manufacture (motors to power brick cars, fans in kilns), in the steel industry (motors and fans in forges), in the industrial gases industry (to compress air), and in the water industry (motors in pumps, to pump water and wastewater).

[12] We spoke to 2 companies in this sector

Previous studies on the potential for DSR in industry, or across all sectors, have by necessity had to make broad assumptions on the proportion of load which is flexible or displaceable. Our experience in speaking to customers from a number of industries suggests that taking an across-the-board and/or top-down approach to estimating potential DSR in industry risks an unduly generalised representation of the potential.

Annex 1 provides a high level picture of key uses of electricity across different sectors of industry. These end-uses are summarised in **Table 3** below.

	Electro[13] intensive?	**Gas intensive?[14]**	**Specific processes accounting for main electricity load**	**General processes contributing to electrical load**	**Technical potential for DSR?**
Sector					
Food	No	Yes	Refrigeration	Pumps, fans, motors	Limited
Paper	No	Yes	Paper production	Pumps, fans, motors	Limited*
Chemicals	Yes (some sectors)	Sector-dependent	Electrolysis	Fans, motors	Good/moderate
Steel Primary steelmaking: Basic Oxygen Steelmaking	No	Yes	Fans and motors (no specific large electric load)	Fans, motors	Poor
Electric Arc Furnace Secondary: Steel mills	Yes	No	Furnace	Fans, motors	Good/moderate
Cement	Yes	Yes	Grinding raw materials, cement grinding	Fans, motors, compressed air	Good/moderate
Industrial gases	Yes	No	Air compression unit (compressor, refrigeration), gas liquefier	Motors	Good / moderate
Ceramics	No	Yes	Materials crushing & mixing	Fans, motors	Good/moderate**
Water	Yes	No	Pumping, water & wastewater treatment	Motors	Good/moderate
Retail	Yes	No	HVAC, refrigeration, lighting.	Fans, motors	Limited

Table 3 Electricity consumption characteristics across industry sectors.

Source: Sustainability First.

*Some potential but from a small electrical load. **Good potential, although from a smaller electric load.

[13] **Electro-intensive:** a process or industry which is a heavy electricity user, derives the greater part of its energy consumption from electricity rather than gas.
[14] **Gas-intensive:** a process or industry which derives the greater part of its energy consumption from gas rather than electricity.

When is electricity used?

We asked respondents to describe their 'typical' overall end-use. A number of patterns emerge in terms of typical electricity demand profiles:

- Very baseload-heavy demand profiles, **driven by continuous production processes**. These are typically higher during the day (when production is operating fully and workforce is present). Night-time demand is lower but also even/predictable, and includes essential equipment.
- Users with an evening peak, and higher daytime than night-time demand.
- Users with very peaky electricity demand, but where those peaks cannot easily be predicted.

Common themes

Unsurprisingly, electricity consumption in many industries is largely driven by production priorities. In short-term operating markets[15], this means production is very reactive, and so is electricity demand. The shorter the operating market, the less scope for managing electricity demand and therefore, currently, for DSR.

In many cases variation in electricity consumption is driven by external market factors outside a company's control: weather, related variation in the characteristics of raw materials (e.g. food or clay), and consumption patterns of their customer base. An extreme of this is found in the industrial gases industry, where some customers are supplied by pipeline from the gases production plant. In this situation, customer demand can very largely drive production levels.

We also learned from respondents that there is generally very little seasonal variation in their output and in their electricity consumption (with some exceptions such as the food and ceramics industry, where there are seasonal variations in the characteristics of raw materials used).

[15] Markets where the timescale between bidding for, receiving and delivering customer orders is short.

3.2. Overall Approach to Electricity Management:

Efficiency and Reduction

This section gives a general overview of key considerations among the large energy users with whom we spoke to regarding: demand reduction, electricity as a proportion of running costs, electricity purchasing, aggregators and self generation.

i) Demand reduction

The main focus of our interviews was on Demand Side Response. However, we also discussed the issue of demand reduction.

In general, good energy efficiency standards were observed among our respondents. For industries where electricity costs account for a large proportion of total running costs, this is financial common sense; however even in sectors where electricity represents a smaller proportion of total running costs, good energy efficiency standards are observed. Many of the companies we spoke to had energy monitoring and management systems in place.

The long-term involvement of respondents in the Climate Change Levy and the Climate Change Agreements has led to increased awareness and action on energy efficiency. More recently the involvement of some in the CRC Energy Efficiency Scheme has had a similar impact.

Regarding energy efficiency awareness and willingness to implement improvements, we observed companies were willing to carry out improvements to the energy efficiency of their operations and equipment, and take up grant funding and/or incentives available for this purpose, provided two conditions were met:

- Reasonable payback times on any investment in new equipment or upgrades.
- Minimal disruption to plant operation caused by the upgrade or installation.

The second requirement often led to any major energy efficiency works being carried out during scheduled annual maintenance shutdown periods, as it did not make financial sense to lose operating time by carrying out upgrades piecemeal over the course of a year.

Also, for businesses located on the same site for many years, retrofitting major equipment for energy efficiency purposes was an added challenge.

ii) Electricity as a proportion of running costs

We asked companies to give us an indication of what proportion of their overall running or variable costs were attributable to electricity. Figures given ranged from 3% to over 90%, a very diverse range.

Notably, in companies where electricity costs account for 10% or less of overall running costs, reducing expenditure on electricity was unlikely to be a key priority. The financial incentive to participate in DSR, even modest TRIAD participation, is smaller.

Companies where electricity costs accounted for over 10% of total running costs were more aware of the potential to participate in DSR schemes, and more likely to already be participating in DSR, particularly at the highest end of electricity as a proportion of total running costs. The table below illustrates this for TRIAD.

Number of companies	Electricity costs < 10% of total running costs	Electricity costs > 10% of total running costs
Participate in TRIAD	1	12*
Don't participate in TRIAD	4*	2

Table 4 Industry participation in TRIAD among companies involved in this work

*Three of the participating companies estimated their electricity costs to be in the region of 10% of total running costs. Of these, two participated in TRIAD response, and one did not.

iii) Electricity purchasing

As part of our questions on electricity purchasing methods and practices, we asked companies how far ahead they purchased electricity. The majority of companies purchased their electricity using a combined short-and-long term approach, ranging from day-ahead or on-the-day for the short term, to month-ahead or year-ahead for the long term.

Several companies purchased a proportion of their electricity needs more than a year ahead (two years ahead, and up to five years ahead), the incentive for this being price certainty. This was particularly important for those companies for whom electricity costs were a significant proportion of their running costs (>10%). When electricity costs account for 50% or more of a company's running costs, long term advance purchasing of at least a proportion of that electricity provides partial cost certainty. How far ahead a company purchases electricity, and how, is a function of a complex set of operational considerations including the trade-off between cost certainty and cost reduction.

Water companies and other regulated businesses are a particular case. Water companies operate on 5-year planning timescales, with 5-year business plans submitted to Ofwat for approval. This provides an incentive to purchase electricity well ahead, balanced against the desire to obtain the best price.

iv) The role of brokers

We asked the industry customers we spoke to whether they purchased their electricity directly from a supplier or through a broker, and found that only two out of the nineteen used a broker.

We assume that in the main brokers are used by smaller customers, e.g. services and commercial customers. We also spoke to Government Procurement Service (see Section 4 below), who effectively act as a broker to a large range of public sector entities.

v) The role of aggregators

The Demand Turndown trial[16] carried out by National Grid established the role of aggregators in providing a single point of despatch for disparate sites (although in that early trial under delivery of declared capacity was a consistent problem, it nonetheless proved the potential for successful aggregation).

Among our industry respondents, only three have so far taken up the services offered by an aggregator. The majority (16 out of 19) have been approached at least once by an aggregator in the past two years.

Of the three businesses currently working with an aggregator, two are providing Short Term Operating Reserve (STOR[17]) and one Frequency Control by Demand Management (FCDM). One of the companies working with an aggregator to provide STOR gave the following account of their reasons:

> Working with an aggregator to provide STOR rather than contracting directly with National Grid enabled them to update their capacity declaration more frequently. Since the company is in the process of increasing its own-generation capacity, being able to offer new capacity as STOR promptly allows new capacity to start generating revenue faster.

Reasons cited for not presently entering into an agreement with aggregators included:

a. Financial incentive offered insufficient to stimulate DSR: loss of revenue or risk of lost revenue from DSR significantly larger than value of financial offer.
b. Value for money. The package offered by the aggregator was not considered to be value for money. This was especially the case where industrial customers have in-house expertise on electricity markets and DSR.
c. Technical – notice period required for DSR too short, not technically possible for the production process.

[16] 'Report on the Demand Turndown Trials' (2006) National Grid. http://www.nationalgrid.com/NR/rdonlyres/AC39024C-C5A2-42E9-BF5F-88DE7A86F733/16873/Demand_Turndown_TrialReport.pdf

[17] For a summary of existing Demand Side Response schemes see section 3.3 below. A full list is available in Annex 3.

d. Technical – insufficient automation in place to enable DSR.
e. Third-party involvement not viewed as necessary in order to participate in DSR schemes.

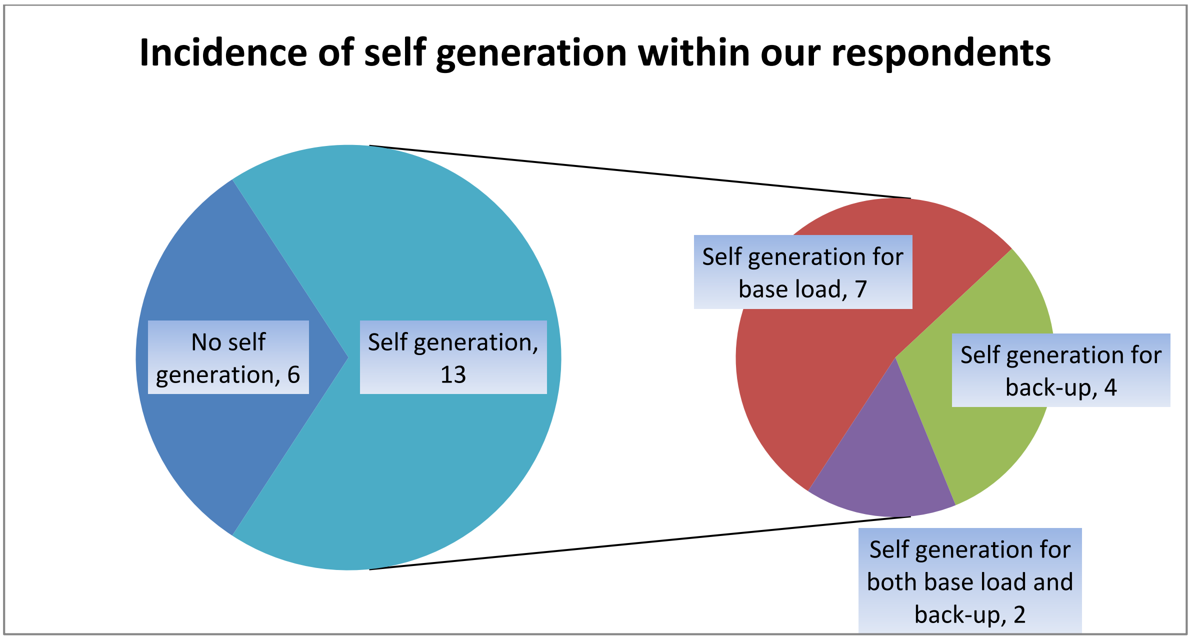
vi) Self generation

We were interested in a number of interrelated questions on self generation, although self generation was not a main focus of this study.

a. Did companies generate part or all of their own electricity on site?
b. If so, for what reasons? Continuity in the case of power failure, ability to export to grid and so provide DSR without reducing demand, or other reasons?

