Sustainability *First*

GB Electricity Demand – *realising the resource*

Paper 2

GB Electricity Demand – 2010 and 2025.

Initial Brattle Electricity Demand-Side Model –
Scope for Demand Reduction and Flexible Response.

by Serena Hesmondhalgh, The Brattle Group.

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

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 ; EdF Energy ; Elexon ; E-Meter Strategic Consulting; E.ON UK ; National Grid ; Northern Powergrid ; 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?, Consumer Focus and National Energy Action; plus DECC and Ofgem, 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 in Years 1 and 2 of the project will include:

Paper 1:
GB Electricity Demand in 2010 - baseline data and context (October 2011).

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

Paper 3:
What demand-side services could GB customers offer?
(Interim Industry paper – March 2012.
Final paper – Industry & Households. Expected – May 2012).

Paper 4:
What demand-side services can provide value to the electricity sector?
(expected - August 2012).

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

Paper 6:
The electricity demand-side and distributed generation

Future topics in Years 2 and 3 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
February 2012

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Introduction

This paper is the second in a series for the Sustainability First project **'GB Electricity Demand – *realising the resource*'**.

It outlines the approach, methodology and initial results from an electricity demand-side model developed by the Brattle Group on behalf of Sustainability First for the GB Electricity Demand project.

The main purpose of this model is to explore (so far as available data allows) the technical scope for GB electricity demand reduction and flexible response, both today and looking to 2025.

The aim of the model is to offer an initial quantitative resource, both for members of the Smart Demand Forum, and also for others with an interest in understanding more about the GB electricity demand-side.

The model necessarily contains many judgemental elements – and as such it is offered as an initial tool to help inform debate.

The model is focused on exploring technical potential for electricity demand reduction and flexibility, both today and in 2025. It is important to stress that this initial model does not attempt to assess electricity demand-side economic value and / or what is commercially feasible on the demand-side. That will depend on many other factors not explored by this model, including: the supply-side position; customer acceptance and participation; commercial arrangements; technical characteristics and scope for demand-side interruption; appliance innovation which might lend itself to demand-side response etc (e.g. storage).

The Brattle model will also shortly be made available on the Sustainability First website, alongside this paper.

In making the initial model available for wider use we hope that this will help (1) to further inform and critique the methodology and thereby help improve the model and (2) enable those with an interest to develop and adapt the model for their own purposes.

Serena Hesmondhalgh at Brattle will be pleased to receive feedback on technical or other aspects of the model - serena.hesmondhalgh@brattle.co.uk.

Responsibility for the model and its initial results rests with the Brattle Group and Sustainability First. As the GB Electricity Demand project proceeds, we hope that it will be possible to develop and improve upon both the model methodology and model inputs.

Sustainability First
February 2012

Part 1 - Overview of Brattle Electricity Demand-Side Model

1 Purpose of model

1.1 This initial electricity demand-side model is being developed for the Sustainability First GB Electricity Demand project by The Brattle Group. The purpose is to:

- Build-up a quantitative picture of current GB electricity demand and customer-use.
- Consider current potential for:
  - Electricity demand reduction.
  - Peak demand shifting – and demand-shifting outside the evening peak.
- Using current electricity demand as a base-line, look ahead to 2025 and explore in a very initial way, potential for demand reduction and demand shifting in 2025.

1.2 This initial modelling is work in progress. In due course, the model and its results will be revised in the light of further inputs from:

- The sponsor group and members of the Smart Demand Forum.
- The DECC/Ofgem Smart Grids Forum scenarios analysis - expected in Spring 2012.

1.3 A number of other demand-side modelling exercises are also under-way. A main challenge for all such work is a lack of published up-to-date and / or disaggregated demand data. For example:

- Breakdown by end-use is generally modelled – and / or relies on historic estimates and survey data.
- Breakdown which combines data on specific end-use and time-of-day - is either absent or relatively historic.

1.4 The Brattle model aims to add insight and to stimulate questions. It is designed to:

- Illustrate the type of analysis that is feasible.
- Stimulate feedback and seek ideas for improvement.

1.5 The model is focused on exploring maximum technical potential for GB electricity demand reduction and flexibility, both today and in 2025. It is important to note that this model does not attempt to assess commercial, consumer or other practical realities of realising the electricity demand-side – all of which will depend on many factors not explored by the model.

1.6 The Brattle model, its results and outputs will provide a resource to the Sustainability First GB Electricity Demand project. It will continue to be refined and developed during the three-year project life-time.

2 Approach to development of the model

2010-2011 modelling

2.1 The model builds a disaggregated picture of the main end-uses of electricity across the GB economy in 2010-11 – both by time-of-day and by time-of-year (i.e. by calendar month). The model seeks to create a half-hourly load curve by month through the calendar year for each major electricity end-use (i.e. for heat, light, appliances, refrigeration, electronic uses etc.) across all economic sectors. The aim is to offer some insight into:

- Which end-uses and how much GB electricity demand might be 'shiftable' today.
- At what time-of-year and / or time-of-day demand is most likely to shift.
- Which sectors may offer flexibility to shift demand.

2.2 While much demand-side modelling has been undertaken, we are unaware of other recently published models which attempt to build up a representation of all end-uses by time-of-day and by time-of-year. Whilst such an approach involves a significant number of assumptions, it does nevertheless provide a platform for considering what type of demand might be shiftable - and when. It also offers some insight as to how much of this potentially flexible electricity demand currently falls within present arrangements for half-hourly settlement.

2025 modelling

2.3 Using derived 2010-11 half-hourly demand profiles as a base-line, the Brattle model then seeks to explore potential GB electricity demand and electricity end-use in 2025 in an initial way.

2.4 Whilst the model can be used to investigate the impact of a wide variety of different scenarios of future electricity demand, it seems sensible (at least in the first instance) to draw on some of the detailed analyses of future electricity demand by end-use that has already been undertaken. It would not be efficient to 'reinvent the wheel' and build 2025 scenarios from scratch.

2.5 Accordingly, the 2025 analysis is based upon two future scenarios developed for the DECC 2050 Pathways Analysis. These are Scenario 1 - Business-as-Usual and Scenario 2 - Environmentally Friendly. In line with these alternative scenarios, the model incorporates assumptions about anticipated major new sources of electrical load - heat-pumps and electric vehicles – and their potential load profiles. On the basis of information available today, the aim is to develop an initial feel for:

- Which end-uses and how much GB electricity demand might be 'shiftable' in 2025.
- At what time-of-year and / or time-of-day that demand may be most likely to shift.

3 Data sources

3.1 The model draws upon today's sources of actual, published and current data for GB electricity end-use and associated time-related patterns of consumption. There are however a number of limitations, described in paragraphs 3.14, 3.15 and 3.16 below.

3.2 The following key data sources were used as inputs to Brattle's model.

- **Energy Trends. DECC**. Quarterly Updates on demand data for 2010.

- **DUKES – Digest of United Kingdom Energy Statistics**. Annual electricity demand for 2009 for residential, commercial (services) and industrial consumers.

- **Energy Consumption in the UK**. Annual electricity demand for 2009 by end-use for residential, commercial (services) and industrial consumers.

- **Elexon –** Load Profile Coefficients for 2011/12 by half-hour - plus - annualised energy consumption by Load Profile Class (and Grid Supply Point group) from September 2011.

- **National Grid Electricity Transmission –** total demand data for each half-hour in 2010/11 – by which residual industrial load in the 100 kW-plus market was calculated.

3.3 Of data inputs to this model (and similarly for other comparable GB demand-side models), it is helpful to understand the split between *actual* energy-use data and *modelled* consumption data as follows:

- **Actual consumption data**:
    - **'Meter Advances' –** i.e. year-on-year difference in meter-reads for non half-hourly customers (source: Elexon. September 2011).

    - **Half-hourly data through a full year**: for total electricity demand for the whole market (source: National Grid).

    - **Data submitted to DECC for the annual DUKES and quarterly Energy Trends updates.** DECC collect data through annual and monthly electricity surveys of (1) major power producers (covering 90% of generation), (2) electricity suppliers (covering 95% of electricity sales), and (3) electricity distributors (recording electricity distributed and losses). The electricity suppliers' survey breaks down electricity supplied by economic sector (industry, transport, residential, commercial, etc)[2].

[2] DECC (undated) Energy Statistics – data sources and methodologies

- **Electricity consumption-data calculated from sample surveys, modelling and calculation / estimation**.

  - **'Annualised Consumption' data for non half-hourly customers derived from 'Meter Advances'** (as above) and **Half-hourly Co-efficients for Load Profiles 1-8 -** which are also modelled (source: Elexon).

  - **Annual demand by end-use and sector -** derived and / or calculated from a mixture of sample surveys and modelling. For example: Building Research Establishment (BRE) stock model on energy use within buildings is used to estimate electricity end-use in the domestic and commercial sectors; Office for National Statistics (ONS) Purchase Inquiry (part of the wider Annual Business Inquiry) is used in support of calculating estimated electricity end-use within industry sectors (source: DUKES, DECC).

3.4 The Energy Consumption in the UK data on end-use, at least in some instances, is based on analysis and/or modelling possibly undertaken some time ago. Since this data is a key input to the model, it is worth noting that this may not represent a very up-to-date representation of current end-use consumption.

3.5 For further information on the main data sources relied on in the model, see Annex 1[3].

[3] Annex 1 draws from a separate note produced for Sustainability First on DECC Electricity Data Sources by Richard Hoggett, Associate Research Fellow, Energy Policy Group. University of Exeter. See http://www.sustainabilityfirst.org.uk/gbelec_documents.html

Load Profile classes

3.6 Large customers with a maximum demand of over 100kW have meters which record their consumption by half-hourly time-periods[4]. Under the electricity market settlement arrangements, the consumption of these large customers is settled by suppliers in the electricity market on the basis of that metered half-hourly consumption data. Currently, this relates to a very small group of customers (~117,000 out of 29 million) but whose end-use represents around one-half of annual GB electricity end-use.

3.7 Increasingly, larger customers with a maximum demand below 100 kW may also have smarter metering which can record consumption on a half-hourly basis. However, the current electricity market half-hourly settlement arrangements do not presently extend to customers whose potential maximum demand is below the 100 kW threshold.

3.8 For the overwhelming majority of GB electricity customers whose consumption is not half-hourly settled, electricity offtake is categorised at the meter according to eight Load Profile classes: Load Profile Classes 3-8 for commercial and services with higher average annual demand; Load Profiles 1-2 for residential customers with lower average annual demand.

3.9 The eight separate Load Profiles are calculated from customer sampling – to generate eight separate models of half-hourly consumption throughout a full calendar year. The eight Load Profile models then serve as a benchmark against which a likely half-hourly consumption pattern is estimated across a year (annualised consumption) and allocated to suppliers for purposes of their financial settlement for each half-hour period in the year.

3.10 Each customer (i.e. meter) below 100 kW is therefore assigned to a particular Load Profile Class. This in turn reflects a meter’s capability to register / record data relating to:

- Unrestricted kWh.
- ‘Switched’ load – kWh consumed in off-peak hours (kWh switched into, and recorded as consumed in, so-called ‘restricted’ hours).
- Maximum-demand.

[4] Half-hourly metering systems required under the Balancing and Settlement Code for customers with an average peak demand of more than 100 kW over the last twelve months.

3.11 In broad terms, the Load Profile classes split between domestic and non-domestic customers as follows:

- **Domestic meters** - do not record maximum demand. All domestic and SME meters are either Class 1 (recording ‘unrestricted’ kWh) or Class 2 (capable of recording *both* ‘unrestricted’ and ‘switched’ kWh).
- **Commercial and business users** - those with relatively low annual consumption - tend to be allocated to Load Profiles Class 3 and 4. The meters for these customers do not record a maximum demand. Load Profile Class 3 meters record only ‘unrestricted’ hours whilst Load Profile Class 4 meters can record both unrestricted and ‘switched’ load (just as Load Profile Class 2).
- **Non half-hourly meters associated with larger commercial users who are classed as Load Profiles 5-8 -** do not record switched load. Instead, an appropriate Load Profile is allocated based on that customer’s maximum recorded demand during the prior 12 month period - plus their historic load factor.

3.12 The eight Load Profile classes therefore offer a broad correlation to likely consumption by that customer class as a whole, and so can be taken as a rough proxy for levels of end-use consumption and for customer size. This needs some caution, because the Load Profile classes are historic, and customers may have different consumption levels or different patterns of daily-usage than their Load Profile class might suggest. However, in the absence of half-hourly or smart meter data for the vast majority of electricity customers today, and given the lack of other available data, each Load Profile class offers a reasonable - if limited – indicator of end-use electricity consumption for each half-hour through the year - and also for annual consumption.

3.13 Table 1 below shows GB annual metered electricity for half-hourly and non-half hourly consumption by load-profile class. As noted above, Load Profiles 1 and 2 apply to domestic customers – i.e. household and micro-businesses. All other Load Profiles are Commercial and Services, with the average consumption level per customer increasing from Load Profile 3 through to Load Profile 8.

Load Profile Class	MSIDs	Annual Energy (TWh)	Comments
Domestic customers			
LP1 - Domestic unrestricted	22,240,503	86.1	
LP2 - Domestic with switched load	5,053,598	29.1	Estimated 35%/65% switched (night)/day load
Commercial customers			
LP3 - Non-domestic unrestricted	1,619,082	23.4	
LP4- Non-domestic with switched load	505,393	11.9	Estimated 26%/74% switched (night)/day load
LP5: MD with peak LF <20%	37,084	2.7	
LP6: MD with peak LF 20-30%	54,238	5.4	
LP7: MD with peak LF 30-40%	25,560	3.1	
LP8: MD with peak LF >40%	49,779	6.3	
Total non-half-hourly metered customers	29,585,237	168.0	
Half-hourly metered customers	~117,000	155.0	
Total	~29,700,000	323.0	

Table 1: GB Half-Hourly and Non-Half Hourly Annual Energy Consumption (TWh) at September 2011[5]

[5] Source. Elexon. E-mail communication. October 2011. (MSID – Metering System Identifiers).

Assumptions, limitations and the role of judgement

3.14 From the description of model inputs above, it is evident that there are some key limitations and gaps in available data – upon which our own and other demand-side modelling is dependent – and which necessitate the use of judgement to create the missing data, as follows:

- **Industry consumption data –** Based on annual sales information provided by suppliers to DECC, DUKES provides information on electricity consumption by industry subsector across 12 subsectors[6]. **Energy Consumption in the UK (ECUK)** provides electricity consumption data at a more disaggregated level (at 2-digit SIC code, across 26 categories). This is based on secondary analysis of DUKES data and historic data from the Office for National Statistics Purchase Inquiry. ECUK also provides industry electricity consumption by end-use, based on secondary analysis of data from the ONS and BRE.

- **Commercial consumption data –** Based on annual sales information from suppliers, DUKES provides information on the breakdown of electricity consumption by sectors (commercial[7], public administration, agriculture). **Energy Consumption in the UK (ECUK)** provides electricity data consumption across a different set of subsectors[8], and electricity end-use data within subsectors, based on secondary analysis of DUKES data and BRE modelling data. Electricity end-use is estimated based on BRE modelling.

- **Household –** total units supplied are based on annual returns of sales data provided to DECC by suppliers – including for standard and off-peak electricity use. Data on household end-use of electricity is derived from modelling using the BRE, CAR (Cambridge Architecture Research) and MTP (Market Transformation Model) stock models, and was explored by Sustainability First in its 2010 analysis[9].

3.15 One additional constraint with regard to available data is the need to align data which originates from different available data-sets. For example:

  - Differences in years between data-sets – i.e. end-use data is from 2009; quarterly consumption data is from 2010; total half-hourly demand data are from 2010/11; Load Profile coefficients from 2011-12; annualised Load Profile consumption from 2011.

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[6] The subsectors are: Iron and steel; Non-ferrous metals; Mineral products; Chemicals; Mechanical engineering etc; Electrical engineering etc; Vehicles; Food, beverages etc; Textiles & leather; Paper & printing Other industries; Construction.
[7] Commercial is further disaggregated into: Shops, Offices, Hotels, Combined domestic/commercial premises, Post & telecommunications, Other, Transport.
[8] Commercial Offices, Communication and Transport, Education, Government, Health, Hotel and Catering, Other, Retail, Sport and Leisure, Warehouses. Note the aggregated end use in the services sectors Education, Government and Health has been scaled to the 'Public Administration' energy use as published in DUKES.
[9] Smart Tariffs and Household Energy Demand Response in Great Britain. Sustainability First. March 2010.

- Differences in units used to record energy consumed – or estimated end-use – e.g. MWh, mtoe etc.

3.16 As noted, much data relating to GB electricity end-use is estimated from sampling, from surveys and from models. Moreover, some data on end-use consumption may derive from somewhat historic material. This means that a significant degree of judgement has to be used to derive half-hourly profiles by end-use. We flag where this is so, and explain the basis of our assumptions.

Future improvements in available data

3.17 Looking to the future, (and subject to issues being resolved with regards to third-party access to meter data), there could be a major improvement in the nature and accuracy of published GB electricity demand data. In particular, it will be feasible to produce annual consumption profiles based on half-hourly consumption data for very many more types of GB electricity customer than today. Initially, this will be facilitated by the requirement for smarter metering to be rolled out to Load Profile classes 5-8 by April 2014, and in due course through the household smart meter roll-out (completion due 2019).

3.18 By itself, improved half-hourly data will not necessarily offer a better feel for actual electricity end-use by activity, by process or by appliance use.

3.19 Until the late 1990's, the Load Research Group of the former Electricity Association sampled and monitored electricity consumption patterns and published its analysis of electricity end-uses across all sectors of the economy. They also carried out surveys on customer usage. That data is now relatively historic – especially I&C data - but it continues to be available from Load Research Limited. To date, we have not had access to this data.

3.20 In considering the topic of generic data collection with respect to the smart meter implementation programme, DECC and Ofgem need to address how to improve upon present arrangements for sampling, collation and publication of GB electricity demand data and statistics. Not least, better demand-side data will be needed for use by the new Delivery Agent to inform any auctions for FIT CfDs and for Capacity (supply and demand-sides) under the new arrangements to be implemented for Electricity Market Reform.