Figure 3 below summarises the key findings on self generation.

Figure 3 Incidence of self generation within our respondents



Looking in more detail at the thirteen businesses that had some form of self-generation to meet part or all of their electricity needs, of these:

- 7 have self-generation capacity for baseload purposes only;
- 4 have self-generation capacity for back-up purposes only;
- 2 have self-generation for both baseload and back-up purposes;
- 5 of these 13 companies have **diesel generation**, originally installed as emergency back-up technology. Of these:
    - Two are already offering their diesel generator capacity as DSR through STOR, and one is actively expanding its diesel generation capabilities for this purpose.

  - A further company with diesel back-up generation capacity is considering the potential to use them to provide STOR.
- 4 of the companies with self generation are using by-products or waste products from their manufacturing process to fuel their self generation.

On **CHP**:

- 4 of the 13 companies with self-generation have CHP.
- A further 2 are in the process of commissioning/installing CHP – to be run by 3rd parties.

For CHP, the determining factor is generally the availability of a permanent heat demand.

General observations on self-generation

Among the companies we met, the majority of self-generation is in place to meet own use baseload requirements rather than for export purposes. The primary objective is to generate electricity to supply a site, and any excess is exported to grid.

Decisions on investment in self-generation are made on financial and operational business grounds. Businesses evaluate the financial investment required, the payback timescales and any potential revenue generation, in addition to operational advantages of own generation. Any incentives – e.g. feed-in-tariff for PV or wind, the potential to generate revenue through STOR provision, are considered as an integral part of the business decision.

3.3. Demand Side Response Today

Annex 3 provides an overview of DSR schemes available today. In summary, these are presented in **Table 5** below:

National Grid operated schemes	
Frequency response services, to maintain frequency on the grid at +/-1% of 50Hz at all times:	**FCDM: Frequency Control by Demand Management**. This provides frequency response through the interruption of demand customers. This is done automatically by frequency relay. FCDM providers must be available 24 hours a day and deliver a minimum of 3MW within 2 seconds of instruction, for a minimum of 30 minutes.
Balancing services, to help balance the national electricity system following unforeseen increases in demand or generator non-availability.	**STOR: Short Term Operating Reserve.** This service provides additional active power from generation or demand reduction. STOR providers must be able to offer a minimum of 3MW for at least 2 hours (ideally 3-4 hours), delivered within 20 minutes to 4 hrs notice, and be able to provide STOR at least 3 times a week.
Supplier operated schemes	
TRIAD – (TRIAD management). The annual £/MW network charge payable by licensed Suppliers to National Grid (TNUoS - Transmission Network Use of System) are in part calculated on the basis of the suppliers' maximum peak load during the average three half-hours of highest system peak demand in year (the TRIAD). Suppliers pass through these charges to their largest HH electricity customers, providing an economic incentive for HH customers to reduce their demand in the three half-hour TRIAD periods. In practice, electricity customers who enter into an agreement with their supplier to actively reduce demand during TRIADs are given either day-ahead or on-the-day warnings of potential TRIADs during the TRIAD season (winter).	
Voluntary Load Management (VLM). This scheme allows electricity customers to purchase electricity as usual, and set price thresholds at which they are willing to reduce their demand and sell back electricity, generating revenue for themselves. VLMs are contracts between a supplier and an electricity customer, tailored to the customer's needs[18].	
Distribution network operated schemes	
DUOS banding. Recently introduced system whereby Distribution Use of System charges reflect time bands with differential pricing (Red/Amber/Green). Large, half-hourly settled customers are likely to have these time differentiated distribution DUOS charges reflected in their contracts with their energy suppliers to encourage peak-time avoidance.	

Table 5 Demand Side Response schemes currently available

We asked companies which if any DSR schemes they were participating in at present in order to obtain a snapshot of current levels of participation and complexity in DSR schemes.

18 http://www.npower.com/Large-Business/Buying-energy/Demand-management/VLM/index.htm

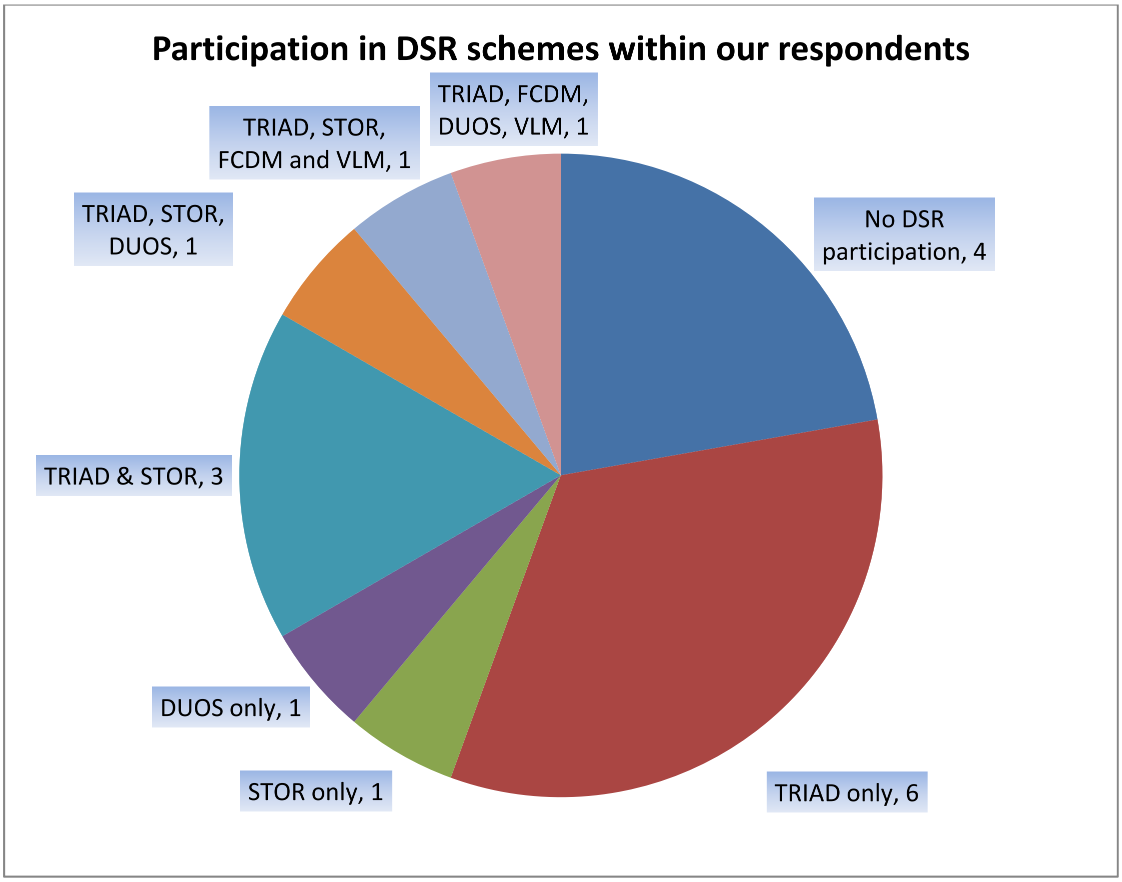
We also noted when customers had historically participated in DSR schemes, which they had since left, taking the opportunity to ask about the reasons for stopping participation, to obtain insight into barriers to participation.

We found a wide variety of levels of participation in DSR schemes across the nineteen industry customers we spoke to.

- 4 companies do not take part in any DSR schemes. All of these have electricity costs which are 10% or less than 10% of their overall running costs,
- 6 companies respond to TRIAD only but do not participate in other DSR schemes,
- 1 company only participates in STOR,
- 1 company only participates in DUOS,
- 3 companies participate in TRIAD and in STOR,
- 1 company participates in TRIAD, STOR, FCDM and has a Voluntary Load Management agreement with their supplier,
- 1 company participates in TRIAD and FCDM, responds to DUOS and has a Voluntary Load Management agreement in place with their supplier,
- 1 company participates in TRIAD and also responds to DUOS banding (Red/Amber/Green) reducing their load in the 4pm-7pm band.

The figure below summarises the participation in DSR schemes found among our respondents.