3.21 During the course of this project we anticipate that better insights should also be gained into electricity end-use from:

- **Industry data –** Sustainability First bi-lateral discussions and a small sample survey among a cross-section of the major electricity consuming industries, focusing on companies with a 100 kW-plus maximum demand.

- **Commercial data** – data from forthcoming Ofgem research on electricity end-use of some of the 2 million commercial customers allocated to Load-Profiles 3-8.
- **Households –** analysis and survey data from EDRP and Ireland electricity smart meter trials and also a forthcoming EST, DECC and DEFRA 'Home Electricity Study'[10].

[10] 'The Elephant in the Living Room – how our appliances and gadgets are trampling the green dream'. Energy Saving Trust. September 2011. page.7 refers to a forthcoming joint EST, DECC and DEFRA study 'The Home Electricity Study 2010-11'. This is understood to be due for publication in March 2012.

The Home Electricity Study 'took detailed measurements of about 90% of the domestic energy use in 240 monitored households across the demographic spectrum. Of these, 60 were monitored for a year. The aim of the study was to provide reliable data on all electrical appliances in the home (including kitchen goods, lighting computers) – especially products, and consumption patterns that have significant impact on peak electricity demand – to enable more accurate projections of expected future use'.

Looking forward to 2025

3.22 In looking forward to 2025, the current model inputs with respect to new electrical load – including penetration rates for electric heat and electric vehicles – will be updated in due course to include, for example, material produced for the DECC/Ofgem Smart Grids Forum 'Scenarios Analysis'.

3.23 In practice, a great variety of factors are likely to shape overall levels of electricity demand and patterns of electricity end-use in 2025, and these are inevitably difficult to foresee. For simplicity, we have assumed that such uncertainties are captured in a consistent way in the scenarios selected for the DECC 2050 Pathways Analysis. We have set our current assumptions about future electricity demand within the context of two scenarios taken from this analysis. **Scenario 1 – broadly business as usual**; **Scenario 2 – a green, energy efficient scenario**. We do not attribute any probability to either scenario.

3.24 A key assumption on our part however, is that these two scenarios appropriately reflect and are internally consistent in their treatment of: general economic development, measures to improve electricity efficiency; and, uptake of renewable and low-carbon technologies. [11]

3.25 The 2050 Pathways Analysis incorporates certain core assumptions on key sensitivities likely to impact end-use electricity consumption in 2025[12]. However, this does not necessarily include detailed treatment of: demographics[13]; trends in electricity wholesale prices; trends in energy retail price-levels relative to disposable income; the development and retention of policies and incentive / subsidy schemes for low carbon technologies – including with respect to electric heat and electric vehicles.

[11] It should be noted, however, that because the 2050 Pathways Analysis was based on 2007 data the 2010 electricity demand assumptions differ for the two scenarios.

[12] The 2050 pathways demand trajectories have been developed to be consistent with two key input assumptions: 0.5% population growth per year, and 2.5% growth in UK GDP (reflecting HM Treasury's assumption for long term growth). Source: 2050 Pathways Analysis (July 2010), available from: http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/2050/216-2050-pathways-analysis-report.pdf

[13] The 2050 pathways calculator includes assumptions on population growth and the rising number of households in future, but not any trend toward smaller households. **Source**: 2050 pathways calculator spreadsheet.

4 Our disaggregated approach to model development

4.1 The model methodology disaggregates electrical load today by:

- **Estimated end-use** – (i.e. estimated for the reasons outlined in section 3 above).
- **Sector consumption** – domestic; commercial; industrial.
- **Time-of-day** - by half-hour periods – (1) for each of eight historic customer 'Load-Profiles' – (whose main use today is for purposes of electricity market financial settlement) and (2) for residual industrial demand, which amounts to around half of all demand.
- **Calendar Month.**

4.2 Based on the data sources discussed in the previous section, the model allows a user to create a half-hourly demand-curve *for each major electricity end-use category* by economic sector (domestic, commercial, industrial) to be created. The purpose is to:

- Provide insight into what might be technically achievable with smart tariffs, direct load-management, automation etc.
- Understand how much demand might be technically shiftable; when it might shift; and in which sector of the economy.

4.3 The 2010 demand profiles are used as a base-line for the model, which can then be used to estimate demand curves for each end-use, in each sector of the economy, for future years. Thus far, we have concentrated upon modelling different views on how demand for different end-uses might develop by 2025 - and what role flexible demand could potentially play.

4.4 The modelling methodology, designed around creation of half-hourly end-use load-profiles, has both strengths and limitations as follows:

- **Strengths –** by separately identifying electricity end-use in each half-hour - and for each calendar month throughout the year – the model starts to bring together an initial GB-wide half-hourly overview across all economic sectors. This allows an initial feel for potential for both demand-reduction and for peak-shifting – both by time-of-day - and by time-of-year. In turn, this could also offer a benchmark by which to estimate the technical potential for cost-savings, both today and potentially in 2025 – either in the balancing and / or the wholesale markets – as well as in any future capacity market.

- **Limitations** – national half-hourly load-profiles do not offer a geographic or location-specific picture – potentially important from a network perspective. However, other demand-side models, which may couple half-hourly load-curves with detailed sub-regional annual consumption data (published by DECC) and location-specific customer and housing-stock data, would be able to build a more geographic or regional picture. A strong locational element may be particularly relevant to the demand-side modelling associated with Distribution Price Control business planning, for example.

Part 2 – Electricity Demand in 2010

5 Building up a picture of demand in 2010

Domestic and commercial demand

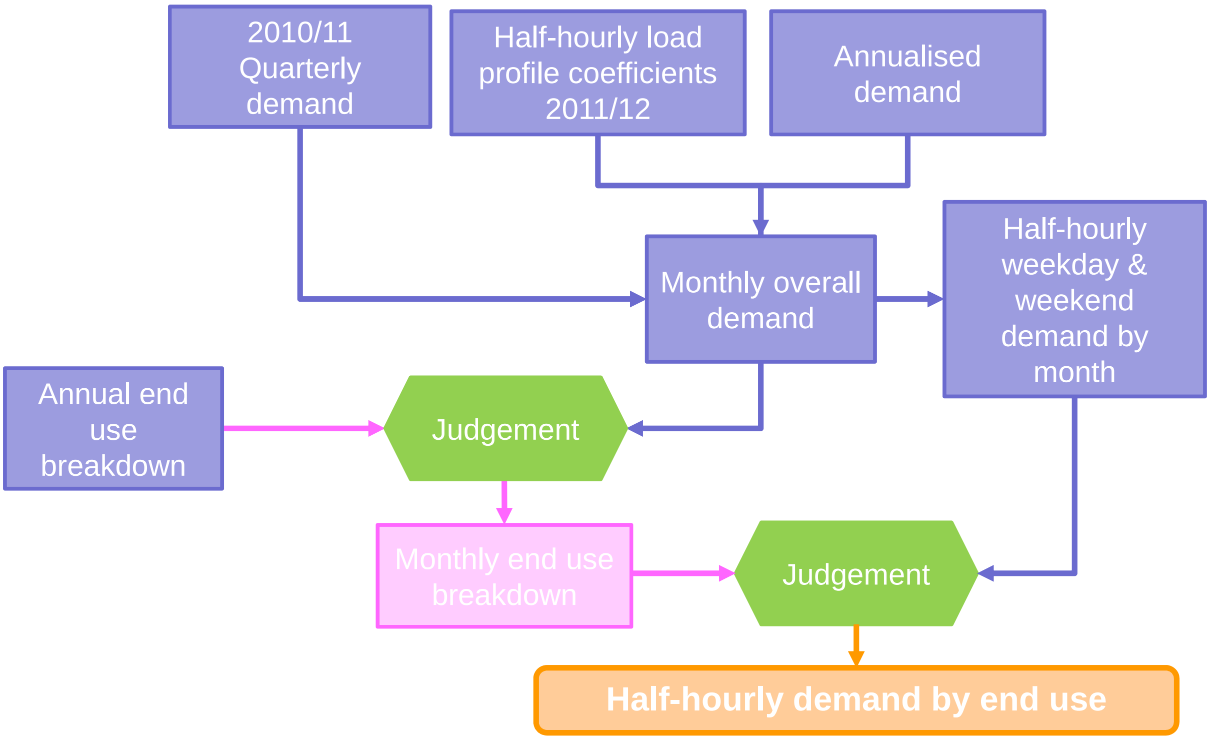


Figure 1: Determining half-hourly demand in the domestic and commercial segments

5.1 Figure 1 above depicts the modelling steps taken to build up a picture of current domestic and commercial electricity demand We have defined ‘commercial’ electricity demand to cover the services sector (for which DUKES provides high-level end-use information) and agriculture.

5.2 Key steps entailing a judgemental element were the estimation of:

- **End-use by calendar month** – taking a view based upon annual end-use breakdown (DUKES) and quarterly consumption for each sector (Energy Trends).
- **Half-hourly demand by end-use** – taking a view based on the estimated break-down of end-use by calendar month and the half-hourly week-day and weekend demand by calendar month (Elexon Load Profile coefficients and annualised demand).

6 Household Demand 2010

Overview of household electricity usage

6.1 There are around 27 million domestic electricity meter points in GB – households and micro-businesses.

- **Elexon** - records annual GB consumption for the domestic sector to September 2011 as 115 TWh – 37 % of all GB consumption of 322 TWh.
- **Energy Trends -** records final UK annual domestic consumption in 2010/11 as 117 TWh: 36 % of total UK final consumption of 326 TWh.

Household electricity end-use is estimated to break down as shown in Table 2.

Usage	Percentage of total use
Lighting & appliances	75%
Space Heating	14%
Water Heating	6%
Cooking	5%

Table 2: Initial breakdown of domestic demand (Source: DUKES 2009)

Domestic space heating

6.2 Domestic space heating was estimated at 14% of all household electricity end-use in 2009. Similar values apply for each of the two preceding years. At 14% of estimated household electricity end-use, electric space-heating remains a modest proportion overall of:

- All household electricity consumption
- All household energy consumed for space-heating[14].

6.3 Our calculations suggest that ~9% of all household electricity-use is 'switched' i.e. off-peak load. However, not all this consumption will correspond to space heating - we estimate that only around 74% of total off-peak consumption by households relates to space heating.[15] This means that around 7% of all household electricity supplied is used for off-peak space heating.

6.4 Based on these assumptions, we estimate that 47% of domestic electric space heating takes place in off-peak hours - with the remainder occurring during peak hours (53%).

[14] In 2009, ~82 % of UK household heat was estimated to be gas-fuelled. DECC. Energy Consumption in the UK. Table 3.7 (2011)
[15] See Annex 2 for details of how we arrive at this figure.

(This analysis ignores the possibility that some direct-acting space heating may take place during off-peak hours).

6.5 Hitherto, a commonplace assumption was that most electricity consumed for domestic space heating was consumed at off-peak times. In effect, from an electricity system efficiency point of view, it was believed to already be largely ‘shifted’ into a lower-cost period, via an off-peak tariff such as Economy 7 or 10.

6.6 Notably however, the modelling indicates that around one-half of electricity used for GB household space heating is most likely being consumed in on-peak rather than off-peak periods. Given that from 2007-2009 (1) total units consumed for household electric heating have remained steady at ~14% of all household electricity units consumed – and that (2) the reported proportion of off-peak units being supplied has been steadily declining - it is possible to conclude that GB household electric space-heating load:

- Has neither grown nor declined over the past three years – including as a proportion of all household electricity use.
- Is characterised by a growing proportion of higher-priced day-time units.[16]

[16] It is, of course, possible that some non-switched space heating occurs during off-peak periods but charts on the website of Load Research Ltd suggest that this is likely to be small.

Household hot water

6.7 Household water heating is estimated to comprise 6% of household end-use of electricity[17]. Some, but not all of this will be on Economy 7 - and is included in the estimated 26% of switched demand that is not associated with space heating.

6.8 Historic off-peak old-style electric storage heaters are therefore apparently in decline while at the same time there is a growing proportion of on-peak household electric heating (albeit not necessarily in the same households). **It is therefore possible to come to an initial conclusion, assuming suitable appliances are available (and coupled with good thermal insulation-levels and attractive off-peak tariffs), that some of this new on-peak electric heat could be a candidate, in principle at least, to shift to lower-cost times of the day**[18].

Household lighting and appliances

6.9 Lighting and appliances comprise 75% of all estimated household electricity end-use (~76 TWh in 2009). We have broken down this 75% of household electricity lighting and appliances on the basis of earlier (2010) Sustainability First analysis (itself derived from the Market Transformation Programme appliance stock model) to provide a more complete breakdown of domestic demand as shown in Table 3.

Usage	Percentage of total use
Consumer Electronics and Computing	28%
Lighting	16%
Cold Appliances	15%
Wet Appliances	15%
Space Heating	14%
Water Heating	6%
Cooking	5%

Table 3: Breakdown of domestic electricity consumption by end use

[17] DECC Energy Statistics. Energy Consumption in the UK. Table 3.7. September 2011.
[18] Annual returns made by suppliers to DECC (in support of the DUKES' Tables on electricity supply and consumption), record purchase both of household standard rate units – and household purchases 'that include an element of off-peak electricity'.

DUKES record 21 % (25.5 TWh) of all household units supplied in 2010 as 'Economy 7 and other off-peak' (down from ~30% in 2007) [DUKES. 2010. DECC. July 2011. P.139. Table 5.3. July 2011. Commodity balances – Public distribution system and other generators].

In contrast the Elexon figure for off-peak household load (based on actual household load switched to off-peak period) seems to be ~10 TWh for year to September 2011 i.e. around 9% of all recorded household units.

The difference between the DECC and Elexon volumes attributed to off-peak household consumption, appears to be because DUKES attributes *all* units purchased in Load Profile Class 2 as 'Economy 7 and other off-peak' (footnoted as 'electricity consumed under an off-peak tariff') – albeit not all Load Profile Class 2 units are consumed at off-peak times. In practice, Elexon estimate that around one-third of household LP Class 2 units are off-peak (~ 10 TWh) – and around two-thirds (~20 TWh) are likely to be day-time load. Some care is therefore helpful in interpreting the volumes indicated for 'Economy 7 and other off-peak purchases' in DUKES Table 5.3.

Key variations of household electricity use by time-of-day, month, week-day and weekend

6.10 Figure 2 and Figure 3 below illustrate variations in household electricity use by time-of-day, month, week-day and weekend.

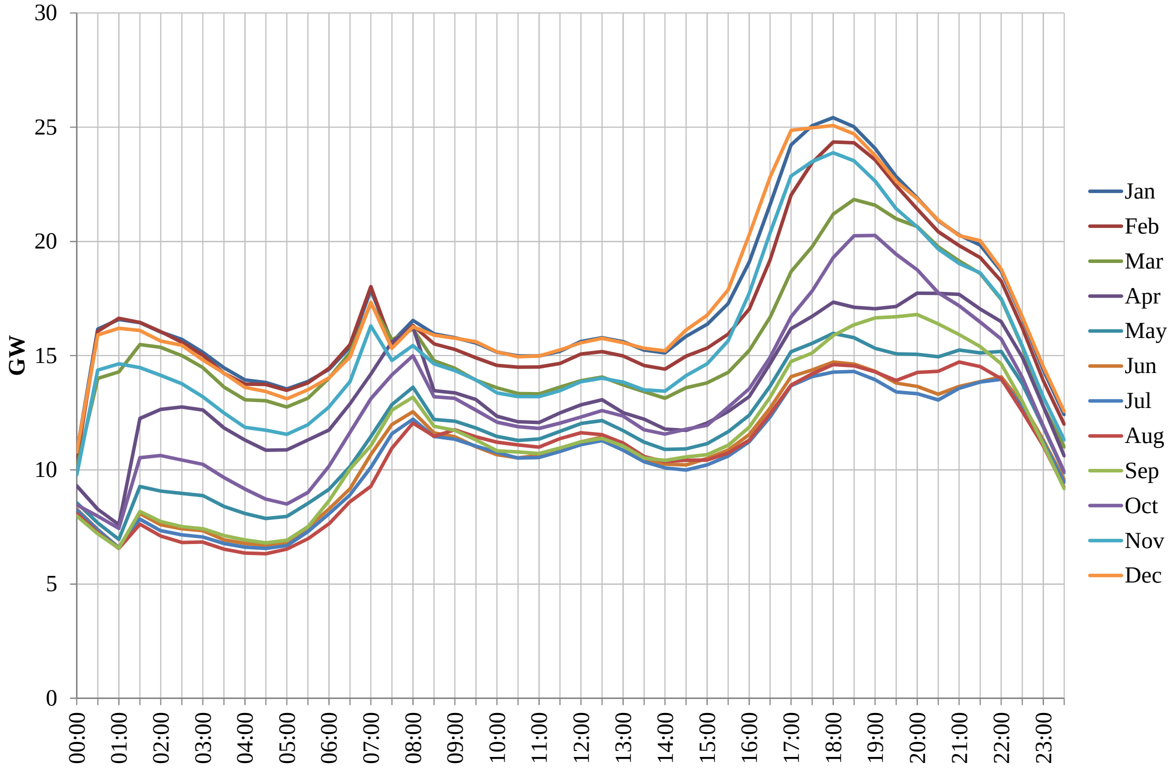


Figure 2: Average GB Half-Hourly Domestic Demand on Weekdays by Calendar Month

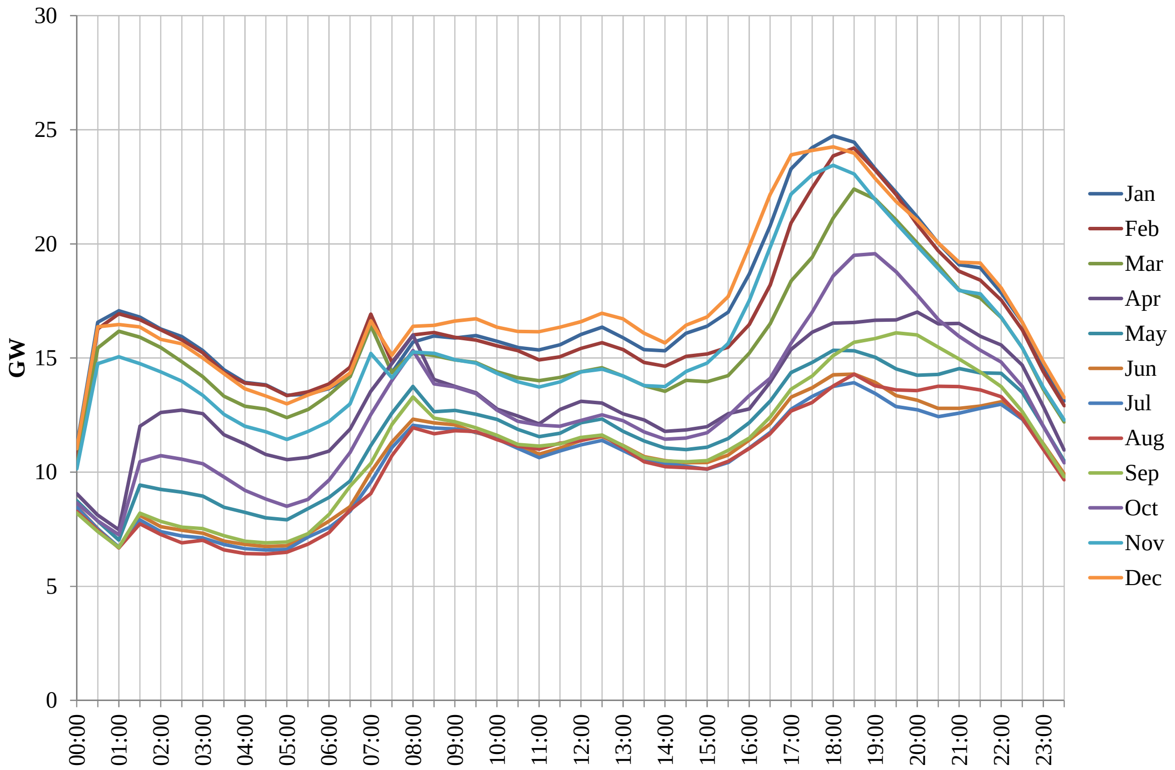


Figure 3: Average GB Half-Hourly Domestic Demand on Weekends by Calendar Month

6.11 The modelling results indicate as follows:

- **Time-of-day:** considerable variability through-out any 24-hour period; pronounced evening peak – especially in winter ; morning peak - in winter there is a double morning peak.