Figure 4 Participation in DSR schemes within our respondents [19] [20]

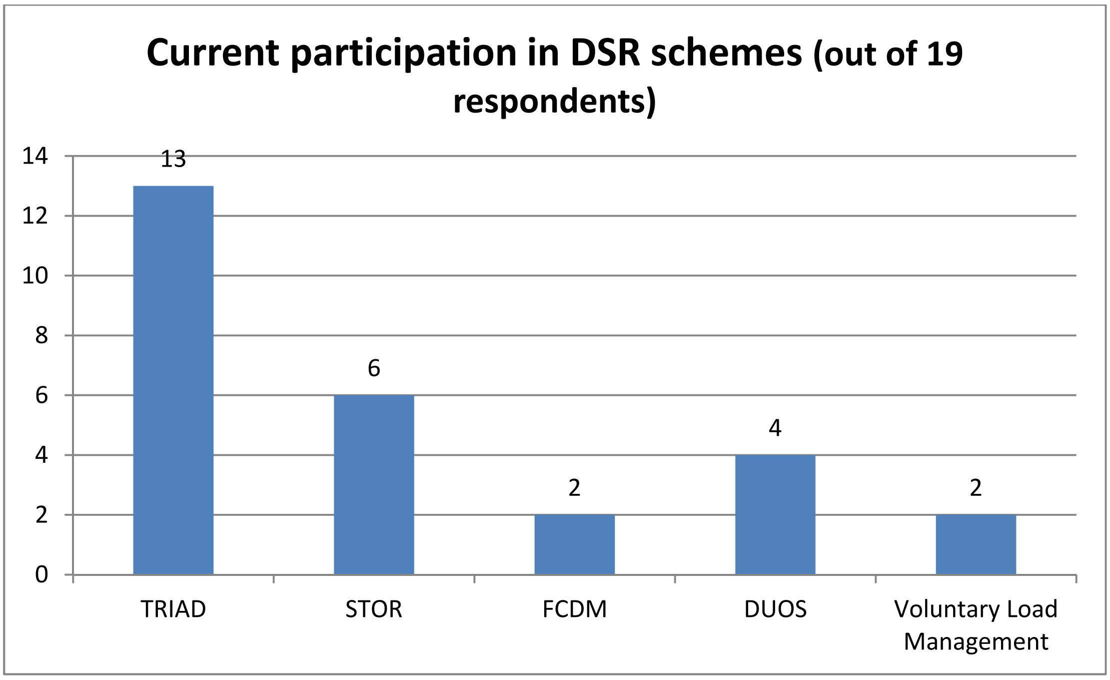


As can be seen from the above, there is a wide range of engagement with DSR schemes, and this re-enforces the idea that a one-size-fits-all approach would not necessarily increase the amount of flexible load available.

Figure 5 overleaf summarises respondent participation in DSR to date.

[19] Among a total of 19 respondents, excluding the Government Procurement Service.
[20] Customers participating in both TRIAD and STOR did not participate simultaneously in both, rather they participated in TRIAD and STOR at different times of the year.

Figure 5 Summary of DSR participation among respondents to date[21]



[21] Excluding Government Procurement Service

DSR: 'true' demand shift or shift to own-generation?

Paper 1[22] notes that National Grid estimate that at present a proportion of the ~1GW of Operating Reserve contracted by them entails a switch by the demand-side provider to on-site back-up generation, rather than 'true' demand-side response: 650 MW switching to on-site back-up generation, and 350 MW of 'true' demand-side response. The 650MW of Operating Reserve provided by a switch to back-up generation is estimated to include a proportion of diesel back-up generation.

DSR provided by diesel back-up generation can help National Grid to balance supply and demand on the networks. However there is some debate regarding the carbon balance of diesel generation. Diesel generation has higher CO_2 emissions than e.g. CCGT generation, however, when operating in STOR, diesel generation may displace part loaded BM generating units such as coal-fired power plants. In addition, diesel generation, if suitably located, may be able to avoid transmission and distribution losses which would apply to generation from large BM units (there is a strong locational element to STOR requirements).

We asked our participants (those participating in DSR), whether they provided demand response by reducing their actual demand or by switching to alternative power sources.

- **TRIAD**: The majority of those participating in TRIAD did so by actively reducing their demand (2 businesses responded to TRIAD by both actively reducing demand *and* using their generation capacity).

- **STOR**. The picture for STOR response was more mixed: two businesses responded by both reducing their demand and deploying their generation capacity; three actively reduced their demand (of which two historically had taken a combined 'true' DSR and self-generation approach), and a final STOR participant responded to STOR by using diesel generation, and was actively building up its diesel generator capacity in order to offer further capacity on STOR.

Additionally, one of the businesses who currently does not participate in **any** DSR schemes is assessing the potential of its existing diesel generators to provide STOR. It seems to be the case that a subsector of industry customers, who have pre-existing diesel generation capabilities originally commissioned as back-up in case of power failure, will and/or could consider running these to provide STOR or other forms of DSR.

Factors to consider include:

a. Cost of generation of own power (diesel or otherwise, some industries have the potential to burn waste products or by-products of their manufacture) compared to the cost of electricity and the financial incentive to provide DSR.

[22] Sustainability First. Paper 1: GB Electricity Demand – Context and 2010 Baseline data' (2011). Page 62. See: http://www.sustainabilityfirst.org.uk/gbelec_documents.html

b. Technical: notice period for provision of DSR – some self generation facilities cannot start up fast enough to be used for STOR provision.

We found that the potential to provide DSR – in STOR or other form – was often taken into account as a factor in the decision-making process when existing onsite generation equipment is nearing its end-of-life – if there is potential to generate electricity and make a profit, businesses are more likely to renew or expand their self-generation capacity.

3.4. Demand Side Response: Unexploited Potential?

We asked all the industrial customers we spoke to, to describe what potential they had to provide further demand side response, additional to any which they were already providing through any existing commitments.

We identified four different example timescales for demand side response services, and asked customers which if any of these they would be able to provide, and under what conditions.

The exemplar timescales we identified for potential future DSR services were:

a. **Seconds response** – short term demand reduction, with very short notice period, provided for a few minutes.
b. **15-minute block demand reduction**. Notice period would be a few seconds, to be provided for 15 minutes.
c. **4-8 hour sustained demand reduction**. Like an extended STOR service.
d. **Sustained demand reduction across several days**[23].

We asked customers to estimate, for each exemplar:

a. Whether they would be able to provide the service;
b. How much they could provide;
c. What notice they would require to be able to provide each service;
d. The frequency with which could provide the service;
e. What financial incentive would be required.

*See the full questionnaire in **Annex 4** for further information.

Several companies felt they had the potential to provide further DSR, over and above what they are currently committed to providing. Different subsectors could provide DSR in different timescales – some cannot provide the short term DSR response of the first two exemplars, but could provide more DSR services of longer duration, and vice versa.

Aggregators have the potential to bring all these services together.

The potential to provide further DSR would be subject to one or more of the following:

a. **Greater financial incentives**. Most often, for the group of industries we have spoken to, providing DSR will have some knock-on effect on production – either production time will be lost, or there may be a risk to product quality (particularly where refrigeration is concerned). Therefore, the financial incentives must be sufficiently large to take the risk and/or compensate for expected or potential loss of revenues.

[23] This last option would be designed to help during extended winter anticyclone / no-wind situations as envisaged in the capacity market, in a future with high wind power penetration in the generation mix.

b. **Technical upgrades –** again linked to financial incentives. Companies are happy to invest in equipment upgrades which will allow faster response times and/or greater automation, if they know they will get a return from their investment via DSR incentives.
c. **More flexibility in the design and requirements of DSR schemes –** including shorter timescales between sign-up and delivery of DSR (e.g. week ahead rather than 3 month ahead), and more flexibility opting in & out of DSR schemes on short timescales/at short notice.
d. **Increased compatibility/coordination between DSR schemes**. Under current arrangements, a customer bidding to offer DSR on STOR will submit a bid, and if the bid is taken up, will be called upon to provide that DSR. If the bid is not taken up however, the general perception is that there is no option to offer the DSR elsewhere, so this is potential flexibility which is lost.
e. **Longer notice periods**. This would enable more DSR, particularly in safety-critical industries, where longer notice periods (several hours or day-ahead as opposed to 20-40 minutes) would enable significantly more DSR as well as DSR which could be provided for **longer** (hours/days).
f. **Increased price information and visibility.** At present it is difficult for companies to know what the potential value of / revenue from different DSR schemes is, and without greater price visibility it is not possible to optimise DSR participation and maximise revenues. This is a deterrent to participation.

Potential for automation

We asked for an estimate of whether it would be a) technically feasible and b) acceptable to have remotely enabled DSR. Although historically there has been resistance to this practice (seen from an operational point of view as relinquishing operational control to an outside agent) we found some instances of a developing acceptance of automation. Technical advances mean safe automation of processes is increasingly possible, which is contributing to an increased acceptance of automation.

Higher awareness and acceptance of automation went hand-in-hand with higher electricity costs and sophistication of DSR schemes already in use by the industry customer.

Within existing DSR schemes, Frequency Control by Demand Management is always operated remotely by National Grid using frequency relays.

3.5. Barriers to Participating in DSR

We asked companies what barriers there are currently, which may inhibit them from participating in more (or any) DSR schemes. Barriers fell under a number of categories:

Financial

Often the financial incentives on offer from market actors to the industry companies are deemed insufficient to warrant response.

There are two main points:

a. **Where electricity accounts for a small proportion of running costs overall** – e.g. <10%, and therefore the impact of reducing the electricity bill is smaller overall, it can be more productive to focus efforts on reducing other running cost elements (be they labour, raw materials, or gas). Compounding this, when electricity is a small component of running costs, there may not be the dedicated resource and expertise within a company (especially in smaller companies) to focus on reducing electricity expenditure and learn about all the DSR available. In these situations, aggregators can play a useful role.

b. High-volume throughput manufacturing processes are negatively affected (disproportionately so) by interruptions to the manufacturing processes. Across several sectors (brick, food, steel manufacture) a key message was that lost production time meant lost income from product manufacture and sale, which was potentially far greater than the financial incentive on offer to provide DSR.

Technical barriers

a. Process. Some industrial processes are non-interruptible – interruption of process is highly likely to lead to total failure or loss of quality of the product. A complicating factor arises for some from labour costs and shift patterns, which are fixed and not readily changed.

b. Process unpredictability. Some processes are interruptible but only at certain points in the production process, and it can be difficult to predict the production cycles – and therefore the times at which interruption is possible - due to natural variation in the operating cycles. This does not tie in well with current arrangements for e.g. STOR where response within 20 minutes is required. A good example of this is steel smelting, which operates in smelting cycles, and has different interruption potential at different stages in the cycle.

c. Lack of automation. Some processes are interruptible, but the current site equipment and layout do not allow automatic stopping or restarting, making participating in DSR unwieldy or infeasible. Additionally many industry sites are not greenfield sites, so operate with constraints due to historical layout or equipment. Equipment is generally replaced at end-of-life, potentially leading to slow uptake of new control technologies not directly associated with the main production process.

Institutional

a. **Risk averse**. From food through to chemical manufacture, there are industry sectors which are process and/or safety-critical and therefore have no interest in taking unnecessary risks in order to provide DSR.

b. **Smaller businesses** have inherently smaller electricity demand, and therefore less to offer to the DSR market (unless they are particularly electricity intensive). The financial rewards available to them through DSR schemes will be proportionally smaller. In addition, they are less likely to have the in-house knowledge and expertise necessary to make the most of the DSR opportunities. These businesses may benefit from the services offered by aggregators.

Economic

a. **Impact of the recession**. Lower production loading due to the recession, together with the need to maximise revenues, has led companies to reconsider their interest in and their potential to provide DSR, when they may not previously have considered it. Lower production loading may offer more flexibility in operating patterns, and DSR schemes may offer potential new revenue streams.