- **Monthly / Seasonal Variation:** flatter daily demand curve through the summer months. Maximum-minimum variation declines from around 14 GW to 9 GW.

- **Weekday / Weekend Variation:** The range of domestic demand on weekdays and weekends is very similar – on average, maximum demand is 0.5 GW higher and minimum demand 0.1 GW lower than on weekends.

6.12 Figure 5 below show two half-hourly demand-curves over a 24-hour period as a percentage of average daily demand by Load Profile class (1) for a typical winter weekday when system demand is high and (2) for a typical summer weekend when overall system demand is low.

6.13 The two demand curves depicted are:

- **Load Profile Class 1**(red) – representative of 22 million customers whose electricity meters do not distinguish by time-of-day (unrestricted hours customers) – and who pay a uniform rate at all times of day; and

- **Load Profile Class 2** (blue) – customers who have the potential for separately metered hours between midnight and 06.00 hours. Load Profile Class 2 therefore includes all those customers with non-smart meters whose off-peak and peak-hours consumption can be separately measured and billed on a two-part (or three-part) off-peak / peak hours tariff.

  Some 5 million household customers seem to be still metered as Load Profile Class 2. However, our estimate is that around some 2 million of these may in practice be on an off-peak tariff (Economy 7, Economy 10 etc.)[19].

[19] 2 million based on estimates by Gill Owen for forthcoming Paper 3.

Also, see discussion at footnote 9 above on the likely proportion of actual household load being supplied by off-peak units.

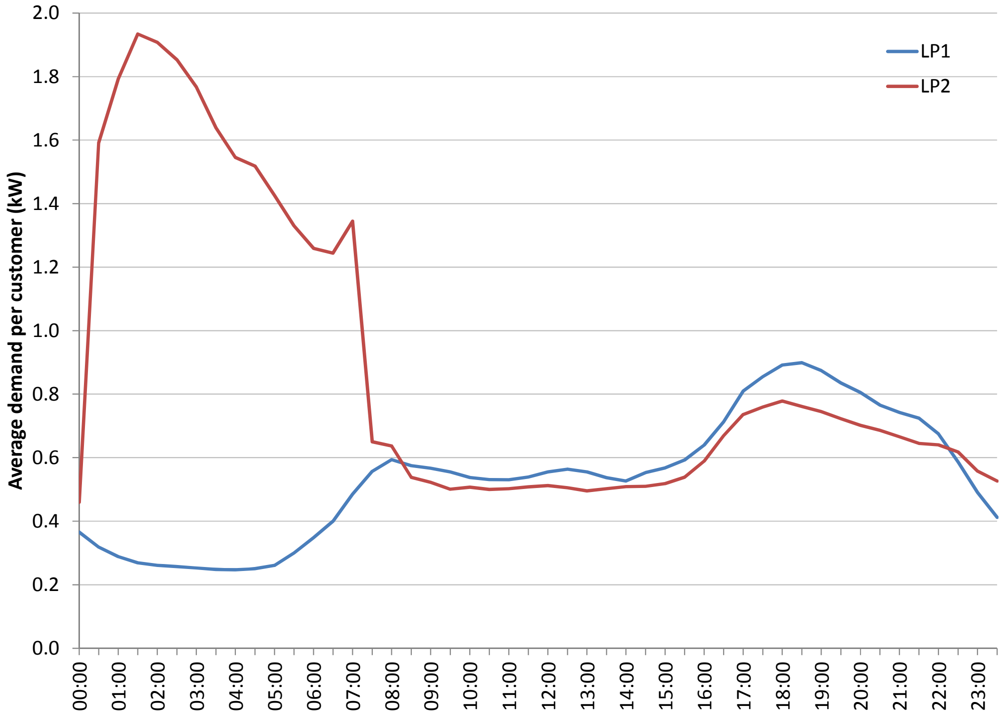


Figure 4: Winter (Dec-Mar) Weekday Demand Profiles for Domestic Demand (Load Profiles 1 & 2).

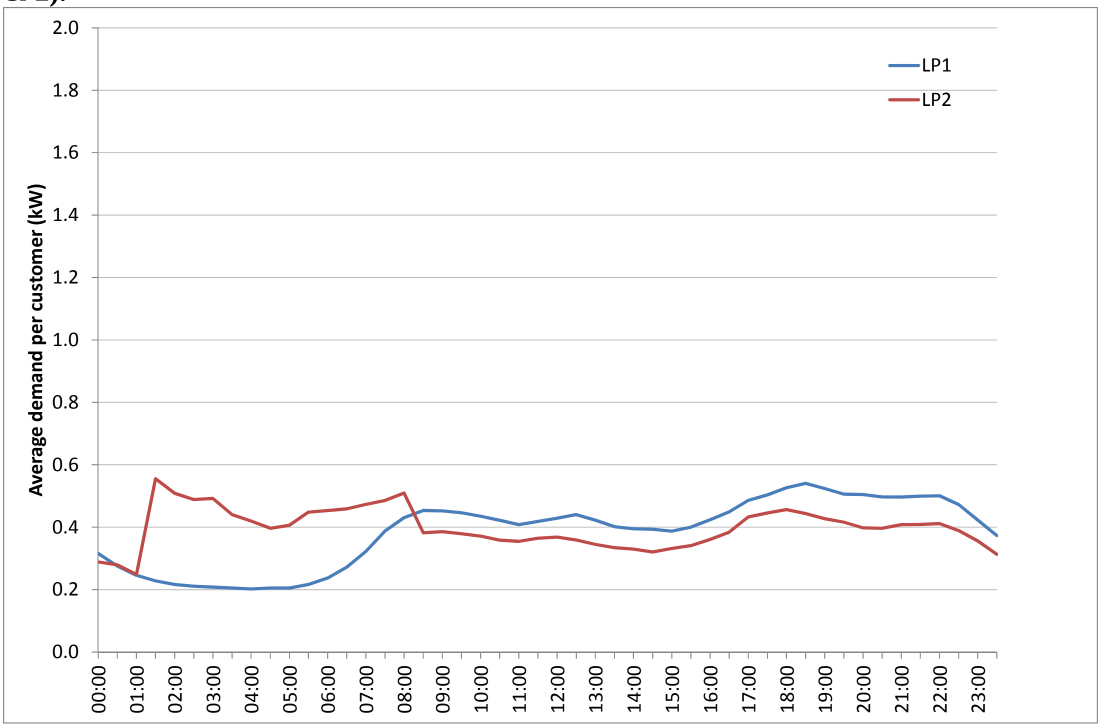


Figure 5: Summer (Jun-Aug) Weekend Demand Profiles for Domestic Demand (Load Profiles 1 and 2)

6.14 The demand curves show how demand is already successfully shifted in response to household time-of-use pricing for electric space heating – and in so doing may offer a pointer for the future as to how household load can be shifted and / or smoothed given a sufficient source of flexible load.

6.15 The modelling indicates (1) key differences in winter between the electricity consumption for customers with off-peak meters (Economy 7, Economy 10) and those without and also suggests (2) considerable similarity in respective patterns of use between the two Load Profiles in summer.

- **Winter Weekday –** the major effect of household electric heat-load in winter being shifted into the early hours off-peak period is very apparent.

    - On average, the switched consumption of Load Profile Class 2 customers amounts to around one-third (30 %) of total winter weekday domestic demand between 01.00h and 06.00h.

    - Load Profile Class 2 average demand consumed during the winter evening peak (17.00h-18.00h) is notably less than that consumed by Load Profile Class 1 customers. However, the two Load Profile classes seem to have similar average values for electricity consumption overall.

    - Load Profile Class 2 customers have less use in general during the course of the day. This difference might reflect the 6% direct electric space-heating load noted above. Or, it may reflect Load Profile Class 2 customers shifting load - other than heating and hot-water - into the off-peak hours (e.g. wet appliances).

- **Summer Weekend** – the load profile curves of both customer groups at a summer weekend (unrestricted and off-peak) are more aligned during on-peak hours, when average daily electricity demand is at its annual lowest, although there is still a significant difference during off-peak hours. In summer, Load Profile Class 2 customers have :

    - A peak around 8am.
    - A one hour later start to switched demand than during the winter; and
    - A peak at 01:30h, but thereafter a flatter demand shape during ‘off-peak’ hours than in the winter months.

Estimated household end-use by calendar month

6.16 Figure 6 below attempts a break-down of household demand by end-use by calendar month.[20] The aim is to increase understanding of what end-use demand could shift and when.

6.17 Main seasonal differences in household end-use are likely to relate to:

- **Heat** – both off-peak and on-peak.
- **Lighting.**

6.18 In addition, it seems likely that cooking load will be somewhat lower in summer (perhaps more cold food) and refrigeration load somewhat higher (due to the higher ambient temperature).

6.19 On the basis of these assumptions, the monthly consumption levels from the data on Load Profiles and annualised consumption provided by Elexon, and the annual end use data from DUKES and the previous Sustainability First report, we have estimated monthly end-use data to match both monthly total domestic consumption and annual end use consumption.

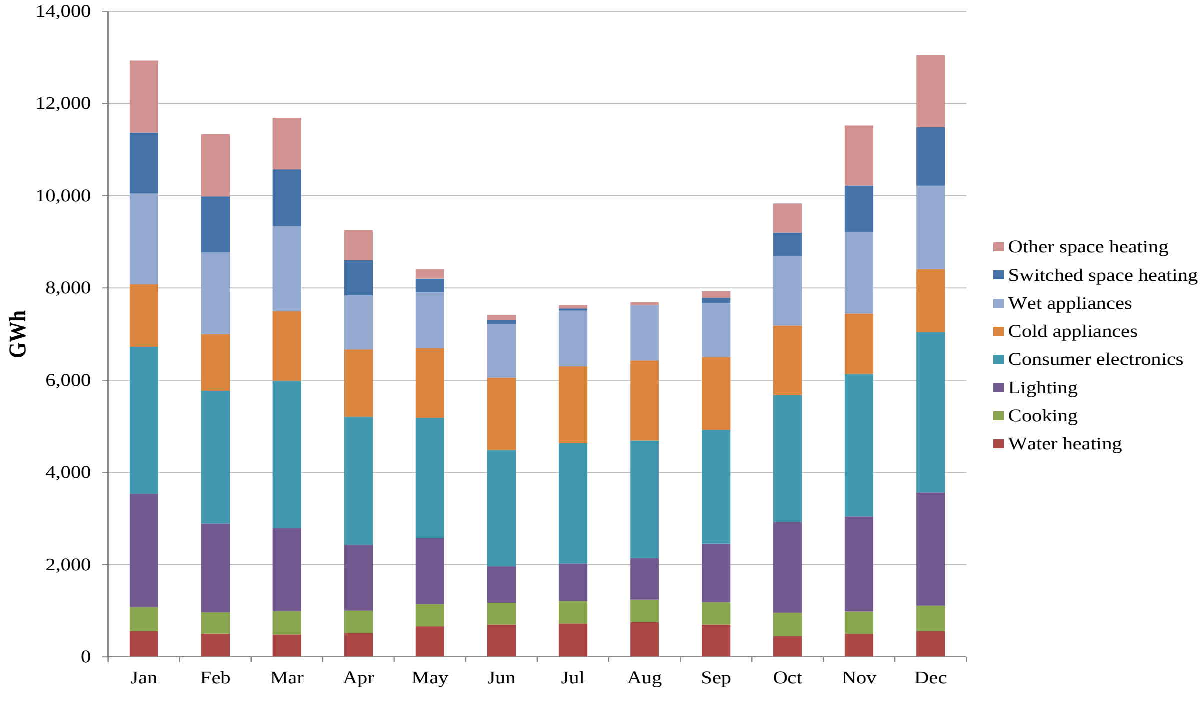


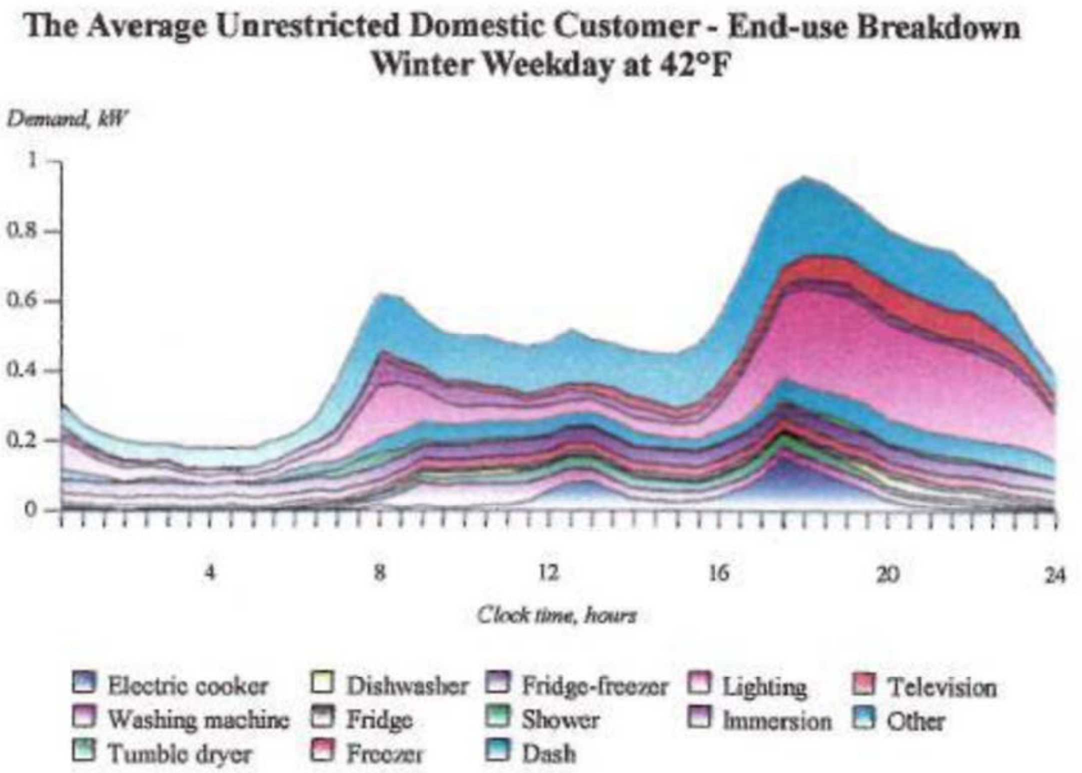
Figure 6: Estimated monthly domestic demand by end use

[20] The fact that total demand in March is higher than total demand in February simply reflects the fact that February has fewer days. Average daily demand is higher in February than in March.

Estimated household end-use by half-hour

6.20 The most comprehensive empirical GB research to disaggregate household end-use of electricity by individual electrical appliance and time of use was conducted in the 1990's for the Load Research Group of the then Electricity Association. The data was acquired by Load Research Limited.

6.21 **Figure 7** below is from the website of Load Research Ltd[21] . It indicates end-use for twenty-four hours on an average winter week-day broken down by heating and appliance end-use for the average Load Profile Class 1 Unrestricted customer and the average Load Profile Class 2 Off-Peak Economy 7 customer.



Source: website of Load Research Limited.

[21] Load Research Limited - www.loadresearch.co.uk

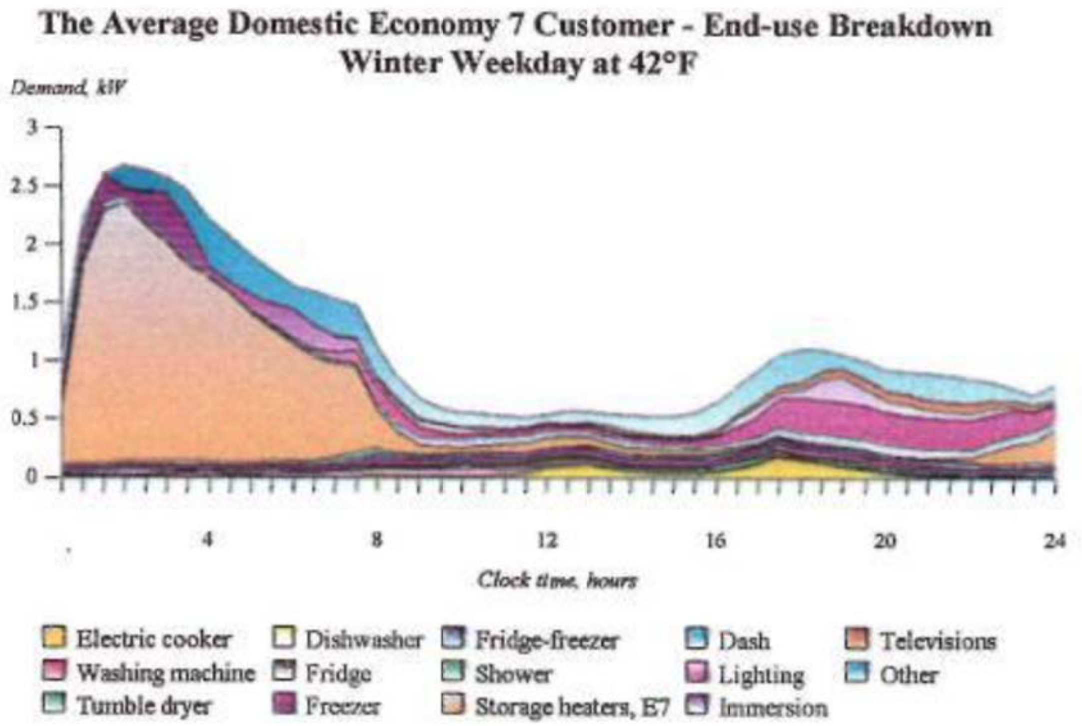


Figure 7: Winter weekday domestic end use breakdowns from Load Research Ltd

Source: website of Load Research Limited.

6.22 The end-use breakdown indicated above was derived from earlier empirical load-research conducted in the early 1990's and then again in 1996-97 for the then Electricity Association. Monitoring equipment was installed on samples of household appliances in order to monitor their half-hourly usage in customers' homes. The monitoring data was supplemented with survey questionnaires. Appliances and end-uses monitored included: cookers, washing machines*, tumble dryers*, dish-washers*, refrigerators, fridge-freezers, showers, storage heaters*, direct acting electric heaters, televisions, lighting and immersion heaters (winter only)*[22].

[22] Appliance-usage marked * - also monitored in Economy 7 homes.

6.23 Although now somewhat historic, Figure 7 may nonetheless may offer a good feel for how appliance end-use may break down throughout a 24-hour period ; week-day, week-end, and seasonally – including the likely contribution of each appliance-type to winter-peak demand. Some examples of insights : domestic lighting ~30% of unrestricted (Load Profile Class 1) winter-peak demand ; fridges using more electricity at meal-times (door-opening); washing machines being more heavily used on certain days, or certain times of day.

6.24 The original Electricity Association load research data may now be a little historic, so some possible considerations regarding today's relevance may be:

- Over-indicating: off-peak consumption (heat, hot-water); direct electric heating; cooking; consumption from lighting – possibly now more efficient on average (but possibly more household lighting load today, than fifteen years ago).

- Under-indicating: home computing and consumer electronics; multiple and / or larger flat-screen televisions, monitors; phone and other chargers etc.

6.25 Nonetheless, this offers a useful starting point for the largely judgemental estimation of domestic end use by half-hour by month. The Elexon Load Profile Class 2 co-efficients, in conjunction with the assumptions regarding the split of switched demand between space-heating and other uses, provide a relatively reliable estimate of half-hourly switched heating demand. For other end uses, we have constructed monthly average profiles by weekday and by weekend to match the assumed monthly consumption levels, reflecting pointers from the website of Load Research Ltd and the overall level of demand in each half-hour consistent with the overall domestic Load Profile Class data.

6.26 The likely half-hourly profile for end-use consumption on household computing and consumer electronics is the most challenging component of household demand to estimate - given little historic data – either empirical or modelled (Market Transformation Programme excepted). We therefore predicted all other household end-uses first - and then used the 'residual demand' in each half-hour as a reasonable proxy for household computing and consumer electronics[23] .

6.27 Creating profiles that appear 'reasonable' i.e. profiles that are consistent with our own experience of domestic electricity consumption and do not jump around unduly from one time-period to another, is quite complex. We have therefore concentrated upon

[23] So: we estimated household end-use demand in each half-hour for all end-uses - except for computing and electronics; we summed all household end-uses together; deducted them from total demand – to leave residual demand in each half hour to be assumed to be household computing and consumer electronics.
As noted, in March 2012, the EST will publish its Home Electricity Study for DECC & DEFRA, which is expected to provide up-to-date empirical data on household appliance use.

producing half-hourly profiles for January weekdays and August weekends as two broadly 'representative' periods. However, in practice the model is designed to allow profiles to be created for all months, for weekdays and weekends.

Scope for Household Electricity Demand Reduction

6.28 GB household electricity end-use demand reduction is likely from progressively improved product standards, being introduced under the EU Eco-Design Framework Directive. Currently, eight Eco-Design Regulations cover 50% of household electricity consumption – and by the end of 2012, for the household (and tertiary) sectors, there will be 100% coverage of product groups responsible for electricity consumption in those sectors[24].

6.29 Running counter to this are demographic changes (more, smaller households), more small appliance ownership and, most notably, continued growth in home and personal electronics.

Scope for Household Electricity Demand Flexibility

6.30 Most likely sources of GB household electricity end-use flexibility seem to be:

- On-peak electric heat.
- On-peak electric water heating.
- Wet appliances.
- Possibly refrigeration – subject to widespread uptake and proven technology for flexibility; existing stock-turnover and, most important of all, customer acceptance.

[24] Sustainability First. Paper 1. GB Electricity Demand – Context and 2010 Baseline Data. October 2011. p.16.

7 Commercial Demand 2010

Overview of commercial electricity use

7.1 There are two key ways by which data on commercial and services electricity customers - and therefore their consumption - are currently classified. This has knock-on implications for how volumes are apportioned to commercial and services end-use.

- **Elexon's annual consumption figures –** show commercial end-use of electricity to be around 16% of final end-use of electricity in the year to September 2011. This annual consumption figure relates to end-use consumption of 52.9 TWh at the 2.2 million meter points in Load Profile Classes 3-8 (see section 3 for explanation). None of these customers are 100 kW half-hourly settled customers.

- **DECC – DUKES and Quarterly Energy Trends –** classify the services sector into commercial and public administration and then further divide electricity consumption into a number of sub-sectors, as shown in Table 4 below. The services sector is recorded by DUKES as accounting for just under one-third of end-use electricity consumption (97 TWh of 328 TWh in 2010). We have also included agriculture in this segment, which DUKES reports as consuming 4 TWh in 2010. The manner by which DECC classifies commercial and services users, therefore includes some (but not all) of the population of 100 kW half-hourly metered and settled customers - as well as all customers in Load Profiles 3-8.

Sector	Sub-sector	% enduse
Commercial	Offices	9%
	Communication and Transport	5%
	Hotel and Catering	11%
	Other	4%
	Retail	32%
	Sport and Leisure	5%
	Warehouses	11%
Public administration	Education	8%
	Government	6%
	Health	4%
Agricutlutre		4%

Table 4: Breakdown of commercial demand

7.2 Table 5 below shows DUKES breakdown of electricity consumption for each of these commercial and services sub-sectors (except agriculture) by the following end-uses: catering, computing, cooling and ventilation, hot water, heating, lighting and other. We are not aware of additional published data on how these sub-sectors consume electricity by time- of-day or year.

	2009 Consumption (GWh)	2009 end use share						
		Catering	Computing	Cooling & Ventilation	Hot Water	Heating	Lighting	Other
Commercial								
Offices	8,829	3%	15%	21%	2%	20%	32%	6%
Communication and Transport	4,854	8%	2%	7%	2%	14%	48%	20%
Hotel and Catering	10,905	34%	1%	11%	5%	7%	32%	10%
Other	6,321	11%	17%	7%	5%	19%	26%	15%
Retail	4,232	12%	4%	0%	0%	11%	63%	9%
Sport and Leisure	10,905	34%	1%	11%	5%	7%	32%	10%
Public administration								
Education	8,888	11%	12%	2%	7%	8%	51%	9%
Government	6,321	11%	17%	7%	5%	19%	26%	15%
Health	4,232	12%	4%	0%	0%	11%	63%	9%
Total	65,489	13%	6%	8%	3%	14%	39%	13%

Table 5: Commercial and services sector breakdown by end-use 2009 (not agriculture)

7.3 Load Research Ltd may hold some historic information (1990's) on electricity end-use disaggregated by commercial and services sub-sector – but this may now be somewhat historic.

Commercial Load Profile Classes 3-8

7.4 As noted in section 3, a proportion of load classified as commercial and services load by DUKES is categorised according to six different Load Profile classes by Elexon: Load Profile Classes 3-8. As explained, these are not 100 kW half-hourly settled customers (although some of the large users will have half-hourly meters).

7.5 DUKES also include a proportion of the 117,000 100 kW-plus customers (half-hourly metered and half-hourly settled) in their data on commercial and services demand. Given that the load for Elexon Load Profiles 3-8 load amounts to 52.9 TWh pa and the DUKES commercial and services total load is 101.2 TWh, we have assumed for the purposes of this model that an equivalent volume of commercial and services load - i.e. some 50 TWh - is made up of customers with 100 kW meters.

7.6 In the absence of other data, we have additionally assumed that the daily demand profiles from Load Profile Classes 3 to 8 can be applied to these other large 100 kW metered commercial customers. However, we assume that the 100 kW customers are likely to consume more electricity and hence we have assumed that their demand will follow the patterns of the Load Profile Classes with higher average customer demand levels i.e. LP 6 to LP 8. This enables us to determine an overall shape for commercial demand based on the assumed consumption levels for each Class shown in Table 6 below.

Initial demand breakdown			
LP 3	[1]	Elexon	23.4
LP 4	[2]	Elexon	11.9
LP 5	[3]	Elexon	2.7
LP 6	[4]	Elexon	5.4
LP 7	[5]	Elexon	3.1
LP 8	[6]	Elexon	6.3
LP 3 to 5	[7]	[1]+[2]+[3]	38.0
LP 6 to 8	[8]	[4]+[5]+[6]	14.8
Total commercial	[9]	DUKES	101.2
Adjusted LP 6 to 8	[10]	[9]-[7]	63.2
Adjusted demand breakdown			
LP 3	[11]	[1]	23.4
LP 4	[12]	[2]	11.9
LP 5	[13]	[3]	2.7
LP 6	[14]	[4]x[10]/[8]	23.1
LP 7	[15]	[5]x[10]/[8]	13.2
LP 8	[16]	[6]x[10]/[8]	26.9

Table 6: Assumed Load Profile Class breakdown of commercial demand

7.7 We have derived half-hourly values by month for weekdays and weekends for the overall commercial sector in exactly the same way as we derived the equivalent values for the domestic sector.[25] The resulting monthly breakdowns by (adjusted) Load Profile Class are shown in Figure 8 below.

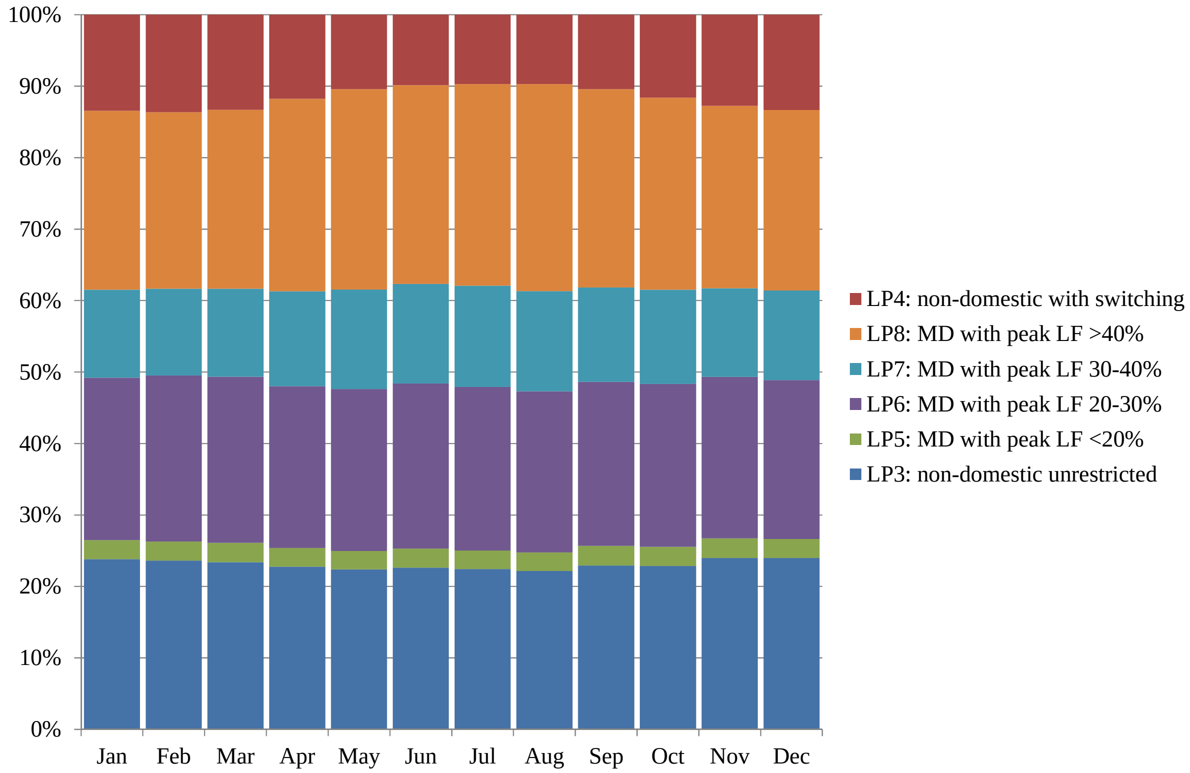


Figure 8: Monthly breakdown of load in the commercial sector by Load Profile Class

[25] Further details can be found in Annex 2.

7.8 On the basis of the DUKES 2009 data, we have assumed that commercial sector electricity end-use breaks down as shown in Table 7 below[26].

End use	Estimated share
Lighting	39%
Heating	14%
Catering	13%
Other	13%
Cooling and ventilation	9%
Computing	6%
Agriculture	4%
Hot water	3%
Total	100%

Table 7: End use breakdown of electricity consumption in the commercial sector (Source: DUKES 2009)

Commercial space heating

7.9 Commercial space heating was estimated by DUKES at nearly 14 % of all commercial electricity end-use in 2009. An estimate by Elexon indicates that switched Load Profile Class 4 demand accounts for 26% of total Load Profile Class 4 demand - and we have used this assumption to derive an estimate of off-peak i.e. switched, space heating load using the same methodology adopted for the domestic sector. Our calculations suggest that *off-peak* space heating represents only 2 % of all commercial electricity-use, which means that almost all of space heating in the commercial sector (86%) must be direct acting space heating. This suggests that up to 12 TWh[27] of commercial load used for direct-acting space heating could perhaps have some technical scope for flexibility / shifting.

Commercial hot water

7.10 Water heating is estimated to comprise 3% of commercial end-use of electricity. Some, but not all of this will be on an Economy 7 or equivalent tariff.

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[26] As outlined in section 3 and Annex 1 these estimates of end-use are derived from models, such as BRE. It is not clear whether some end-uses (e.g. computing, refrigeration) could also appear in ‘Other’.
[27] (14% - 2%) x 101 ~ 12.

Commercial lighting

7.11 Lighting comprises 39% of all estimated commercial electricity end-use (~ 40 TWh). This is a very significant proportion of total end-use in the commercial and services sector.

7.12 A key conclusion is that commercial lighting – apparently representing over one-third of all commercial electricity end-use - may be open to greater efficiency improvement – but seems unlikely to lend itself to shifting to different times of day.

Key variations of commercial electricity use by time-of-day, week-day and weekend, monthly and seasonal variation

7.13

7.14 Figure 9 and Figure 10 below illustrate variations in commercial electricity use by time-of-day, week-day and weekend across the months. Interestingly the modelling results indicate a very different consumption pattern during the course of a day for commercial and services load, than for household load (section 6 above).