4. Government Procurement Service: demand-side response within the public sector

Note: This section does not attempt to provide a comprehensive overview of demand side response within the public sector. It only reflects the potential for demand side response within the public sector organisations who avail themselves of the Government Procurement Service for their electricity purchasing needs.

<u>Government Procurement Service</u>

Government Procurement Service (GPS) is a trading fund of the Cabinet Office. Its overall priority is to provide procurement savings for the UK Public Sector as a whole and to deliver centralised procurement for Central Government Departments.

In addition to Central Government Departments, it provides procurement services to local government, health, education, emergency services, defence, devolved administrations and not-for-profit organisations.

GPS provides procurement services across energy, travel, fleet, office solutions, communications services, professional services, ICT, eCommerce and property & facilities management.

The Energy department at GPS procures electricity and gas, in addition to liquid fuels, carbon offsetting and AMR (Automated Meter Reading) technology.

GPS: procurement of electricity

GPS is the largest buyer of electricity (and gas) in the UK.

GPS purchases electricity on behalf of: central government, over half of government agencies, local authorities, hospitals & healthcare providers, emergency services and defence sites among others.

GPS has framework agreements with energy suppliers to supply GPS customers with half-hourly, non half-hourly and unmetered (UMS) electricity. GPS is not a licensed supplier, but it has its own energy trading and risk functions, so it can source electricity directly from the wholesale market on behalf of its customers. The energy suppliers are responsible for metering and billing electricity for GPS customers.

GPS also is investigating long term Power Purchase Agreements (PPAs) with a number of independent generators, enabling it to purchase electricity further ahead in time than is possible on the wholesale market.

Volume of electricity procured

GPS procures electricity on behalf of over 80,000 sites in the UK. The total electricity demand across all these users is close to 12TWh. Users are divided into half-hourly, non-half hourly and unmetered (UMS) supplies.

Demand profile of procured electricity

The overall demand profile for electricity procured by GPS is very flat. This is due to the great variety of users making up the overall demand curve. Individual users have widely varying demand patterns. The combination of peak load from offices and schools, for example, is offset by more unusual demand patterns of hospitals and street lighting.

<u>Demand Side Response</u>

Demand Side Response: participation today

To date there has been limited participation in Demand Side Response schemes by customers of the GPS. GPS is aware of some hospitals participating in STOR by using their back-up generation facilities. In addition, a central government building (Whitehall) is in the process of joining the Low Carbon London trial, and is using their CHP unit to provide DSR.

Demand Side Response: future potential

There is increasing interest in DSR from central government, agencies and other users of GPS electricity procurement. GPS has engaged with its users to identify the level of interest and the potential for a centralised approach to DSR. As a result, GPS is currently putting in place a national pan-Government framework for DSR and related services. The framework, which will be an EU compliant set of agreements, will allow individual GPS user organisations (local authorities, etc.) to engage a suitable aggregator to enable their DSR potential. The aim is to secure lower procurement costs and reduced complexity via streamlined and standardised documentation. This is expected to be in place by the end of 2012.

Nature of the potential DSR resource within GPS users

Many current GPS users, such as hospitals, have existing self-generation capacity. This includes CHP units, diesel generation back-up units and renewables. In the first instance it is likely that Demand Side Response services would be provided through use of existing self-generation capacity.

<u>Current barriers to DSR</u>

Perception barriers: Demand Side Response is still perceived by some public sector bodies as introducing an element of risk to site operations and power reliability.

Regulatory / contractual barriers: many public sector sites or buildings have facilities management contracts in place with third parties. These facilities managers operate building services such as heating, ventilation and air-conditioning. Facilities management contracts often include Key Performance Indicators which include a specified temperature range within the building, and if the specified temperature range is exceeded the facilities manager is subject to a financial penalty.

These types of contracts may inhibit the flexible use of building services to provide DSR, as facilities managers could risk financial penalties for breaking existing KPIs by engaging in DSR services.

it is not in the facilities manger's interest to engage in DSR services if in so doing it risk financial penalties for breaking existing KPIs.

Future facilities management and other similar contracts could enable DSR by removing such contractual barriers.

Conclusion

Potential Demand Side Response for GPS customers is significant, with subsequent revenue and savings opportunities. This potential would initially arise from the use of existing self-generation facilities, including back-up generation, but in time, with improved information and greater engagement could progress to 'true' demand side response provided by load-shifting. Government Procurement Service will facilitate the initial uptake of DSR schemes amongst GPS users by managing the procurement and contractual aspects of DSR.

Contacting Government Procurement Office

For further information on GPS schemes contact Scott.buckleton@gps.gsi.gov.uk

5. Headline Conclusions

Our key headline conclusions are:

1) **Contract length and timelines for DSR services.** At present some companies feel the lengthy time period (2-3 months) between tendering and provision of DSR in STOR adds difficulty and reduces flexibility. Businesses working in short turn-around markets do not have a view of their operations 2-3 months ahead of real time. There is potentially more DSR to be accessed in shorter timescales.

   Framework contracts / call-off agreements which allow customers to join a scheme for a season/period of time, but with the opportunity to confirm DSR participation in the short term (e.g. day-ahead, week-ahead), might support more DSR participation (similar to National Grid's current STOR flexible scheme, and the Irish Winter Peak Demand Reduction Scheme (WPDRS)).

2) **Potential to expand frequency response and fast reserve type services**. There was a willingness to consider take up of more diverse fast-response DSR schemes among some of the industry customers we spoke to. This opportunity is presented by technology improvements (in software, communications equipment, systems automation etc.), but has not been a matter of focus to date. Looking to the future, especially in a higher wind world, fast response services may have greater revenue potential (from a business perspective) and, potentially, less significant operational impact.

3) **Price visibility and hierarchy of DSR schemes.** At present there is relatively little price visibility for industry customers on the value available to them of different DSR schemes and relatively little information on the pros and cons of each from a customer perspective (STOR, FCDM, TRIAD). Businesses cannot easily optimise their DSR participation to maximise revenues. From a business perspective this seems to be a deterrent to wider participation. We have also discussed understanding DSR values in Paper 4.

4) **Impact of the recession**. The recession may have increased the willingness and ability of industry customers to participate in DSR services, due to an increase in spare capacity on production lines and the desire to find additional revenue sources. Conversely, at full output there may be less appetite to provide DSR for operational reasons.

5) **More engaged relations between energy market actors and industry players:** are the right forums in place for all industry players to communicate easily with each other? At present there appears to be some disconnect between different parties involved. From our initial conversations there would seem to be a wish for more engaged relationships between market actors and customers on DSR.

6) **Top-down estimates of potential for DSR in industry are problematic.** Our research reinforces the message that obtaining accurate top-down estimations of DSR potential in industry is extremely difficult, due to the individuality of industry subsectors and their largely bespoke uses of electricity. A more bespoke subsector-by-subsector understanding is probably the main way to fully understand the scope for and encourage DSR participation from industry end-users.

7) Unexploited potential? On the basis of these interviews[24], we believe there may be some unexploited DSR potential within the industry sector. For example, we learned that some businesses reduce their demand in anticipation of a TRIAD half-hour to avoid incurring higher TNUoS charges – and some businesses were in practice reducing their demand in anticipation of a TRIAD period, up to 10-20 times per annum. However, to realise such potential, the points outlined at 1 through 6 above will need to be considered and resolved.

[24] and supported by the technical potential identified in the Brattle modelling.

6. Definitions

DUOS banding. Recently introduced system whereby Distribution Use of System (DUOS) charges reflect the time bands with differential pricing (Red/Amber/Green). Large energy users are likely to have these time differentiated distribution DUOS charges reflected in their contracts with their energy suppliers to encourage peak-time avoidance.

Electro-intensive: a process or industry which is a heavy electricity user, derives the greater part of its energy consumption from electricity rather than gas.

FCDM: Frequency Control by Demand Management. Frequency response service operated by National Grid to maintain frequency on the grid at +/-1% of 50Hz at all times. It provides frequency response through the interruption of demand customers. This is done automatically by frequency relay. FCDM providers must be available 24 hours a day, to deliver a minimum of 3MW within 2 seconds of instruction, for a minimum of 30 minutes.

FFR: Firm Frequency Response. Frequency response service operated by National Grid to maintain frequency on the grid at +/-1% of 50Hz at all times.

STOR: Short Term Operating Reserve. Balancing service operated by National Grid to balance the national electricity system following unforeseen increase in demand or generator non-availability. This service provides additional active power from generation or demand reduction. STOR providers must be able to offer a minimum of 3MW for at least 2 hours, deliver within 20 minutes to 4 hrs notice, and be able to provide STOR at least 3 times a week.

TRIAD – (TRIAD management)[25]. Scheme operated by electricity suppliers to reduce electricity demand in the three half-hours of highest system peak demand in the year (the TRIAD). Licensed electricity suppliers pay annual £/MW network charge to National Grid (TNUoS - Transmission Network Use of System) calculated in part on the basis of the supplier's maximum peak load during these three half-hours. Suppliers provide economic incentives to their electricity customers to reduce their demand in the TRIAD half hours by passing on part of the TNUoS costs.

Electricity customers who enter into an agreement with their supplier to actively reduce demand during TRIADs are given day-ahead or on-the-day warnings of potential TRIADs during the TRIAD season (winter).

Voluntary Load Management (VLM). Supplier operated scheme which allows electricity customers to purchase electricity as usual, and set price thresholds at which they are willing to reduce their demand and sell back electricity, generating revenue for the customer. VLMs are contracts between a supplier and electricity customer, tailored to the customer's needs.

[25] STOR and TRIAD are mutually exclusive – one company cannot offer both simultaneously in the same time period.

Annex 1: Overview of electricity use in industry.

This is a brief high level overview of electricity end-use in different industry sectors. We have not come across a recent or summary broad-picture of this kind.

Food sector

Energy use and electricity use within the food sector varies by subsector, process and end-product. However, a few common themes emerge:

- Frying and baking processes are gas-powered and are significant loads.
- Refrigeration accounts for the largest electrical load (both process and storage refrigeration).
- Ancillary processes and equipment such as pumps, fans and motors also account for a significant amount of overall electrical load.
- Energy and electricity consumption is influenced by external factors, e.g. characteristics of the raw product feedstock.

The potential for DSR provision from refrigeration load is very limited, due to food safety and product quality concerns associated with changes in refrigeration temperatures.

Paper sector

The paper making process consists of three process stages:

- Pulp production.
- Paper production (the most electricity intensive process stage).
- Rewinding.

There are also ancillary processes which consume electricity, such as pumps, fans and motors.