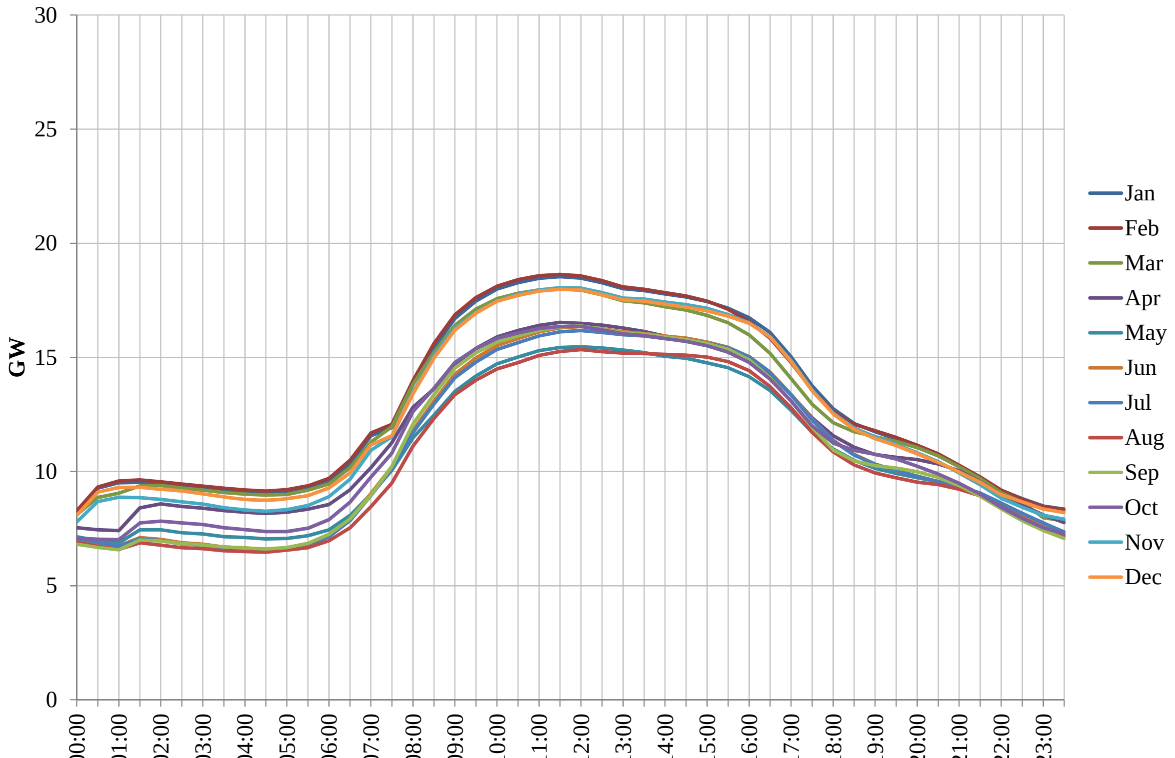

Figure 9: Average GB Half-Hourly Commercial Demand on Weekdays by Calendar Month

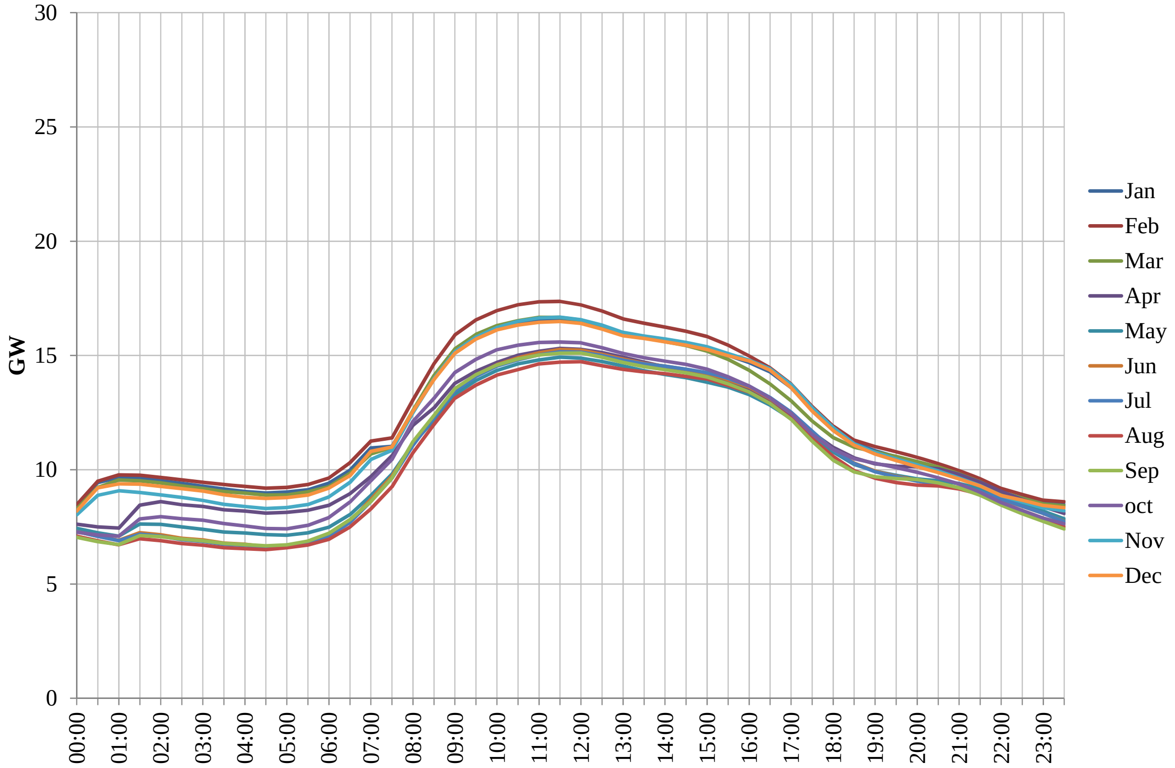

Figure 10: Average GB Half-Hourly Commercial Demand on Weekends by Calendar Month

7.15 The modelling results for commercial load suggest as follows:

Time-of-day:

- A distinctive morning rise between 08.00h to 11.00h of ~15-19 GW.
- A relative plateau shape during the day from 09.00h to 16.00h.
- A steady ‘coasting down’ of demand through the remainder of the day.
- Absence of an evening peak (in contrast with household demand between 17.00h – 18.00h).

Weekday / Weekend Variation:

- Broad similarity between the pattern of both weekday and weekend consumption, including a morning peak.
- Morning demand increase - around 1-2 GW lower at weekends.

Monthly / Seasonal Variation:

- Less seasonal variation than for domestic demand. Interestingly, the difference between average summer and winter maximum demand is only 10%, compared to 50% for domestic demand.

7.16 From Figure 11 it can be seen that most of the seasonal variation in demand comes from Load Profile Class 4 (which includes some switched heating load). By contrast, Classes 7 and 8, which have highest load-factors, unsurprisingly have the most constant level of demand across the year.

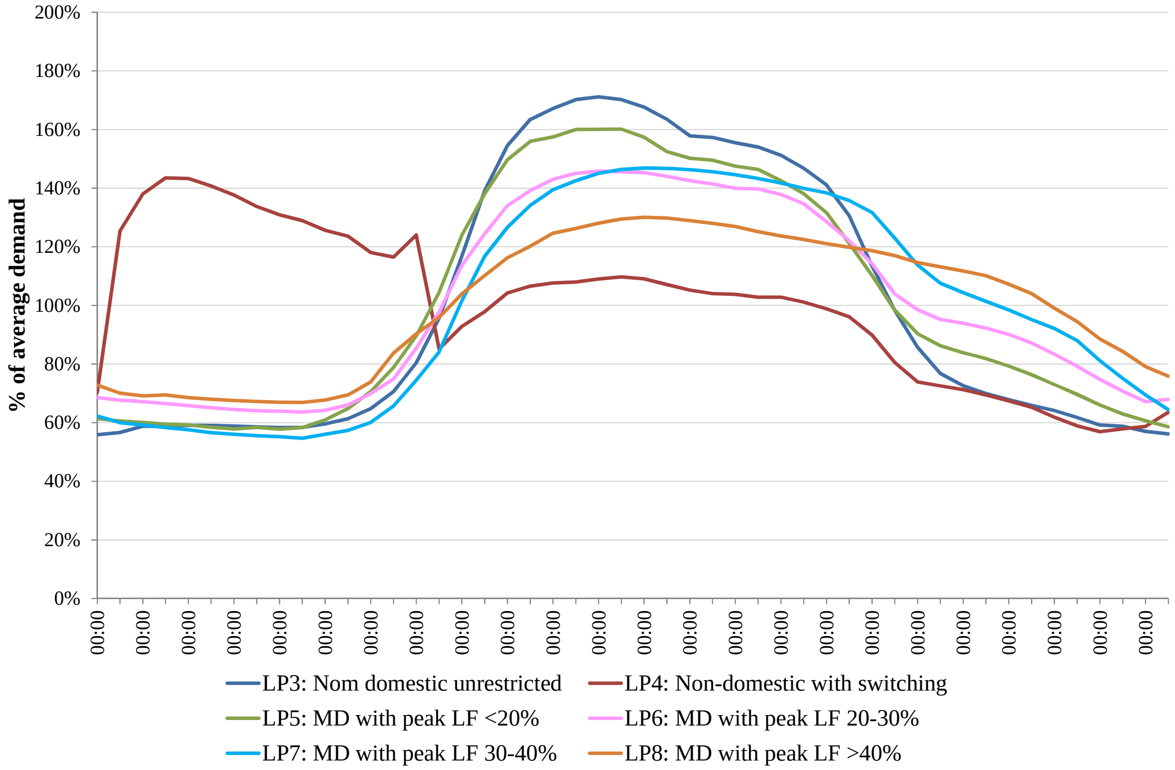

Figure 11: Winter (Dec-Mar) Weekday Demand Hourly Profiles for Commercial Demand

7.17 Figures 11 and 12 show the hourly load shape of each commercial Load Profile Class (3-8) - for average winter weekdays and for summer weekends – as a percentage of the average hourly demand for that Load Profile class.

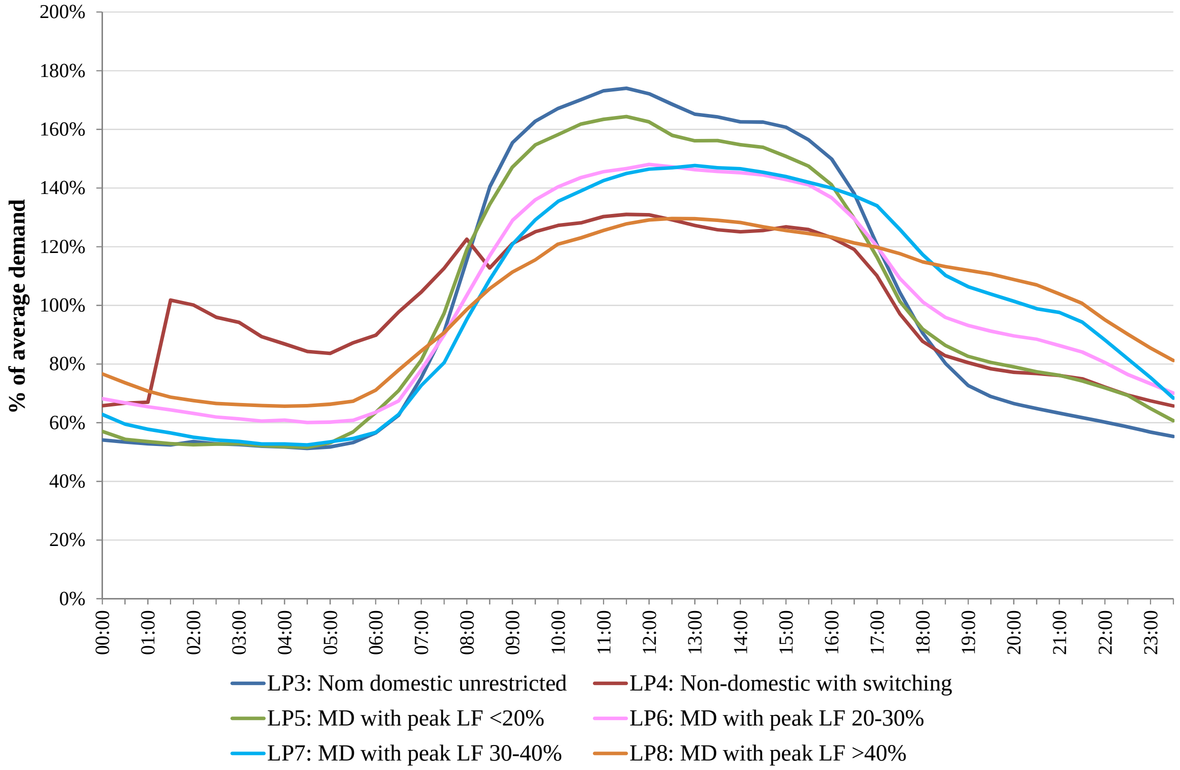

Figure 12: Summer (Jun- Aug) Weekend Demand Hourly Profiles for Commercial Demand

7.18 With the clear exception of Load Profile Class 4 (paragraph 7.18), daily consumption profiles for Load Profile classes 3-8 display broadly similar load shapes, regardless of season and time of day i.e. for both winter weekdays and summer weekends. As the load factor increases (moving up through Load Profile Classes 5 to 8), the percentage of demand which occurs in the evening increases - but this is the only difference.

7.19 However, there is a degree of difference in the contribution to morning peak as a percentage of average daily demand by Load Profile Class in both winter and in summer between Load Profiles. The two groups which seem to stand out as using proportionately most electricity at morning peak are:

- **Load Profile Class 3** (dark blue) – smaller commercial enterprises whose electricity meters do not distinguish by time-of-day (unrestricted hours LP3 customers and all new commercial customers whose maximum demand and load factor has yet to be established) – and who pay a uniform rate at all times of day. This group represents the largest number of individual non-half-hourly metered commercial customers (~1.6 million of 2.2 million total); and their consumption approaches half of all non-half-hourly metered commercial end-use.

- **Load Profile Class 5** (green) – commercial customers with a peak load factor below 20%. This customer group has a relatively low load-factor and therefore a high proportion of their consumption has a ‘peaky’ characteristic i.e. a morning peak.

7.20 **Load Profile Class 4** (brown) – includes off-peak commercial customers (midnight to 06.00 hours), so the load curves for a winter weekday and a summer weekend differ quite considerably. Of the 500,000 commercial customers metered as LP4 only a proportion will be on an off-peak tariff (Economy 7, Economy 10 etc), and by no means be all. As noted above, Elexon estimate that 24% of LP Class 4 annual consumption to be off-peak.

- **Winter load:** High off-peak use over-night is clear. In addition to space heating, it is likely to include some hot water load. Depending on the nature of the business, it could perhaps include ventilation, refrigeration and computing load, and possibly, some overnight lighting. Outside off-peak hours, this Load Profile Class has no morning peak and demonstrates a flatter consumption profile than the other commercial Load Profile classes i.e. represents a smaller percentage of day-time average demand than all other commercial Load Profiles.

- **Summer load:** Some limited off-peak overnight use – more so than for the domestic sector – presume for ventilation, refrigeration and computing. However, because the off-peak consumption in summer is lower as a percentage of this class’s average daily demand, it has a morning peak – and on-peak demand represents a higher percentage of average demand throughout the day than it does in the winter.

Estimated commercial end-use by calendar month

7.21 Figure 13 below attempts a break-down of commercial demand by end-use by calendar month. The aim is to increase understanding of what demand could shift and when, from a technical point of view. Main source is DUKES, but the allocation of end-use to each calendar month is otherwise largely judgemental.

7.22 Main seasonal differences in commercial end-use are likely relate to:

- **Heat** – both off-peak and on-peak.
- **Cooling and ventilation –** higher in summer than winter (includes refrigeration).

7.23 Unlike the domestic sector, it seems likely that the commercial lighting load will remain relatively constant over the year as many commercial premises have lighting load, irrespective of whether there is external light.

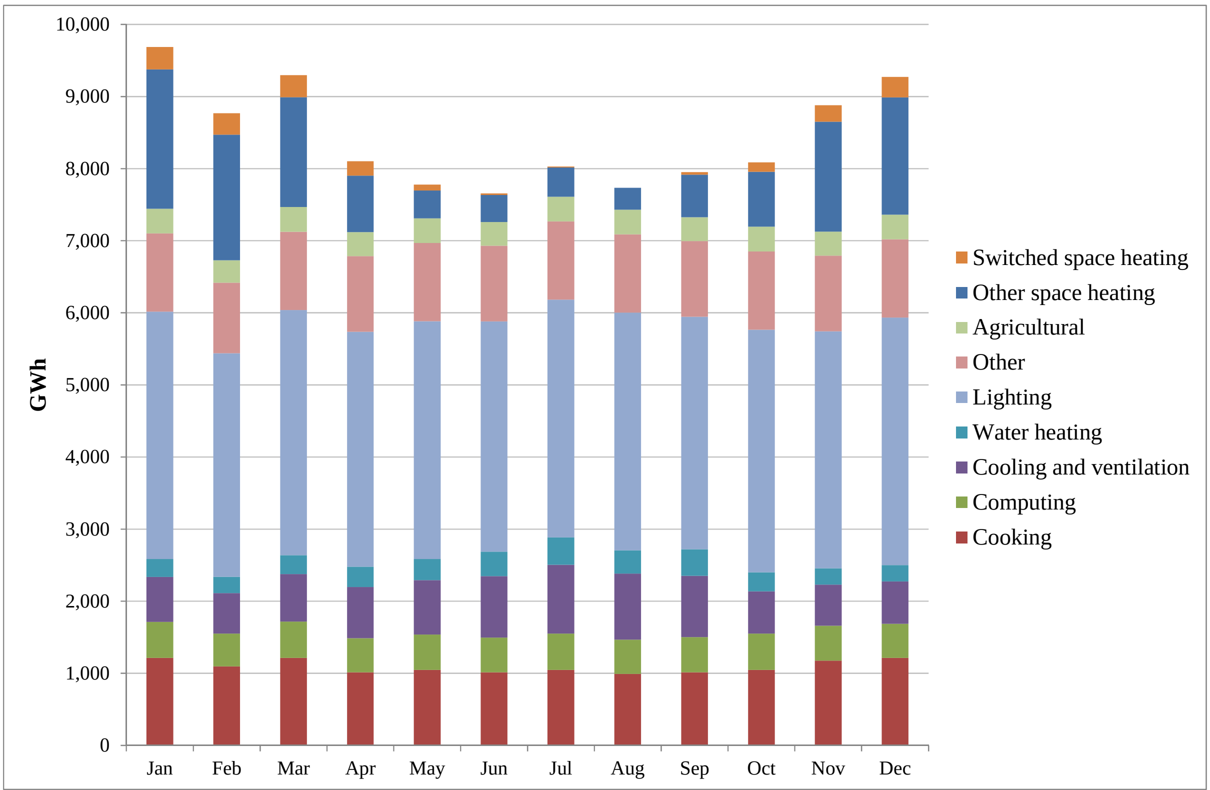

Figure 13: Estimated monthly commercial demand by end

Estimated commercial electricity end-use by half-hour

7.24 Exactly the same procedure as for the domestic sector (see section 6) is used to estimate half-hourly commercial demand by end use. In this case, we use the 'other' end-use category as the residual demand.

Scope for Commercial Electricity Demand Reduction

7.25 There should be scope for progressive GB commercial electricity end-use demand reduction as a result of improved:

- **Building regulations.**
- **Product standards –** The EU Eco-Design Framework Directive will provide 100% coverage of product groups in the services (tertiary) sector by the end of 2012.
- **Commercial Lighting - given that lighting appears to represent 39% of end-use in the commercial and services sector, efficiency improvements for lighting could become very significant in reducing commercial sector electricity end-use.**

7.26 Running counter to these trends may be changes in commercial and services development going forwards (likely to be driven by pace of economic growth, balance of commercial and services development – i.e. offices, retail, growth in air-conditioning, IT, computing etc.).

Scope for Commercial Electricity Demand Flexibility

7.27 Most likely sources of GB commercial electricity end-use flexibility seem to be:

- Heating.
- Cooling and Ventilation – assumed to include refrigeration (subject to widespread uptake of new technology for flexibility; existing stock-turnover and, most important of all, customer acceptance).
- On-peak electric heat.
- On-peak electric water heating.
- Wet appliances – perhaps those used in catering, hotels and hospitals – but we currently have no basis for estimating these.

8 Industry Demand 2010

8.1 The broad approach taken to estimating electricity end-use for the industry sector was to assume that all residual end-use in our data – i.e. not domestic or commercial end-use – could be regarded as industry use. Thus, half-hourly industrial demand is determined by taking NGET's half hourly national demand, scaling it to match the Energy Trends monthly GB total consumption and then deducting the half-hourly commercial and domestic demand estimated from the Elexon Load Profile Class data. From this point onwards, the process of producing monthly and then half-hourly end-use consumption estimates is the same as for the commercial and domestic segments. As in the case of the commercial segment, there is no publicly available time-of-use data by end-use - so a significant element of judgement is involved in creating the half-hourly end-use data. The resulting average profiles for weekdays and weekends are shown in Figure 14 and Figure 15 below.

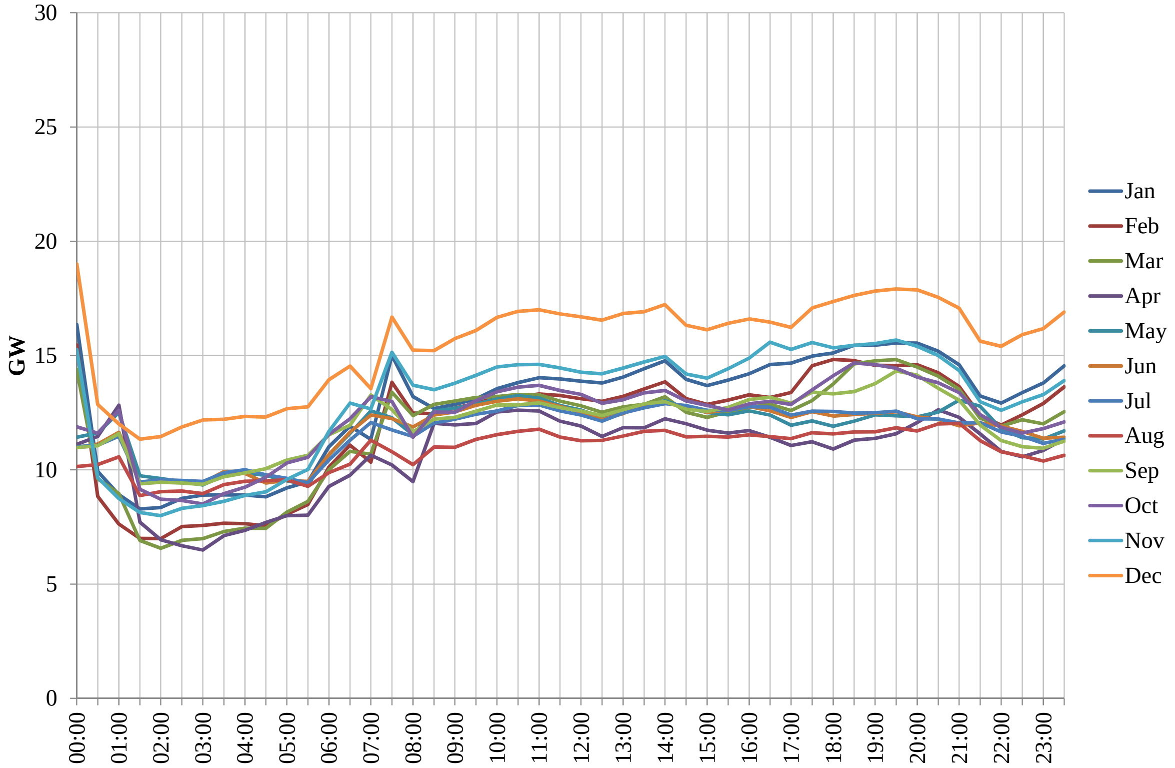

Figure 14: Average GB Half-Hourly Industrial Demand on Weekdays by Calendar Month

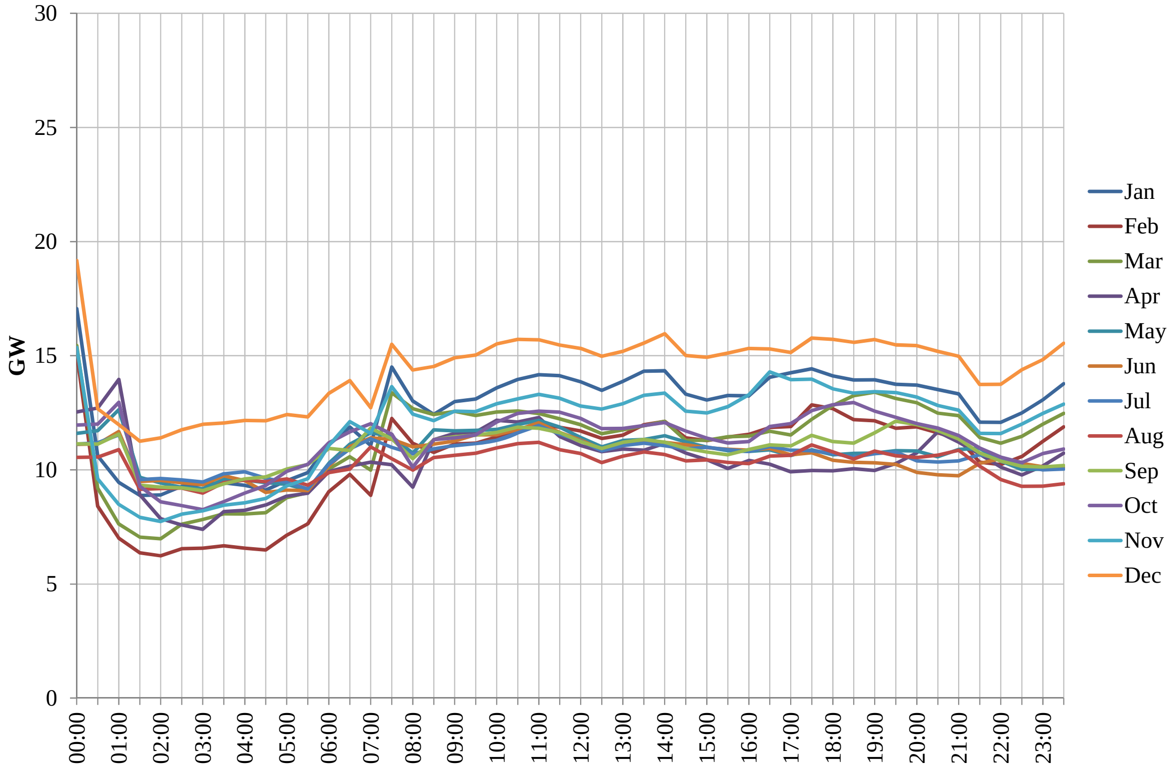

Figure 15: Average GB Half-Hourly Industrial Demand on Weekends by Calendar Month

8.2 These profiles show that calculating industrial demand as the difference between total demand and the sum of commercial and domestic demand leads to some slightly unexpected shapes – in particular between 00:00 and 01:00 and 06:00 and 08:00. It seems possible that at least part of the problem is caused by relying on data from different periods – the Elexon annualised Load Profile Class demand is for the year ending September 2011 and the total consumption is from the year ending March 2011 i.e. including a period of exceptionally high winter 2010 electricity demand, (see Figure 16 below).

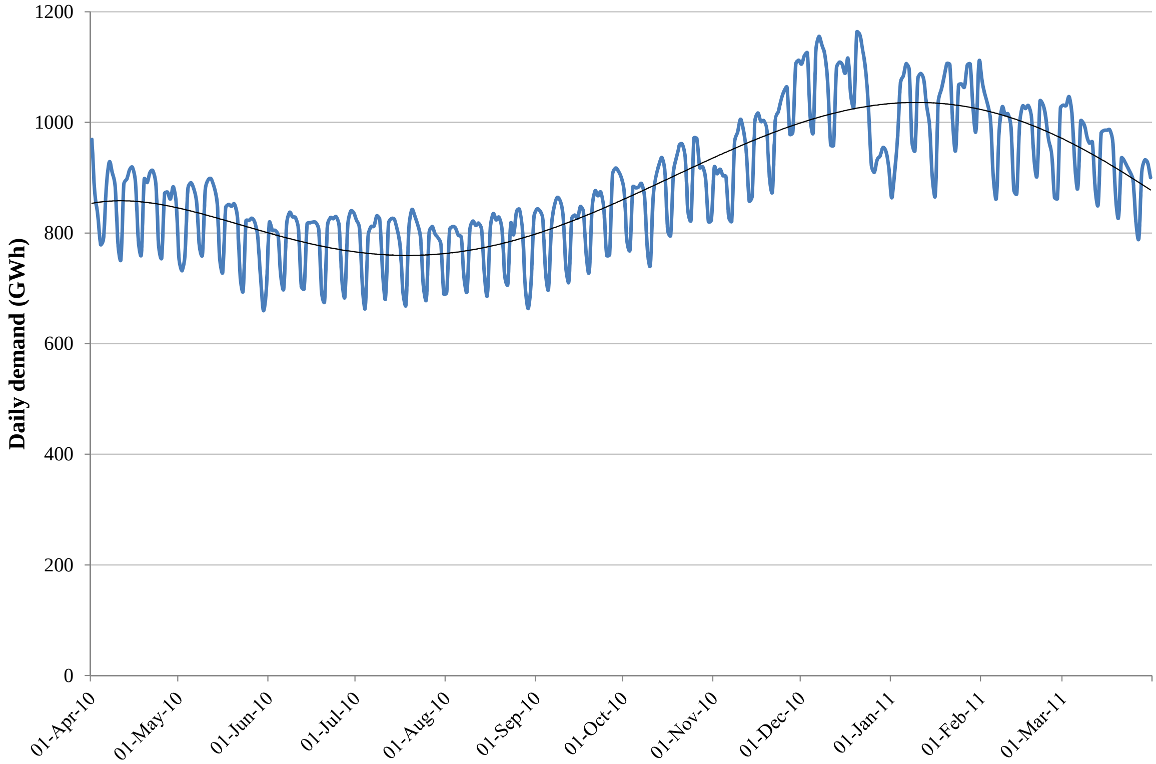

Figure 16: Total daily GB electric demand

8.3 Noting the health-warning outlined in the previous paragraph, the modelling results for industry load, suggest as follows:

Time-of-day:

- A fairly flat / gently rising load curve from 08.00h to 17.00h
- A prolonged evening peak from 17.00h to 20.00h. This is most marked in winter (16GW), but also evident in summer. The peak is more prolonged – and relatively lower than - the winter household evening peak of 17.00h – 18.00h.
- A surprisingly sharp morning winter peak at around 08.00h of ~14 GW (which may be attributable to quirks of data).
- Steady overnight consumption. This may perhaps point to relatively few electro-intensive overnight processes.

Weekday / Weekend Variation:

- Broadly similar consumption pattern for weekdays and weekends, including evening peak.
- Evening peak somewhat less pronounced at weekends, particularly during the summer.

Monthly / Seasonal Variation:

- Winter evening peak higher and earlier in winter than in summer.

8.4 In other words, the load-curves indicate a very different consumption pattern during the course of a 24-hour period for industry load - when contrasted either with household or with commercial and services load (see Figure 2, Figure 3,
8.5 Figure 9 and Figure 10 in sections 6 & 7 above).

Overview of industry electricity use

8.6 There are two key ways by which published data on industry electricity customers - and therefore their consumption – is currently collated. This has knock-on implications as to how volumes are apportioned to industry end-use.

- **Elexon's annual consumption figures** – show industry end-use of electricity to be around one-half of final end-use of electricity in the year to September 2011. This annual consumption figure of 115 TWh (of 322 TWh total) is based on all of the 117,000 meter points with a maximum demand of 100kW plus – and which are half-hourly metered and half-hourly settled.

- **DECC – DUKES and Quarterly Energy Trends SIC Classifications –** based on SIC classifications, show industry end-use to be around one-third of all annual consumption (104 TWh out of 324TWh[28] in 2010). This means that the end-use group classified as industry by DECC includes a proportion of the population of 100kW half-hourly metered and settled customers – but not all. (As discussed in the previous section, DUKES includes some half-hourly settled customers under 'other final users' in the Commercial and Services sector).

8.7 Consistent with our approach to the commercial sector, we have used the DECC data (i.e. rather than Elexon) to determine the overall level of industrial demand.

[28] Excluding electricity currently used for transport (4 TWh) which we have not included in the model.

8.8 Electricity use in the industry sector is provided by DUKES, divided across sub-sectors as shown in Table 8 below:

Iron and steel	3%
Non-ferrous metals	6%
Mineral products	7%
Chemicals	17%
Mechanical engineering, etc	7%
Electrical engineering, etc	6%
Vehicles	5%
Food, beverages, etc	11%
Textiles, leather, etc	3%
Paper, printing, etc	11%
Other industries	21%
Construction	2%

Table 8: Breakdown of industrial electricity consumption (DUKES 2010)

8.9 Industry electricity end-use is estimated to break down by key applications as shown in Table 9 below.

End use	Percentage of total use
Heat processes	
High Temperature Processes	12%
Low Temperature Processes	17%
Drying	6%
Space Heating	8%
Non-heat processes	
Motors	34%
Compressed Air	10%
Lighting	3%
Refrigeration	5%
Other	5%

Table 9: End-use breakdown of electricity consumption in the industrial sector (Source: DUKES 2009)

8.10 End-use by standard industry classification (SIC code) is further broken-down as in Table 10 as follows.

SIC code	Description	2009 Consumption (GWh)	2009 end use shares								
			High temperature process	Low Temperature Process	Drying / Separation	Motors	Compressed Air	Lighting	Refrigeration	Space Heating	Other
14	Other mining and quarrying	1,546	50%	4%	4%	36%				1%	5%
15	Manufacture of food products and beverages	10,614		35%	4%	26%			27%		8%
16	Manufacture of tobacco products	127		36%		27%			28%		8%
17	Manufacture of textiles	2,502		21%	6%	50%				23%	
18	Manufacture of wearing apparel; Dressing and dying of fur	292		21%	6%	50%				23%	
19	Manufacture of leather and leather products	207		21%	6%	50%				23%	
20	Manufacture of wood and wood products	2,491		11%	6%	63%	14%			3%	3%
21	Manufacture of pulp, paper and paper products	7,119		19%	30%	17%	21%			5%	7%
22	Publishing, printing and reproduction of recorded media	3,937		19%	30%	17%	21%			5%	7%
23	Manufacture of coke, refined petroleum products and nuclear fuel	5,072		12%	6%	60%	15%			5%	3%
24	Manufacture of chemicals, chemical products and man-made fibres	17,708	3%	8%	4%	53%	14%		15%	1%	3%
25	Manufacture of rubber and plastic products	10,173	0%	11%	6%	63%	14%			3%	3%
26	Manufacture of other non-metallic mineral products	5,465	50%	4%	4%	36%				1%	5%
27	Manufacture of basic metals	9,994	78%			12%					10%
28	Manufacture of fabricated metal products (except machinery and equipment)	4,596	5%	46%		3%	8%	10%		26%	2%
29	Manufacture of machinery and equipment	3,092	5%	46%		3%	8%	10%		26%	2%
30	Manufacture of office machinery and computers	325	3%	25%		2%	7%	24%		34%	5%
31	Manufacture of electrical machinery and apparatus	2,498	3%	25%		2%	7%	24%		34%	5%
32	Manufacture of radio, television and communication equipment & apparatus	2,063	3%	25%		2%	7%	24%		34%	5%
33	Manufacture of medical, precision and optical instruments, watches & clocks	1,563	3%	25%		2%	7%	24%		34%	5%
34	Manufacture of motor vehicles, trailers and semi-trailers	3,172	3%	26%		3%	10%	20%		33%	4%
35	Manufacture of other transport equipment	1,841		37%		6%	16%			34%	7%
36	Manufacture of furniture	2,237		11%	6%	63%	14%			3%	3%
37	Recycling	585		11%	6%	63%	14%			3%	3%
41	Collection, purification and distribution of water	5,108		11%	6%	63%	14%			3%	3%
	Total	104,327	13%	17%	6%	33%	9%	3%	6%	8%	5%

Table 10: Industry electricity end-use by SIC classification. (Source: DECC Energy Consumption in the UK, Industry table, 2009).

8.11 Thus although DUKES provides data on the breakdown of end-use by industrial sub-sector, there is no published data available which can help paint a more detailed picture of how each industry sub-group under SIC classification consumes electricity, by:

- Time-of-day.
- Across the year (apart from a quarterly breakdown of electricity use for iron and steel[29]).

8.12 Load Research Ltd may hold some information (1990's) on electricity end-use disaggregated by industry sub-sector, but being somewhat historic, this may offer only limited insight for today and for the future.

8.13 Given this lack of available data, the modelling has therefore required some major elements of judgement to derive monthly and then half-hourly estimates of industrial end use. This involved:

- Allocating the end-use demand to each month so that in aggregate the end use demand matched total industrial electricity demand. We have assumed the same profile for most end uses - except space heating (winter peaking) and refrigeration (summer peaking).
- Allocating the monthly end-use demand to weekdays and weekends.
- Allocating the daily end-use demand to individual half-hours. As in the case of the commercial sector, we use the 'other' end-use as residual demand – and use it to reconcile end-use and total consumption data.