The most electricity intensive step, paper production, consists of the liquid pulp being fed into a paper machine, and then poured out of a narrow aperture to form a paper web. This is then dried and pressed to remove the water contained in the pulp.

The drying process is a significant and constant heat demand, therefore most paper production sites have onsite CHP which they use to meet their heat requirements, and some of their electricity demand.

There is some scope for providing DSR, due to the buffering potential within the process – it is possible to interrupt pulp production for a short period of time without affecting overall site production. During this time period, pulp is still removed and consumed by downstream processes, but is not being produced. Eventually the pulp store or buffer is depleted and the pulp-making process must be resumed. The alternative – to interrupt the paper-making process – is financially prohibitive, as the loss of revenue associated with lost production times significantly outstrips any financial incentives on offer through DSR schemes such as STOR.

Chemicals sector

We spoke to four chemical manufacturers and also to the Chemical Industries Association. The chemicals sector is particularly diverse: it includes the manufacture of pharmaceuticals, fertilisers, pesticides, plastics, chlorine, organic and inorganic basic chemicals among others. It is therefore difficult to make generalisations about the potential for Demand Side Response within the industry.

However, a few common issues can be highlighted. Key issues for the chemical sector, some of which restrict the potential for demand side response, are:

- **Safety concerns:** many processes cannot be safely interrupted, and / or the intermediate stage products cannot be safely stored, which prohibits interruption of the processes to provide DSR.
- **Interlinked, interdependent processes:** where several production processes on a site are interlinked – e.g. the output of one is the feedstock for another – processes cannot be interrupted without interrupting production across the whole site, which is financially punitive. This severely restricts the potential for provision of DSR through process flexibility.
- Linked to the above is the availability of **storage facilities for intermediate stage products –** where these exist (assuming the product can safely be stored), they permit one or more processes to be interrupted, without stopping the whole site, and therefore enable DSR provision (e.g. can interrupt Process A temporarily, while Process B continues, taking feedstock from a store, until the store is depleted and Process A has to restart) This buffering procedure is also found in the paper industry described above, and the cement industry, see below.
- Some chemical processes have **higher heat demand** than others, and are therefore more gas-intensive, rather than electricity intensive (e.g. fertiliser manufacture). Businesses operating these processes often have on site CHP generation, which can be used to provide DSR if there is the capacity / flexibility within the CHP unit.

It is worth noting that one of the four businesses we spoke to was unable to participate in **any** demand-side response. The reason for this is that they operate a highly interlinked, interdependent plant, where interrupting one process means interrupting the whole site. As previously mentioned this is financially prohibitive.

A specific example within the chemical industry is the production of chlorine, which is particularly electricity-intensive, as it consists of the electrolysis of a brine solution within the chlorine production cells. There are two key issues restricting the potential for DSR in chlorine production:

- There are several downstream processes associated with chlorine production which cannot safely be interrupted, hence interrupting production at the chlorine cells and disrupting downstream processes is problematic; and
- Chlorine cannot safely be stored in significant amounts; so it is not possible to 'stockpile' chlorine to serve downstream processes while production is interrupted.

There is however some potential for DSR from chlorine production cells, both short-term and longer-term, which involves ramping chlorine production up or down, rather than interrupting the process outright. The chief limiting factor to this are the downstream processes, which cannot be safely interrupted.

Steel sector

We can divide electricity consumption in the steel sector across three main processes:

1) Production of steel by the Basic Oxygen Steelmaking method.
2) Production of steel using the Electric Arc Furnace.
3) Downstream processing of steel in mills (rolling, cutting).

1) In the **Basic Oxygen Steelmaking (BOS)** method molten pig iron from a furnace is combined with scrap steel in a refractory-lined vessel. Oxygen is blown into the combination, igniting the carbon dissolved in the steel and burning it to form CO and CO_2, causing the temperature to rise to around 1700C. This melts the scrap, lowers the carbon content of the molten iron and helps remove unwanted chemical elements.

The BOS process:

a) Is predominantly gas-fired or fired from waste gases rather than electricity-fired.
b) Has very limited flexibility in terms of ramping up/down to provide DSR.

2) Production of steel in an **Electric Arc Furnace** consists of the melting of scrap metal by using an electric arc created between electrodes in the furnace. This method can use 100% scrap metal as feedstock. After melting, the steel is refined.

An Electric Arc Furnace is extremely electricity-intensive. It has a very distinctive demand curve, which rises sharply at the beginning of the process and remains high during the short melt period (to melt the scrap metal), followed by a longer period of lower but variable demand during the refining stages. The time for one full cycle (from loading of scrap metal to ladling of molten steel) is known as the tap-to-tap time. The tap-to-tap time at an EAF varies widely (between 45 mins and 3hours approximately), depending on the quality of steel required. Higher-grade steel requires more refining and therefore has longer tap-to-tap times. The overall 24-hour profile demand for an EAF consists of a series of these tap-to-tap curves, with some variability due to operational variations.

The very peaky demand profile and difficulty in predicting the timing of these peaks (due to operational variations) make it difficult for EAFs to provide instant/short term DSR, although it is physically possible. If e.g. immediate load reduction is requested when an EAF is about to start melt, it is difficult to drop load, although it is possible to not increase load by delaying the start of melting. However, not increasing demand is not perceived and rewarded in the same way as demand reduction. For this reason, historically EAFs found participating in STOR to be unrewarding, as non-increase in demand at these points was not rewarded.

EAFs are better suited to providing longer-term DSR services. Given sufficient notice periods (day-ahead or several hours) and suitable financial incentives, melt periods can be planned to avoid peak times.

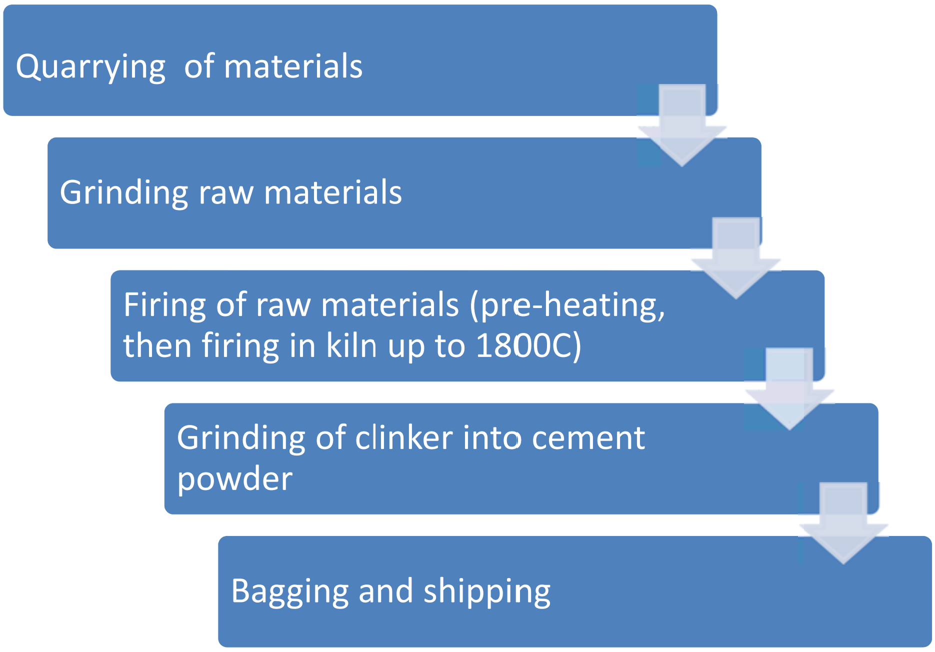
3) Steel mills

Steel mills traditionally turn molten steel into ingots, slabs and sheet through casting, hot rolling and cold rolling. Integrated steel mills have all the primary steelmaking functions as well (iron making, steel making).

The electric load in steel mills includes fans, motors (in e.g. cranes, lifting beams).

Cement sector

Cement manufacture is an energy-intensive process which involves the steps outlined below:



The raw materials grinding and the grinding of clinker into cement powder are both highly electricity-intensive (the grinders or mills have very large motors). The firing stage is very gas-intensive, although alternative fuels can be used and are used by some companies.

Potential for providing DSR arises from the cement mills, as cement grinding can be interrupted for limited periods of time. There are no technical limitations to interrupting cement grinding: clinker can be stored without loss of condition or quality for grinding at a later date. Therefore the main limitation is how to interrupt cement grinding without impacting on overall cement production. This depends on two key factors:

- The sizing of the cement mills compared to the rest of the cement manufacture plant – in some cases cement mills are not required to run 24/7 in order to keep in time with the rest of the plant, and can therefore be flexed to provide DSR.
- Clinker storage capacity. Directly linked to the above, depending on the facilities for storing clinker on site, the cement grinder can be stopped for a number of hours while clinker accumulates in the store. The cement grinder can then be switched back on again and grind through the stored clinker.

From our conversations with two cement manufacturers it appears that generally the clinker storage and overall site capacity and set-up allow for cement mills to be interrupted for a few hours, but no longer (e.g. potential for TRIAD or STOR, but unlikely to be able to provide a more long-term service such as that envisaged to be required to counter for winter anti-cyclonic conditions in a future market with high wind penetration).

A third factor of course is the status of the order book for a cement plant at any time – if business is good and the plant is running at full output 24/7 there is less potential for DSR.

Industrial gases sector

For this sector, the raw material feedstock is air. Air is fed into an Air Separation Unit, where it is cooled, compressed and separated into its constituent parts (N_2, O_2, Ar). These gases are then either supplied directly to customers by pipeline, or compressed until they are liquid in order to enable transport in cylinders or tankers.

The two key electricity consumption processes points arise from:

1) Air Separation Units (consisting of a compressor and refrigeration).
2) Nitrogen Liquefaction Unit.
3) Pipeline product compressors.

As mentioned above, some customers are supplied directly via pipelines from the industrial gases plant. Demand from these customers varies depending on their own production processes and loading, and it is the task of the air separation unit/industrial gases plant to meet this variable demand by adapting the production rate of gases accordingly. The presence or absence of pipeline customers therefore affects the potential for an industrial gases plant to provide DSR.

Accordingly there are three types of industrial gas plants/sites:

1) **Plants exclusively serving pipeline customers**. The production level at these plants mirrors the demand from customers, which is variable. There is limited scope to provide demand side services from these plants. Most plants have some storage of liquefied gases onsite, and it is technically possible to regasify these stored gases to serve pipeline customers while interrupting the operation of the Air Separation Unit (this is also the back-up strategy in case of plant failure). However, there is a large energy cost to this, as the liquefaction of gases is very energy-intensive, and liquefying and regasifying gases is not energy or cost efficient. The financial incentives to provide DSR would have to be very strong to stimulate this response.

2) **Plants exclusively serving non-pipeline customers / liquids customers**. These plants separate gases in the ASU, then liquefy the gases and supply their customers by cylinders or tankers. There is the potential to provide flexibility from either the ASU or the liquefier, by drawing from onsite stored gas supplies. There is still an energy and economic cost to this, as upon restarting an ASU, it will take some time before the quality of the gases produced reaches the desired level, and during this period the ASU is consuming electricity.

3) **Plants serving a combination of pipeline & non-pipeline or liquids customers**. These plants have the potential to provide flexibility, mainly from the Nitrogen Liquefaction Unit. In this case the ASU would continue to operate, supplying pipeline customers, while liquids customers would be supplied by liquid product produced previously. As in the first example, there is the technical potential to interrupt ASU operation and regasify stored products to supply pipeline customers, but this is a costly option.

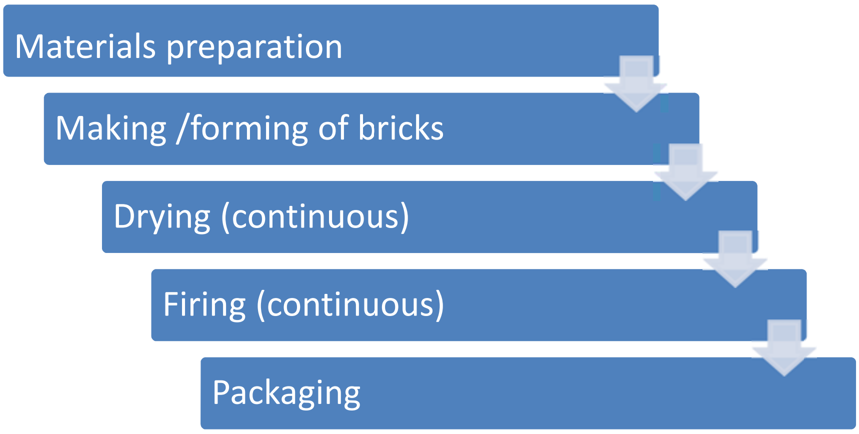
Ceramics sector

The ceramics sector includes the following subsectors:

- Bricks.
- Refractories and industrial ceramics.
- Whiteware (tableware, sanitaryware).
- Materials for the ceramics sector (including frits & glazes).

The ceramics industry consumes several times more gas than electricity. The most energy intensive process within the sector is the firing of kilns. Kilns are predominantly gas-fired, electric kilns are rarely used. Most kilns are run continuously e.g. in the brick industry, although some smaller intermittent kilns are used.

Taking the brick industry as an example, the manufacture process is as follows:



The kiln firing is gas-powered, and the drying process frequently uses waste heat from the kiln.

Electricity is consumed by:

- The materials preparation, making, and packaging stages.
- The fans and motors for the firing and drying.
- The motors drawing the brick-cars through the kiln.

The largest electrical load is in the Material Preparation stage, and there is potential for DSR to be provided by this stage. Materials preparation consists mainly of crushing clay and mixing it with sand & pigments as required.

Materials preparation can be interrupted or scheduled to take place at certain times. Depending on the storage capacity for prepared materials onsite, materials preparation can be interrupted for varying lengths of time (hours to days).

Kilns are run continuously (cooling of kilns to ambient temperature risks structural damage to the kiln), so there is no potential for DSR to be provided by the associated electrical load.

Water sector

The water sector supplies customers with water and provides wastewater treatment services. Electricity consumption arises from the following:

1) Water and wastewater pumping.
2) Treatment of water and wastewater.

Water companies vary in their level of interest and participation in DSR, depending on their size and location.

They have the potential to provide DSR thanks to the flexibility in water pumping operations, by moving pumping operations away from peak hours.

There is some, more limited, scope for flexibility in the pumping and treatment of wastewater. Potential for flexibility is limited by having to mirror the operating patterns of the customers producing wastewater.

Water companies also have the potential to provide demand side response by using their own generation capacity, which can be significant: water companies typically have a number of diesel back-up generation units across their pumping sites. Additionally, many also have CHP units fuelled by sewage sludge digestate from sewage treatment operations.

Retail sector

Retail does not strictly fall within the industry sector as defined by DUKES sector classification, however it is a sector which has been the subject of much discussion regarding its potential for DSR response. Hence we considered it would be useful to speak to at least one major retailer, to gain an insight into the sector.

Electricity consumption within the retail sector electricity arises primarily from:

- Heating, ventilation and air conditioning (HVAC) of buildings.
- Refrigeration (for food).
- Lighting.

There is some potential for the provision of DSR from HVAC, by extending the automated temperature ranges permitted within a building. This can be done with no impact to customers.

The provision of DSR from refrigeration is not viewed positively by industry, due to serious concerns regarding food safety.

There is possibly some potential for Demand Side Response from lighting, although prior communication campaigns to inform the public would be required, in order to avoid perceptions of malfunction currently associated with lower lighting levels, or lighting being switched off.

There is also some potential for demand reduction from lighting, by the introduction of new, more energy-efficiency lighting technologies, i.e. LEDs.

Annex 2 Breakdown of electricity consumption by SIC code

The following table from DECC's Energy Consumption in the UK publication[26] presents annual electricity consumption for industry, across the Standard Industry Classification categories (2007 classification).

Breakdown of industrial electricity consumptions by SIC code in 2011 (ECUK 2012)[27]

SIC (2007) codes	Description	Electricity consumption (thousand tonnes oil equivalent)	Electricity as % of total energy consumption
08	Other mining and quarrying	133	38.70%
10	Manufacture of food products	778	30.37%
11	Manufacture of beverages	187	30.37%
12	Manufacture of tobacco products	12	58.55%
13	Manufacture of textiles	167	30.38%
14	Manufacture of wearing apparel	73	28.14%
15	Manufacture of leather and related products	18	50.15%
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	222	31.99%
17	Manufacture of paper and paper products	604	33.22%
18	Printing and publishing of recorded media and other publishing activities	334	62.03%
19	Manufacture of coke and refined petroleum products	415	9.76%
20	Manufacture of chemicals and chemical products	1,363	37.81%
21	Manufacture of basic pharmaceutical products and pharmaceutical	142	37.81%

[26] DECC – Energy Consumption in the UK, Industrial Data Tables, 2012 Update. Table 4.6D(i). http://www.decc.gov.uk/publications/basket.aspx?filetype=4&filepath=Statistics%2fpublications%2fecuk%2f270-ecuk-industrial-2010.xls&minwidth=true#basket

[27] DECC – Energy Consumption in the UK, Industrial Data Tables, 2012 Update. Table 4.6D(i). As above.

	preparations		
22	Manufacture of rubber and plastic products	906	54.16%
23	Manufacture of other non-metallic mineral products	470	18.90%
24	Manufacture of basic metals	930	42.68%
25	Manufacture of fabricated metal products, except machinery and equipment	379	48.98%
26	Manufacture of computer, electronic and optical products	337	68.51%
27	Manufacture of electrical equipment	213	54.39%
28	Manufacture of machinery and equipment n.e.c.	255	50.40%
29	Manufacture of motor vehicles, trailers and semi-trailers	282	33.69%
30	Manufacture of other transport equipment	164	42.07%
31	Manufacture of furniture	85	42.84%
32	Other manufacturing	114	42.84%
35	Electricity, gas, steam and air conditioning supply	-	
36	Water collection, treatment and supply	455	82.77%
38	Waste collection, treatment and disposal activities; materials recovery	52	8.93%
42	Civil engineering/construction	132	29.82%

Table 6 Breakdown of industrial electricity consumptions

(**Source**: ECUK 2012, table 4.6d(i))

Annex 3 DSR schemes currently available

The following tables were compiled for Paper 4[28] of the GB Electricity Demand project.

Table 7 - NG Balancing Services which may be provided by DSR[29].

Market Service	Notice Period / Speed	Duration	Minimum Load	Time of Day / Year	Location Specific	Communication & Monitoring	Indications on Value	2012 Customer Participation
Firm Frequency Response (FFR). Firm availability of 'Dynamic' and/ or 'Non-Dynamic' frequency response in 'nominated' periods. Aim is to manage system frequency within statutory & operational limits (1) in the event of a loss of either generation or demand and (2) to correct short-term frequency	Dynamic - Automatic / Instant. **Primary Response** - delivered over 2-10sec timeframe sustained for up to 30secs. **Secondary Response** - delivered within 30secs & sustained for up to 30min. **High Frequency Response** - delivered over	Non-Dynamic Response: At least 10 minutes May be tripped 10-30 times pa for a low frequency event (depending on frequency relay threshold setting)	Minimum 10 MW of energy which can respond, although volumes less than this permitted if evidence that the service can grow to 10MW+	Any. Daily.	Location is a secondary factor in the assessment of a frequency service - although it may be taken into account given network constraints and any subsequent restrictions on the use of frequency response energy these might impose	Operational metering / Measurable Able to provide both : **'Dynamic' Frequency** - Automatic / instant changes to load in response to second-by-second changes in system frequency. **'Non-Dynamic' Frequency** – service triggers at a pre-set frequency variation (eg 49.7 Hz).	Frequency Response spend (Total – 2011/12) - £193m Indicative payments £50-£60/kW/pa split between a tendered Availability, Holding and Utilisation fee.	Dynamic Response: (Large B-M generators required to provide 'Mandatory' frequency response). Both BM & Non-BM providers may participate in the Firm Frequency Response market operated through a Framework Agreement -with monthly tender for single or multi-month contracts Demand Examples. **Dynamic** – 3-5 MW of commercial heating

[28] Paper 4: 'What demand side services can provide value to the electricity sector'. June 2012. See http://www.sustainabilityfirst.org.uk/gbelec_documents.html
[29] Balancing Services can be provided to National Grid by : Large Generators (BM Units) ; Embedded Generation ; Back-up Generation ; Large Loads (demand reduction) ; Aggregation of smaller loads e.g. water plants ; heating / chilling industrial units.
Sources : National Grid email correspondence. June 2012. Plus, National Grid website - publications and presentations. Also, report for DTI. URN 06/1432. 'Reducing the Cost of System Intermittency Using Demand Side Control Measures'. 2006. IPA Consulting, E-Connect Ltd & Martin Energy.

variations due to delay in Balancing actions taking effect. Demand *reduces* to balance falling frequency. Demand may also be *increased* to increase frequency (within 10 seconds).	2-10secs timeframe, sustainable indefinitely. **Non-Dynamic** Within 10- 30 seconds							load. OpenEnergi (formerly RLTEC). Frequency response contract with National Grid. Heating & Ventilating Units across 200 Sainsbury Stores – March 2011. **Non-Dynamic –** Not at present.
Frequency Control by Demand Management (FCDM). Frequency control by automatic interruption of demand customers to support management of low frequency. Low frequency relays at providers' sites automatically 'trip' demand if frequency falls below a pre-set point – eg 49.7Hz.	Within 2 seconds (i.e. via trip relay).	At least 30 minutes May be tripped 10-30 times pa for a low frequency event	3 MW (can aggregate at same site).	Any	Location is a secondary factor in the assessment of a frequency service - although it may be taken into account given network constraints and any subsequent restrictions on the use of frequency response energy these might impose.	Operational metering / relay measurement	Maximum potential value in line with Firm Frequency Response (FFR). However FCDM is a 'non-firm' service so actual value achieved may fall short of the firm service offered by 'Firm Frequency Response'.	Procured bilaterally. Aggregated. Typically, can expect to be interrupted around 10-30 times p.a. Potential market size – 500+MW – volume of contracts struck - dependent wholly on economics when compared with other response services. Demand Examples – 150 MW@49.7 Hz.