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[29] In addition to the data sources listed in section 3 above, DECC uses as an additional data source survey information from the Iron and Steel Statistics Bureau (ISSB) on electricity generated, consumed and lost in the iron and steel industry, blast furnace and coke ovens.

8.14 **Figure 17** below estimates a break-down of industry end-use by calendar month. The aim is to increase understanding of what demand, from a technical perspective, could shift and when. The main source is DUKES, but, as noted, the allocation of end-use to each calendar month is largely judgemental.

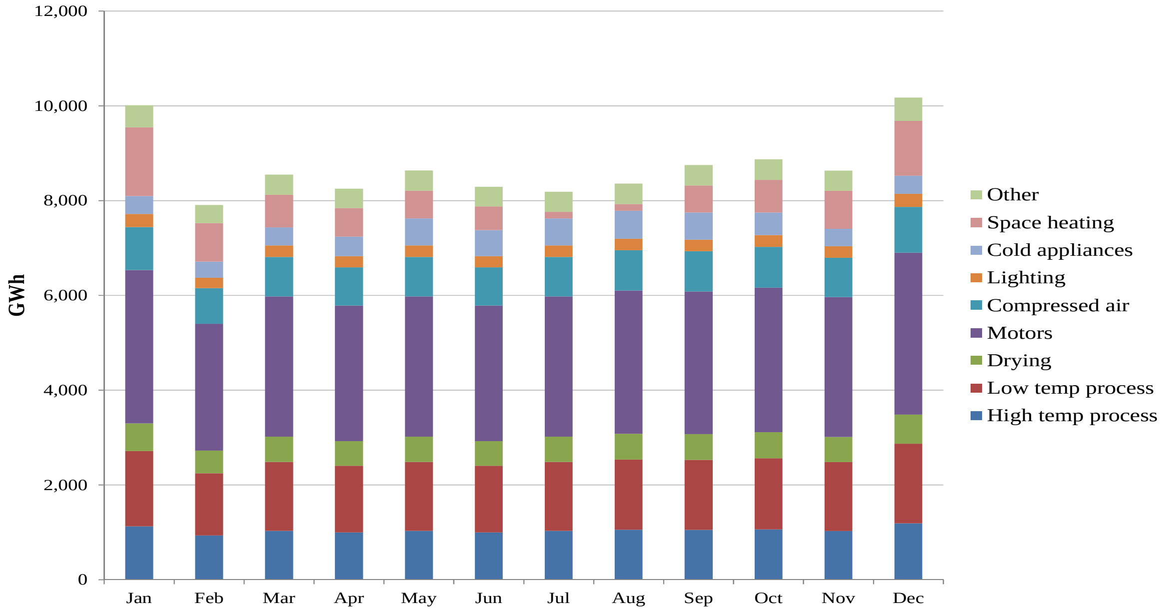

Figure 17: Estimated monthly industrial demand by end use

8.15 Given the strong component of judgement involved, the model results for industry end-use – amounting to one-third of all GB electricity end-use - should be regarded with some caution.

Improving available end-use electricity data for industry

8.16 In principle, given that 117,000 industry customers are half-hourly metered (and half-hourly settled), it should be feasible to develop a far better feel than currently exists for end-use load-profiles for different industry sector groupings. This could be via large-scale customer surveys - and / or (and subject to confidentiality issues) - via a process of matching selected individual load-profiles from metered consumption data to the industry SIC Codes. **For the GB Electricity Demand project, Sustainability First is interviewing a small cross-section of industry users. This will complement – but cannot substitute for - a large-scale quantitative and empirical analysis of industry end-use.**

8.17 **For the commercial and services sector (section 7), equivalent comprehensive quantitative analysis of end-use by half-hourly load-profiles currently represents even more of a challenge given a lack of wide-spread smarter half-hourly metering** (but, this could begin to change after April-2014, once smarter metering has been rolled out to customers in the commercial sector with maximum demands covered by Load Profiles 5-8).

Scope for Reduction

8.18 Scope for reduction in industry electricity demand will come progressively through:

- **Product standards –** driven largely by plant renewal. Regulations under the Eco-Design Framework Directive currently cover 60% of electricity consumption in the industrial sector – including electric motors; pumps; compressors and fans. Preparatory studies for product groups in the industry sector include: A/C, ventilation, furnaces & ovens, machine tools, professional refrigerating and freezing equipment, transformers[30].
- **Process optimisation and improvements –** driven by industry operational demands.

Scope for Flexibility

8.19 Scope for flexibility in industry electricity-use is largely sector and process specific.

8.20 **Paper 3 will outline some initial industry sector-specific findings on scope for industry electricity demand reduction and flexibility[31].**

[30] Sustainability First. Paper 1. GB Electricity Demand – Context and 2010 Baseline Data. October 2011. p.16.

[31] GB Electricity Demand Project - Paper 3. Interim section on industry use will be available in February 2012. Final paper - available May 2012.

9 Total Demand Picture 2010

9.1 The next step in the model is to bring together the half-hourly end-use load-profiles created for each sector – domestic; commercial and services; industry – to build-up an overview of GB electricity demand by end-use.

January Weekday - Modelled 24-hour Load-Profile for GB Electricity End-Use

9.2 Figure 18 below indicates the following traits in overall GB electricity end-use on a January weekday (high system demand):

- Evening peak and day-time plateau – major components: lighting; computing and electronics.
- Product standards will be of central importance.
- 'Other' space heating – i.e. 'on-peak' - contributes significant load.
- Off-peak space heat – over-night load still significant.
- Water heating (immersion heaters topping-up other water heating sources; showers) and domestic appliances (switched on before leaving for / after arriving back from work) assumed to contribute to morning and evening peak.

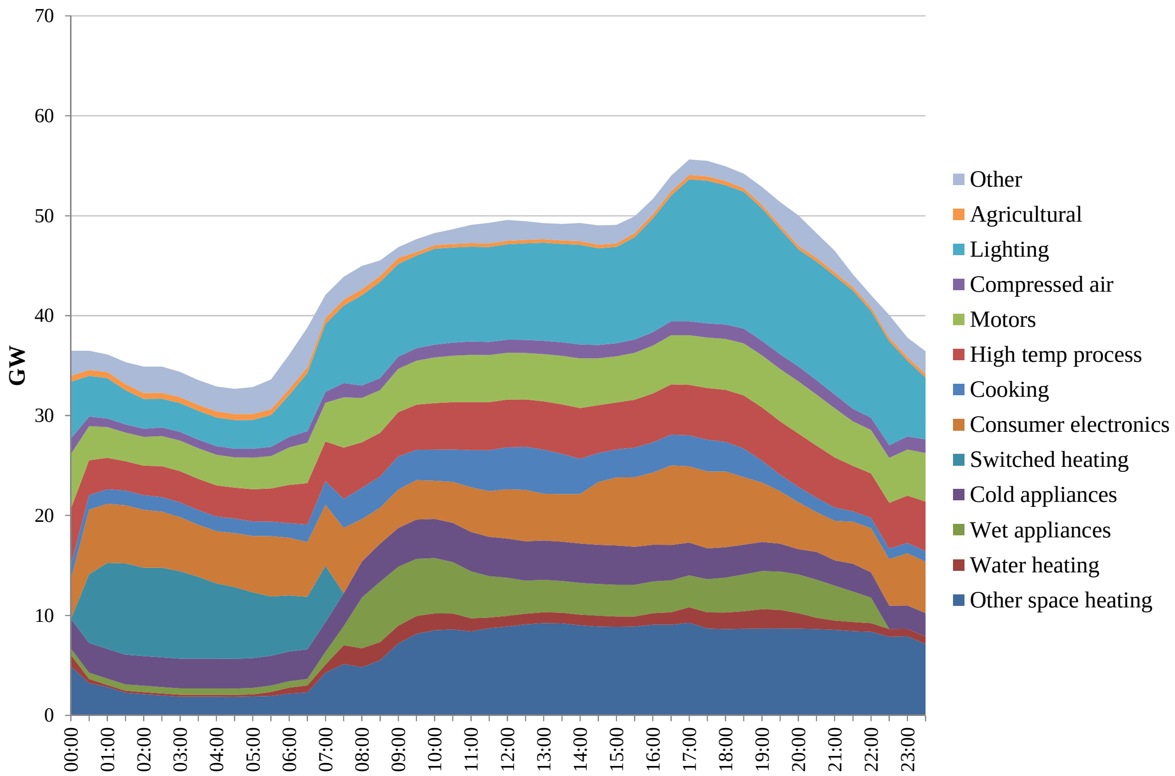

Figure 18: Estimated average daily GB demand breakdown on January weekdays

August Weekend – Modelled 24-hour Load-Profile for GB Electricity End-Use

9.3 Figure 19 below indicates the following traits in overall GB electricity end-use on an August weekend (low overall system demand):

- Flatter load-curve through-out the day.
- Significant demand increase at 07.00h – 08.00h.
- Relatively little overnight load - because no off-peak heat.
- Lighting, electronics and computing still make a major contribution to demand between 07.00h and 23.00h.

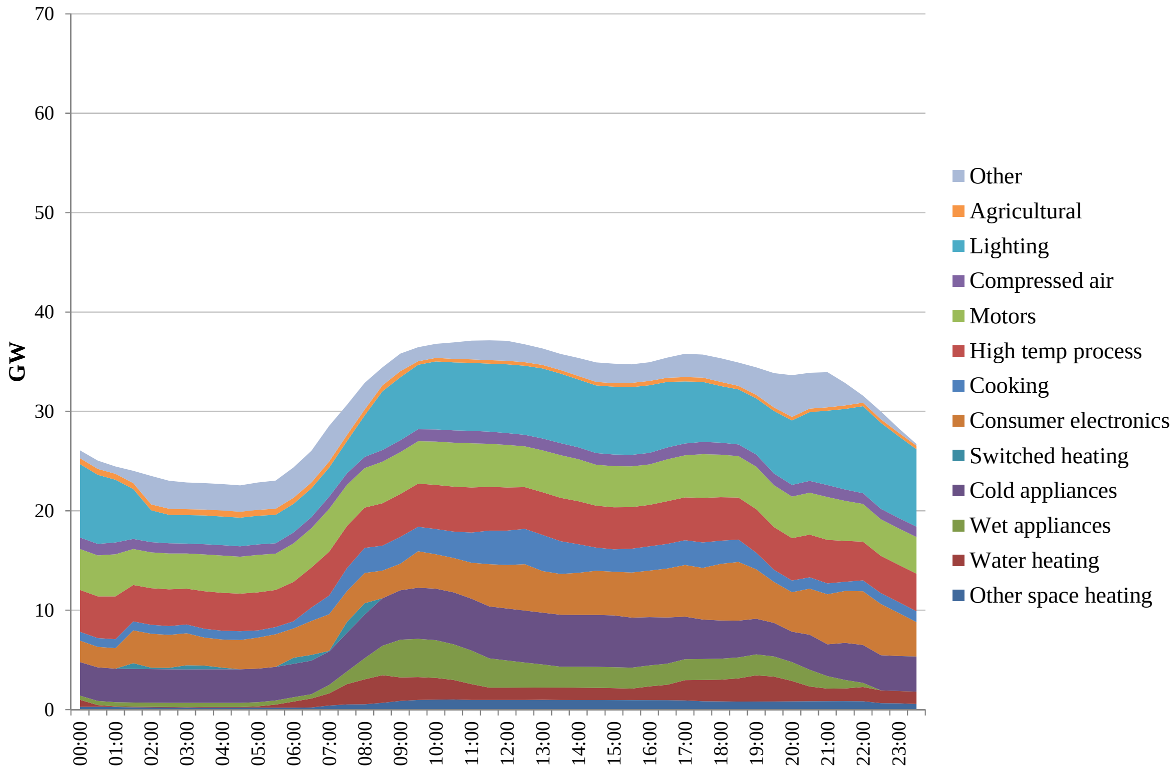

Figure 19: Estimated average daily GB demand breakdown on August weekends

9.4 Views are invited on the realism of these load-profiles – including estimated usage volumes associated with lighting, electronics and computing.

What could be done with current demand?

Peak demand shifting

9.5 On the basis of the end-use load-profiles illustrated above, a next step has been to make a very preliminary estimate of the amount of load which might be potentially shiftable from a technical perspective.

9.6 Figure 20 (for January weekdays) and Figure 21 (for August weekends) below illustrate the breakdown of electricity consumption over the evening peak. Of the end uses shown, we consider that 'other' space heating i.e. not switched heating i.e. "other" heating, water heating, (domestic) wet appliances, cold appliances (including refrigeration) and compressed air are potentially shiftable from a technical perspective. On this basis:

- **January Weekday. Winter Evening Peak: 16.00h – 19.00h: around 18 GW of 54 GW load – 34% of electricity load at winter weekday evening.** The bulk of potentially shiftable load in the model comes from on-peak heating.

- **August Weekend. Evening Peak: 16.00h – 19.00h: around 10 GW of 35 GW – 29 % of electricity load on a summer weekend evening.** In contrast to winter weekdays, the bulk of the potentially shiftable load is likely to come from cold appliances including refrigeration (potentially), cooling and ventilation.

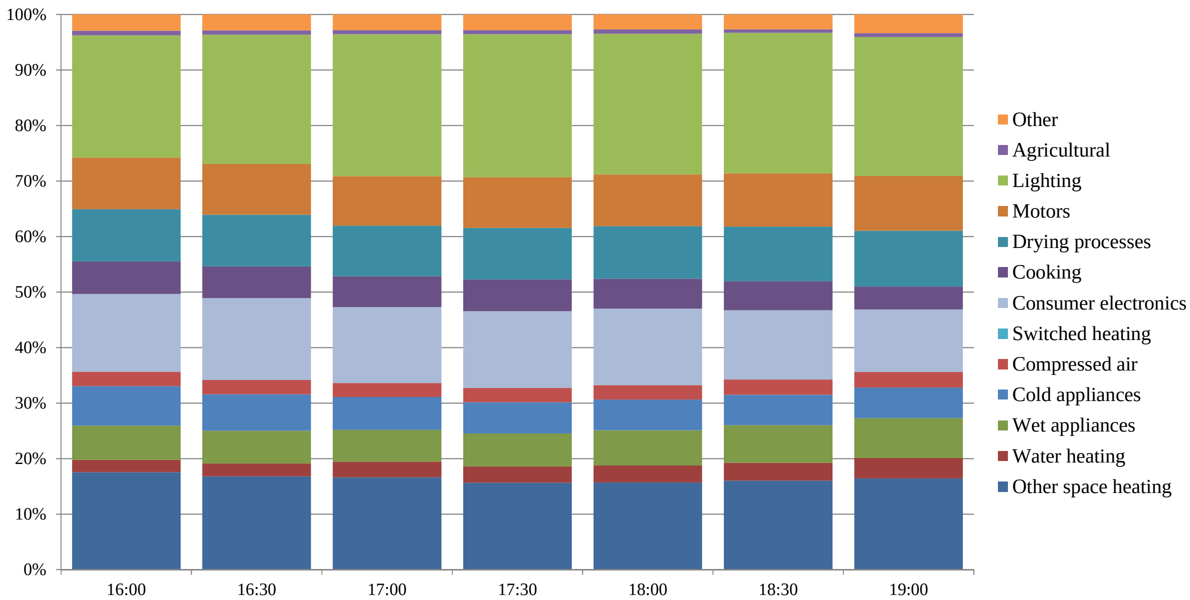

Figure 20: Breakdown of electricity demand by end-use over evening peak on January weekdays

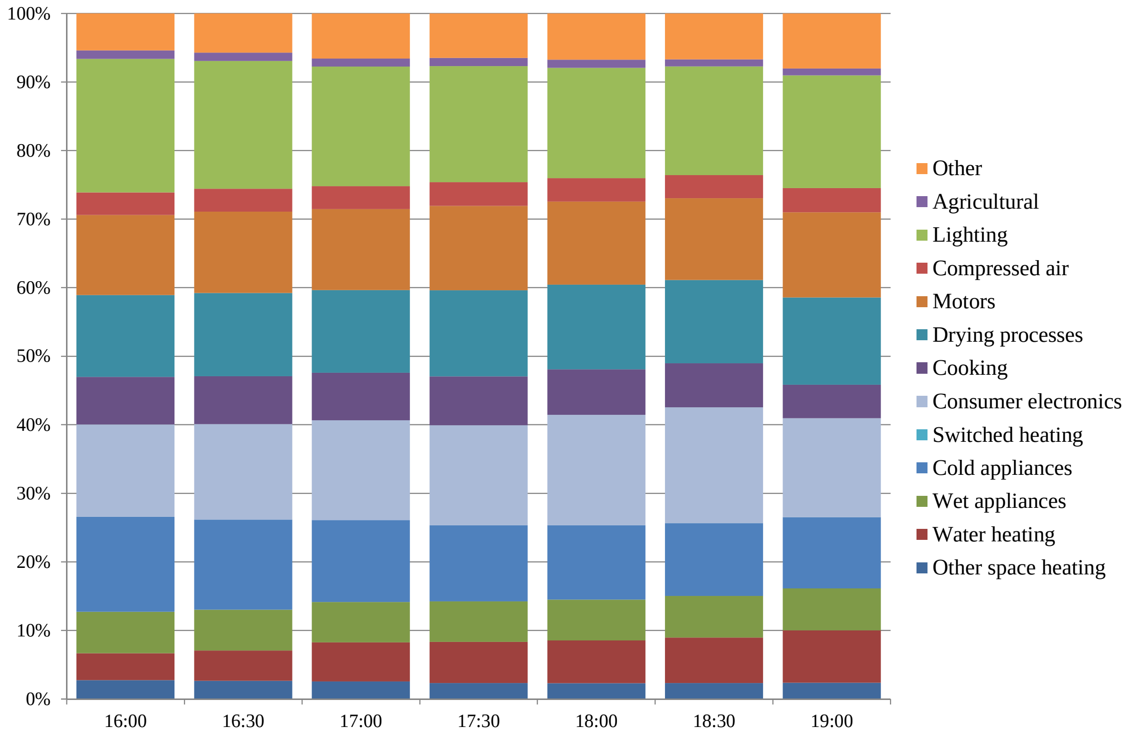

Figure 21: Breakdown of electricity demand by end-use over evening peak on August weekends

9.7 Figure 22 below estimates which sector of the economy is liable to make most contribution to peak shifting in the evening. The domestic sector would clearly be the main contributor. Interestingly this shows shiftable domestic demand increasing towards 19.00h. The domestic sector is likely to offer most shiftable demand at evening peak, regardless of whether winter or summer.