Market Service	**Notice Period / Speed**	**Duration**	**Minimum Load**	**Time of Day / Year**	**Location Specific**	**Communication & Monitoring**	**Indications on Value** (2009 unless otherwise stated)	**2012 Customer Participation**
Fast Reserve Demand reduction (or increase in generation) to manage large and rapid rates of change - e.g. for TV 'pick-ups' ; Autumn & Spring 'shoulders'.	Begin delivery within 2 minutes (at rate >= 25 MW / minute)	Sustain for 15 mins minimum	50 MW (can aggregate).	Any. Daily (during rapid changes in demand).	Location is a secondary factor in the assessment although it may be taken into account given network constraints and any subsequent restrictions on the use of frequency response energy these might impose.	Operational metering	Availability payment - £44k/MW pa Usage payment - £6k/MW pa (For BM generators - £/MWh as per BM bid-offer prices). Plus possible Optional 'enhanced' service fee if can match run-up / run-down rates.	Fast Reserve spend (total 2011/12) - £92 million. Tendered (monthly) and / or bi-lateral - dependent on service-provider characteristics. Can be 'firm'- or 'optional'service under a framework agreement. Requirements vary significantly by time of day. Peak requirements for the service occur late evening and can exceed 1000 MW. A year round 24/7 'average' indicative requirement would be in the range 100-500MW Example - ~250 MW tele-switched storage heater load.

Market Service	Notice Period / Speed	Duration	Minimum Load	Time of Day / Year	Location Specific	Communication & Monitoring	Indications on Value (2009 unless otherwise stated)	2012 Customer Participation
Short Term Operating Reserve	Ideally within 20 minutes – but fully available within 4 hours.	At least 3 times per week. Fully available for at least 2-hours. Ideally 3-4 hours.	3 MW Up to 50-80 hours p.a. (windows)	Either side of morning & evening peaks. All year round. Weekdays & weekends	Location is a secondary factor in the assessment although it may be taken into account given network constraints etc.	Operational (Real-time) Metering	Availability payment - ~£22k/MW pa Usage payment - ~£12k - £18k pa variable (for 1 MW 50 – 80 called hours pa) (For BM generators - £/MWh as per BM bid-offer prices). Average STOR bidder offer prices in 2010-11 were : Availability - £9/MWh Usage - £250/MWh Average STOR bidder offer prices in 2011-12 were : Availability - £8/MWh Usage - £225/MWh	STOR spend (total 2011/12) - £98m 'Committed' or 'flexible' contracts. Contract length – one year plus (and potentially up to 15 years although maximum contract length currently offered is 2 years). Examples – Industrial process interruption Switch to on-site back-up generation
Demand Management	Flexible	Must provide service across a minimum of 2 consec settlement periods (i.e. one-hour).	25MW	Morning Demand Peaks and Evening Demand Peaks	Location is a secondary factor in the assessment although it may be taken into account given network constraints etc	Operational metering	N/A	None

Transmission Constraints Short-term measures to alleviate local power flows / constraints during planned maintenance on Transmission network		Short-term or long-term DSM responses – instead of temporary network constraint measures (e.g. FACs, SVCs).			Yes		Transmission constraint spend (total 2011/12) - £324m	Currently no DSR participaton. National Grid's costs of managing transmission constraints have been increasing with more wind commissioning, especially in Scotland – and associated upgrade works of the transmission system. National Grid seeks to reduce constraint costs via locational contracts. The characteristics of constraints tend to require a service for extended periods - every day, possibly for weeks or months – and this could prove disruptive for a DSR provider. Moreover, constraints may be one-offs – or not re-occur for a number of years – so may offer a DSR provider little revenue continuity.

Table 7 NG Balancing Services which may be provided by DSR

Table 8 – Deferred or Avoided Transmission Network Use of System Charges (TNUOS) from DSR								
Market Service	**Notice Period / Speed**	**Duration**	**Minimum Load**	**Time of Day / Year**	**Location Specific**	**Communication & Monitoring**	**Indications on Value** (2011)	**2012 Customer Participation**
TRIAD avoidance - aims to suppress winter peak demand - and so to enable deferred network re-inforcement – and thereby keep down TNUOS charges. TRIAD avoidance thus offers scope for I&C customers to avoid some peak-related transmission charges (TNUOS). The annual £/MW TNUOS network charges payable by licensed suppliers to National Grid, are based, in part, on a supplier's maximum load in each of 14 zones. TNUOS charges for the year ahead, are based on maximum demand / load - averaged over the three winter peak half-hours – the TRIAD. TRIAD-related TNUOS charges therefore seek to create an incentive to curtail peak demand.	~Day Ahead ?	One-hour - at three winter peaks – 17.00h – 18.00h	>100 kW (Most likely)	Yes – three winter peak demands (but may be 10-20 'warnings').	Yes – charges vary by 14 zones.	Half-hourly settlement.	**Demand Tariff for H-Hly metered customers**: applied to average half-hourly metered demand over the three TRIAD (winter peak) half-hour periods. TNUOS Charges vary according to geographic zone **Locational Charge** 2012-13. North Scotland - £10.74/kW London - £31.17/kW. **Non-Locational 'residual' element** - £22.83p/kW in 2012-13 (regardless of zone).	Transmission demand charges are payable by suppliers. Split into 14 geographic zones. Generally, lower in north and higher in south. ~Three-quarters of £1.7 billion annual transmission network use of system charges (TNUOS) are levied from Demand (G:D T-charges split is 27:73%). Of this, approx £370million is recovered from Half-Hourly metered demand customers who are eligible to participate in the TRIAD avoidance mechanism. **For half-hourly settled customers** (so >100kW), customers can agree for the supplier to 'pass-through' transmission charges directly to them. In effect, this is akin to an opt-in Critical Peak Rebate – available to half-hourly settled 100 kW-plus I&C customers, if they so choose . **For Load Profile 1-8 customers** : an **Energy Consumption Tariff** is charged by transmission networks to each supplier in each

								zone (as per settlement) during the period 16.00h-19.00h each day. **Example - 2012-13 Energy Consumption Tariff :** North Scotland Zone – 1.48p/kWh Southern Zone – 4.34p/kWh

Table 8 Deferred or Avoided Transmission Network Use of System Charges (TNUOS) from DSR

Table 9 – Deferred or Avoided DNO Investment from DSR.								
Market Service	**Notice Period / Speed**	**Duration**	**Minimum Load**	**Time of Day / Year**	**Location Specific**	**Communication & Monitoring**	**Indications on Value** (2011)	**2012 Customer Participation**
EHV / HV Networks Fault Response –bi-lateral arrangement between DNO and customer(s) or aggregator.	~3-4 hours	Possibly, up to several weeks	? 1 MW (but can be aggregated).	Any	Yes	Half-hourly metering	SF Guesstimate ~£40-60k/MW/pa (so, £40-60/kW/pa)	Aggregated I&C Load – see Annex 1 for practical examples.
Low Voltage Networks Thermal constraint management				Winter	Yes	Teleswitch		Example – Economy 7
Distribution Use of System Charges (DUOS) – payable by suppliers to DNOs to allow cost-recovery by a DNO of the fixed and variable costs of network investment, re-inforcement, maintenance, repair and operation. A generic charging methodology - the **CDCM – Common Distribution**	Customer aware of ToU charges	3 hours	100 kW +	Mostly (but not only) winter.	No	Half-hourly meters No - Load Profile according to meter-type No - Load Profile according to meter-type	See DNO Annual Statement of Charges for the Use of the Electricity System (each DNO web-site). DUOS charges, for all half-hourly customers include (inter al) : a fixed charge per customer per day (standing charge); a separate capacity-related charge –	**EHV directly-connected Half-Hourly customers** – DUOS charges passed-on by supplier. Super-red time bands charged at winter weekday evening peak across all DNO areas. (In London, super-red time bands apply both during winter evening peak hours – 16.00h-19.00h Nov-Feb *and* summer 11.00-14.00h June-August). **Half-hourly customers connected at any voltage** – DUOS charges passed –on by supplier. A seasonal 3-part time of day element incorporated in DUOS charges. Red, Amber and Green periods. **Load Profile 5-8 Customers** (166,000) – 2-

Charging Methodology – introduced in April 2010. **DUOS charges** typically include a **daily fixed cost of pence / customer** plus a **p/kWh energy-related charge**. Other costs (e.g capacity-related) on basis of customer load profile. **Seasonal Time of Day Tariffs** – for 117,000 half-hourly metered and settled customers. **All other customers -** some limited day / night tariff s - subject to the meter Load Profile.							and 3-(seasonal) p/kWh unit rates. These elements vary, depending at which network voltage the customer is connected.	part day-time and lower night-time p/kWh unit charge payable by supplier. **Load Profile 1-4 Customers** (29 million) – connected at Low Voltage. p/kWh unit DUOS charge payable by supplier – plus a night-rate for Econ 7 & off-peak customers (LPs 2 & 4).

Market Service	Notice Period / Speed	Duration	Minimum Load	Time of Day / Year	Location Specific	Communication & Monitoring	Indications on Value (2011)	2012 Customer Participation
Non-Firm Connection Agreement Connection charges allow cost-recovery by DNO of any necessary works / new capital assets to connect new generation or demand to its network to the requested 'required capacity' (kVA). 'Non-firm' connection agreement may allow customer to pay lower charges.			Likely to be half-hourly customers (so 100kW+). – but could also be 'community-level' schemes.	Winter peak – but not just.	Yes	Communications and metering	'Discount' against published DNO connection charges. Lower DUOS charges.	Customer has non-firm connection agreement whereby load can be curtailed where network constrained, in return for a lower initial up-front connection payment – and lower ongoing DUOS charges).

Table 9 Deferred or Avoided DNO Investment from DSR

Table 10 – Supplier Demand Management Schemes via Retail Tariffs.

Market Service	Notice Period / Speed	Duration	Minimum Load	Time of Day / Year	Location Specific	Communication & Monitoring	Indications on Value (2011)	2012 Customer Participation
Suppliers seek reduced operating costs through management of (1) wholesale energy procurement risk and (2) imbalance risk. 117,000 100kW+ customers: ~48% of all electricity consumed (155TWh p.a.) 166,000 Load Profile 5-8 customers: ~5% of all electricity consumed (~17 TWh p.a.)		ToU and seasonal retail tariffs over a 24 hour period.	Half-hourly -so 100kW plus Load Profiles 5-8.	Yes	No	Half-hourly meters for 100kW+. LP5-8 meters for others	~60% of an I&C customer's total end-bill is likely to be energy related.	**I&C Customers** Half-hourly metered and settled customers - will be on a variety of fixed and flexible energy management contracts – & which may incorporate some fairly granular time-varying pricing – peak / off-peak, day/ night, seasonal elements. Load Profile 5-8 customers - likely to be on a somewhat more limited range of day/night/ seasonal tariffs – unless half-hourly metered. Example : Government Procurement Service procures around 4% (~14TWh p.a.) of all electricity consumed. GPS offers public bodies opportunity to access power in the half-hourly and non-half-hourly wholesale markets – incl. via 10MW hourly 'base-load' blocks – 19.00h-07.00h.

Market Service	**Notice Period / Speed**	**Duration**	**Minimum Load**	**Time of Day / Year**	**Location Specific**	**Communication & Monitoring**	**Indications on Value** (2011)	**2012 Customer Participation**
Load Profiles 1-4 – Small Business and Household Customers Economy 7 / Off-Peak customers : Load Profile 4 - 0.5 m customers Load Profile 2 Customers - ~5 million.	Instant – but staggered switching	Midnight to 07.00h	1-7 kW	Yes	Customer pays a lower Econ 7 night-time retail tariff – irrespective of their location. However, radio-teleswitch can in fact be switched by location - or not – as required.	Radio Teleswitch for ~ 2 million of the 5.5 million total LP2 & LP 4 meters. Discussion about Radio Teleswitch being maintained beyond 2017.	Supplier shares the benefit with their customers – of the customer consuming most of their electricity overnight - when wholesale prices are lower – via a lower overnight retail tariff. Customer may however pay a higher day-rate than a standard day rate (for fixed cost recovery). Overnight tariff therefore may be best suited to customers who have more load running overnight (eg storage heaters) to offset disbenefit of a possible higher day-rate.	LP 1 & 3 meters are ‘unrestricted’. LP 2 & 4 meters can be ‘switched’ and/ or are 2-rate - for those customers on an Economy 7 or equivalent overnight tariff. **Load Profile 3&4 customers** – ~2 million small & medium enterprises. **LP 4 customers** – ~0.5m customers. May consume ~3 TWh p.a. as off-peak night-time units (i.e. at most ~ 10% of all LP 3&4 units combined (~35 TWh). **Load Profile 1&2 customers** – mainly households and small business. 27 million customers total. 22 million LP1 and **LP 2 customers –** ~5 million. May consume ~10 TWh as off-night-time peak units (so, ~9% of all household units).

Table 10 Supplier Demand Management Schemes via Retail Tariffs

Annex 4 Questionnaire as used with industry customers

Demand Side Response Industry Questionnaire

1. **About the company**

1.1 Company name:
1.2 Interviewee name & job title:
1.3 Date of interview:
1.4 Company chief activity:
1.5 Number of sites:
1.6 Number of employees:

2. **About your current electricity usage**

2.1 How do you use your electricity? Describe the key processes using electricity.

2.2 Which of your processes consume most electricity? Please describe.

2.3 How much electricity do you use? (annually, monthly).

2.4 What is your peak (maximum) demand?

2.5 When do you use your electricity? Is there variation - day/night, week/weekend, seasonally?

2.6 Are some or all of your sites half hourly metered (totally or partially)? HH settled?

2.7 Do you use an energy monitoring system on your site?

3. **Energy management**

3.1 Do you buy your electricity directly from a supplier or through a broker?

3.2 How far ahead do you buy your electricity? For example, monthly, six-monthly, year ahead.

3.3 How significant is your expenditure on electricity as a proportion of your overall variable or running costs?

3.4 Do you generate any of your own electricity? If so, is this base-load or back up? Have you considered using it for export?

3.5 Are you on a Time of Use type tariff?

3.6 Has your supplier suggested any DSR or flexible arrangements?

3.7 Have you been approached by an aggregator in the past?

3.8 Do you take part in the EU ETS? Or the CRC?

4. Demand Side Response – current

4.1 Do you currently participate in any of the Demand Side Response schemes available? This includes TRIAD avoidance, STOR, frequency balancing. Describe which ones.

4.2 If yes, what has your experience of these been?

4.3 When you participate, are you actively reducing demand, or are you switching to back-up generation? If back-up, what fuel does it use? (diesel?).

4.4 If you do not participate, what are the barriers or reasons for this?

5. Demand Side Response – potential

5.1 What potential for Demand Side Response is there within your operations? (including both demand shift and demand reduction).

5.2 Which of your processes has the most potential for Demand Side Response?

5.3 What notice period would be required to activate this DSR? (mins, hours).

5.4 How long could you provide this DSR for?

5.5 With what frequency could it be provided?

5.6 What level of financial incentive would be needed for you to realise this DSR?

5.7 Would you be willing to accept automated or partly automated enabling of DSR[30]?

[30] To clarify: this does not mean surrendering all control, rather enabling remote control, while keeping an override facility option which can be used for operational or other reasons.

Types of Demand Side Response service

	Possible examples			
Demand side service to offer	Millisecond response short-term demand reduction	15-minute block demand reduction	Sustained demand reduction across 4-8 hours	Sustained demand reduction across several days
Potential to provide this service? List the processes which could do so				
How much could provide? (MW?)				
Notice required to provide service (mins/hrs)				
Frequency with which can provide service?				
At what price / financial incentive?				

Include brief description of the processes which have flexibility and the technical reasons for their flexibility.

Annex 5 Questionnaire overview as circulated to industry customers prior to interview

Demand Side Response Industry Questionnaire

Introduction to GB Electricity Demand project and the Smart Demand Forum

Sustainability First is a UK environmental think-tank with a focus on practical policy development in the areas of sustainable energy, waste and water. It is a registered charity (www.sustainabilityfirst.org.uk)

The Sustainability First project on **GB Electricity Demand** is a three-year project which started in April 2011. It is supported in its first year under the Northern Powergrid (formerly CE Electric UK) Low Carbon Network Fund project, and thereafter by a group of sponsors.

Sponsors include BEAMA, British Gas, Cable & Wireless, Consumer Focus, EDF Energy, Elexon, E-Meter strategic consulting, E.ON UK, National Grid, Northern Powergrid (formerly CE Electric UK), Ofgem, ScottishPower Networks, UK Power Networks.

Work is coordinated through a **Smart Demand Forum** whose participants include a number of key consumer bodies (Energy Intensive Users Group, Which?, and National Energy Action), together with DECC and the sponsor group members.

The project aims to identify the potential resource which the electricity demand side could offer into the GB electricity market through demand response and through demand reduction. The project aims to:

- Evaluate and understand the potential GB electricity demand-side resource across all economic sectors (including the role of distributed and micro-generation) ;
- Develop a clearer understanding of the economic value of this resource to different market actors and to different customers over the next 10-15 years ;
- Evaluate the key customer, commercial, regulatory and policy issues and interactions.

Focussing on the industry sector, as part of this work we are carrying out a survey of industry companies across a number sectors. We are also speaking to the relevant sector trade bodies.

The aim of the survey is to explore the potential for Demand Side Response (DSR) within your company: what the technical potential for DSR is; how feasible it is to access this DSR; what period of notice would be required; and what level of financial incentive would be required to stimulate this DSR; among others. The full survey is included overleaf.

Demand Side Response Industry Questionnaire

1. **About your company**
    - Chief activity
    - Number of sites
2. **About your current electricity usage**
    - How do you use your electricity? Describe the key processes using electricity
    - Which of your processes consume most electricity?
    - How much electricity do you use? (annually, monthly)
    - When do you use your electricity? (day/night, week/weekend, seasonally)
    - Are you half hourly metered (totally or partially)? HH settled?

3. **Energy management**
    - Do you buy your electricity directly from a supplier or through a broker?
    - How far ahead do you buy your electricity?
    - How significant is your expenditure on electricity as a proportion of your overall variable / running costs?
    - Do you generate any of your own electricity? If so, is this base-load or back up? Have you considered using it for export?
    - Are you on a Time of Use type tariff?
    - Has your supplier suggested any DSR or flexible arrangements?
    - Have you been approached by an aggregator in the past?
    - Do you take part in the EU ETS? Or the CRC?
    - Describe your site(s) electrical connection. (grid connection, on-site voltage used, etc)

4. **Demand Side Response – current & historical**
    - Do you currently participate in any of the Demand Side Response schemes available? Or have you done in the past 10 years?
    - If yes, what has your experience of these been?
    - If not, what are the barriers or reasons?

5. **Demand Side Response – potential**
    - What potential for Demand Side Response is there within your operations? (including both demand shift and demand reduction)
    - Which of your processes has the most potential for Demand Side Response?
    - What notice period would be required to activate this DSR? (mins, hours)
    - How long could you provide this DSR for?
    - With what frequency could it be provided?
    - What level of financial incentive would be needed for you to realise this DSR?
    - Would you be willing to accept automated or partly automated enabling of DSR?

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Finally, our thanks go to all those individuals in the industry who took part in our interviews, giving up their time to discuss the issues with us.

Interviews were on a non-attributable basis. We have sought to represent a balanced view, and responsibility for the findings and conclusions rests with Sustainability First.

Sustainability *First*

Sustainability First was set up to develop new approaches to sustainability. Its primary focus is on policy and solutions within the UK, but draws on experiences and initiatives both within and outside the UK.

Sustainability First develops implementable ideas in a number of key policy areas – notably, energy, water and waste - where it can make a difference. It undertakes research; publishes policy and discussion papers; organises high level seminars and other events. Sustainability First is a registered charity.

Sustainability First is a registered charity number 107899.

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