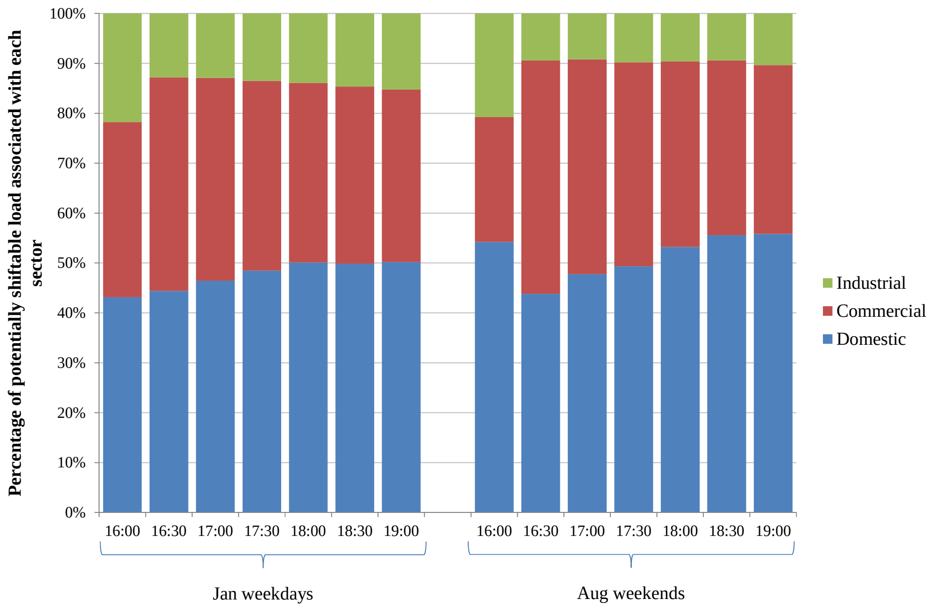

Figure 22: Sectoral breakdown of potentially shiftable load

Scope for demand-shifting outside evening peak

9.8 The model also explores the potential for demand-shifting across the course of a day. In principle, the types of load that are shiftable (direct acting space heating, water heating, wet appliances, cold appliances and compressed air) do not have to be shifted from the evening peak to off-peak times. Instead, they could be shifted between other periods, for example, to accommodate variable output from wind farms. As demonstrated in Figure 23 and Figure 24 below.

- **Winter morning peak** – potential shiftable demand of up to 20 GW.
- **Summer morning peak –** potential shiftable demand of up to 13 GW.

9.9 From a perspective of overall system cost efficiency, it may therefore help to understand more about the potential to shift and or smooth load in the morning - as well as in the evening.

9.10 In their recent paper, Poyry[32] suggest that low wind periods may generally prevail in the mornings, potentially at around 10.00h. For the long-run, there may therefore be value in exploring the potential flexibility of morning peak load – including the sectoral end-uses which make up that load: the potential for flexibility; how that might shift; and to what time of day it might shift instead etc.

[32] Demand Side Response : Conflict Between Supply and Network Driven Optimisation. Poyry and University of Bath. Report to DECC. November 2010. Published August 2011.

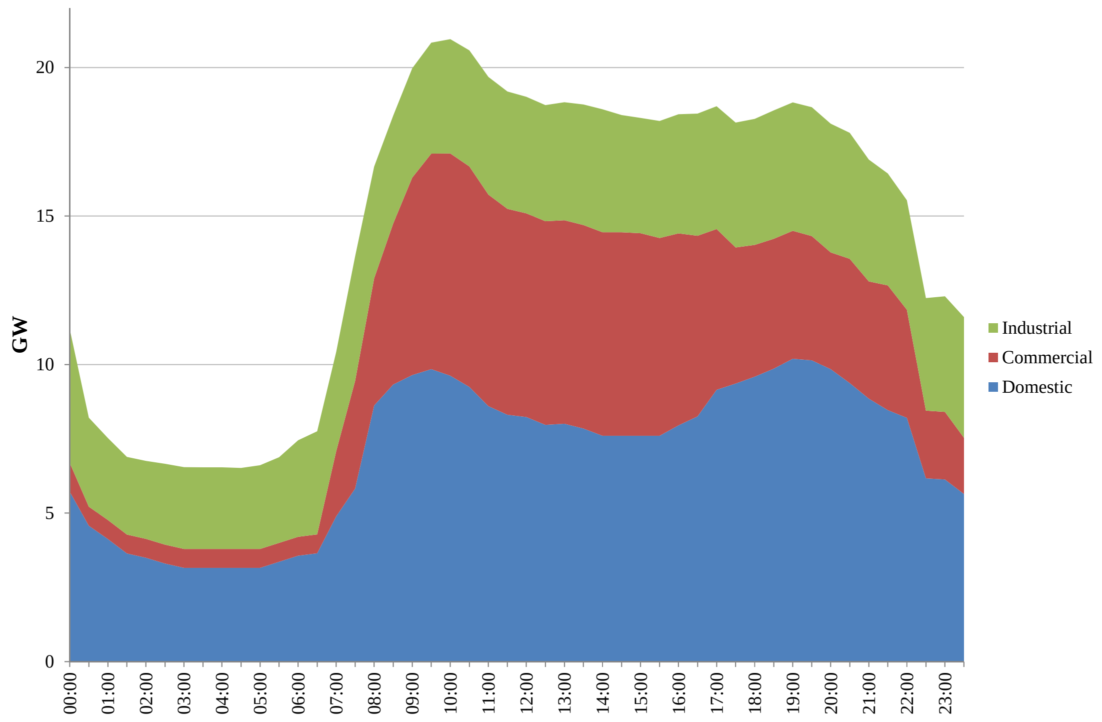

Figure 23: Potentially shiftable load across the course of a January weekday

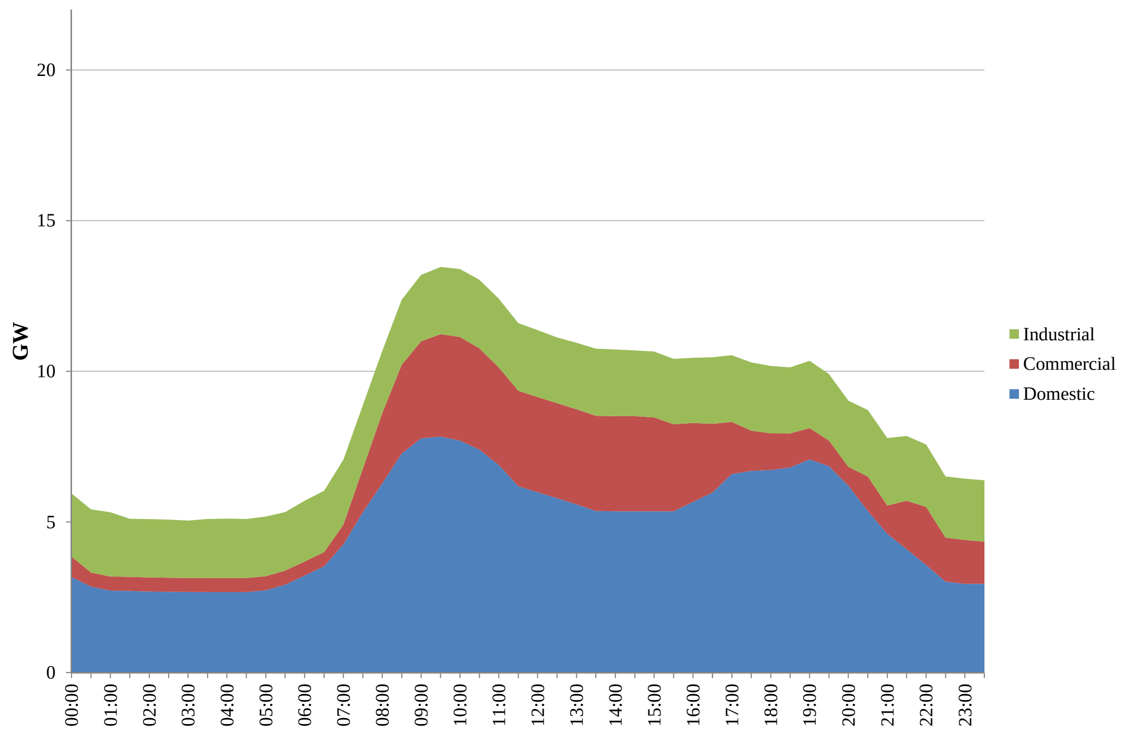

Figure 24: Potentially shiftable load across the course of an August weekend

Conclusion on the Picture for Overall Electricity Demand in 2010

Scope for GB Electricity Demand Reduction 2010

9.11 The modelling suggests that scope may exist for reducing GB electricity demand in 2010 as follows:

- **Lighting -** accounts for around 19% of total estimated demand on a January weekday, of which around 39% is domestic lighting and 56% is commercial lighting. On an August weekend, the commercial share of lighting rises to ~70%. This suggests considerable scope for more efficient lighting and / or better lighting controls (in particular in the commercial sector).
- **Domestic appliances (cold and wet) –** potential scope for demand reduction through improved efficiency. They currently contribute over 10% of total electricity end-use - both for a January weekday and on an August weekend.
- **Commercial and Industrial End-Uses –** Likely to be some further scope for commercial and industrial electricity demand reduction. For example, industrial motors – represent ~10 % of total GB demand – so could have significant benefits. Product standards should also make an impact.
- **Electric heating / Air conditioning –** On-peak electric heating accounts for 15% of demand on a January weekday; 2% on an August weekend. Better controls and thermal insulation should reduce on-peak heating demand. Air conditioning (separated out as cooling and ventilation for the commercial sector) accounts for 3% of total demand on both Jan weekdays and Aug weekends – so is currently small (but could increase if domestic air conditioning takes off). (Also, not clear that all commercial air conditioning load is captured in this category).
- **Refrigeration –** industrial refrigeration accounts for less than 3% of total demand on both Jan weekdays and Aug weekends.

Scope for GB Electricity Demand Flexibility 2010

9.12 As discussed in paragraphs 9.5 to 9.8 above main technical potential for demand shifting would seem to be:

- **Winter:** Up to 18 GW at evening peak – much of which likely to be household demand; up to 20 GW in the morning – likely to be a mix of household, commercial and industry demand.

- **Summer:** Up to 10 GW in summer in the evening – much of which likely to be household demand; up to 13 GW in the morning – likely to be a mix of household, commercial and industry demand.

- **Main end-uses likely to shift are:** on-peak space heating; on-peak water heating; domestic wet appliances; refrigeration (all sectors) and compressed air.

9.13 Interestingly, this possibly points towards more 'flexible' load on winter weekday *mornings* than winter weekday evenings.

9.14 A number of questions relating to the settlement arrangements may need to be addressed to enable individual suppliers - or other market actors – to realise the full benefits of any demand-side investment they may make on behalf of their customers[33].

[33] Current arrangements for half-hourly settlement include customers with half-hourly meters in the 100 kW market. In principle, this means that the benefits of any customer actions taken to deliver demand-side flexibility in any given half-hour can be fully attributed to that customer's supplier in the settlement system.

By April 2014, larger customers with consumption covered by Load Profiles 5-8 will also have smarter metering with a half-hourly capability – and increasingly households too - but most likely without full half-hourly settlement. Questions will therefore continue to arise as to how far within a competitive market, without full half-hourly settlement, the full benefits of avoided-costs (e.g. avoided fuel-costs, avoided capital costs) from demand-side actions taken by their customers can be fully re-couped by individual suppliers – or aggregators – for demand-side investment they have made on a customer's behalf. The Ofgem consultation 'Promoting smarter energy markets' (Dec. 2011) identifies facilitating wider half-hourly settlement, including on an 'elective' basis, as an area for further work. For example, it states: 'An electricity supplier can elect to settle any supply point on a half-hourly basis – but there may be disincentives to them doing so' (para. 4.16).

Part 3 – Modelling Electricity Demand in 2025

10 General approach to developing the model to 2025

10.1 The next step in development of the model was to look forward to 2025. A number of dimensions needed consideration:

- Domestic, commercial and industry demand – changes in the likely shares of total end-use *between* sectors.

- Changes in the end-uses *within* each sector:
  - E.g. Whether industry mix may change?
  - Evolution of off-peak heat (Economy 7, Economy 10) – in both the domestic and commercial sectors – e.g. Continued decline? Stable? Increase?

- Likely major new sources of electrical load:
  - Heat pumps.
  - Plug-in electric vehicles.

- Whether half-hourly demand curves *for particular end-uses* may change – and if so how? For example, through efficiency improvements (lighting; motors); new air-conditioning load; wet appliances - uptake of ToU tariffs; flexible response from refrigeration etc.

10.2 In developing the model to 2025, a key aim was to develop a relatively simple approach. This meant adopting a largely ‘business as usual’ approach – and changing relatively few variables – while keeping focused on the main aim of being able to assess the technical potential for demand-side flexibility by 2025 from measures such as smart meters and other load-management initiatives. We also sought to make comparison straightforward between 2010 and the future scenarios. This entailed keeping load profiles for 2025 constant with 2010 (see 10.3 below) – and making a distinction between any shifting explicitly incorporated into scenario assumptions – and ‘additional’ demand flexibility potential.

10.3 The following main assumptions were made:

- **Demand curves created for 2025 –** the end-use curves created for 2010 were kept constant for 2025. In effect, this means that a load-curve for an individual end-use does not change in the model – but can either grow or shrink depending on assumptions made.

- **Heat pumps –** incorporated into the model as representing new electric load in 2025 – but in practice to 2025 heat-pumps may replace some existing off-peak or on-peak electric space heating. Heat pump uptake assumptions are currently taken from 2050 Pathways Analysis. **A key underlying assumption on heat pumps adopted in this model is that the heat-pump end-use load-profile remains very largely constant**

across the day. This is a key assumption in this model - and is open to debate. The model assumes an optimal operating regime in 2010 for a heat-pump without a thermal storage capability. If there is widespread heat-pump uptake by 2025, it seems more likely that they will be installed in combination with thermal storage and high levels of thermal insulation. In turn, this would suggest greater potential for flexible operation. (A number of LCNF projects are likely to inform this discussion in due course).

- **Electric vehicles –** incorporated into the model as representing new electric load in 2025. A key assumption in the model is that most charging takes place during the day and evening.[34] **This assumption is also open to debate.**

Indicative Scenarios

10.4 Two indicative scenarios were selected from the DECC 2050 Pathways Analysis against which to develop the possible outlook for potential electricity demand in 2025 and to illustrate possible model outcomes.

10.5 However, because the pathways calculator is based on 2007 data, it automatically adjusts all the 2010 assumptions depending on which trajectory and case are chosen. Given that the 2010 electricity demand data are now known, this approach is no longer appropriate. Instead we have applied the change in consumption between 2010 and 2025 under the various pathways to the actual 2010 demand to create the following scenarios:

- **Scenario 1**: trajectory A, level 1 case from the 2050 Pathways: essentially a **Business As Usual scenario, with relatively little change from today.**
- **Scenario 2:** Trajectory D, level 4 case from the 2050 Pathways: **the most environmentally friendly case**

10.6 The assumptions underlying these two 2050 Pathways cases are shown in Annex 3.

10.7 Assumptions about efficiency of electricity end-use are therefore largely driven by the Scenario.

10.8 The 2050 Pathways take into account the following factors:

- Demographics: population growth, household numbers.
- Economic growth.

[34] This assumption therefore enables EV-charging to be regarded as load which is potentially 'flexible' from a technical point of view. This is based on Figure 17 from the Energy White Paper, which itself is stated to be derived from the 2050 Pathways "spread effort" pathway.

10.9 Additionally, electricity demand will also be influenced by:

- Housing stock improvements.
- Fossil / electricity prices[35] – and possible impacts on demand-reduction and demand elasticity.
- Product regulation for electricity (and energy) efficiency (esp. lighting, motors). (Eco-Design Framework Directive and EU Regulations).
- Progress on commercial, regulatory and policy measures – including on new business models – which might stimulate electricity DSR.
- For current Economy 7 customers ; assumptions on up-take of electric heat pumps, off-peak electric storage heaters, electric water heating, electric vehicles ; PV and microgen.

10.10 **Scenario 1 (BAU)** is illustrated in Figure 25 and Figure 26 below. It indicates**:**

- Increased annual demand from 328 TWh to 370 TWh, with the increase occurring mostly in the domestic and industry sectors[36]. Domestic demand grows because of an increase in electric heating, which does not occur in the commercial segment. Scenario 1 also appears to assume increasing electrification in industry whereas there is much less opportunity for this in commercial (as more demand is already electrified).
- Assumes increased electricity end-use occurring largely in: space and water heating (with our own assumption that the use of switched electricity for these purposes will decline) but not significant new heat pump or cooking load (particularly in the domestic sector) and a modest uptake of EVs.
- Decreased end-use occurring in: lighting and appliances.

Figure 25: Change in sectoral electricity demand by 2025 under scenario 1

[35] In November 2011 DECC published the report 'Estimated impacts of energy and climate change policies on energy prices and bills', estimating the impact of policies on energy prices (to 2030).

[36] This reflects data in the 2050 Pathways Calculator, based on the 2011 Carbon Plan. DECC has since revised its overall central demand assumption down (possibly to reflect current outlook for economic growth). For example, DECC EMR Technical Update, December 2011, Central Scenario to 2020 shows 335 TWh (down from 362 TWh).

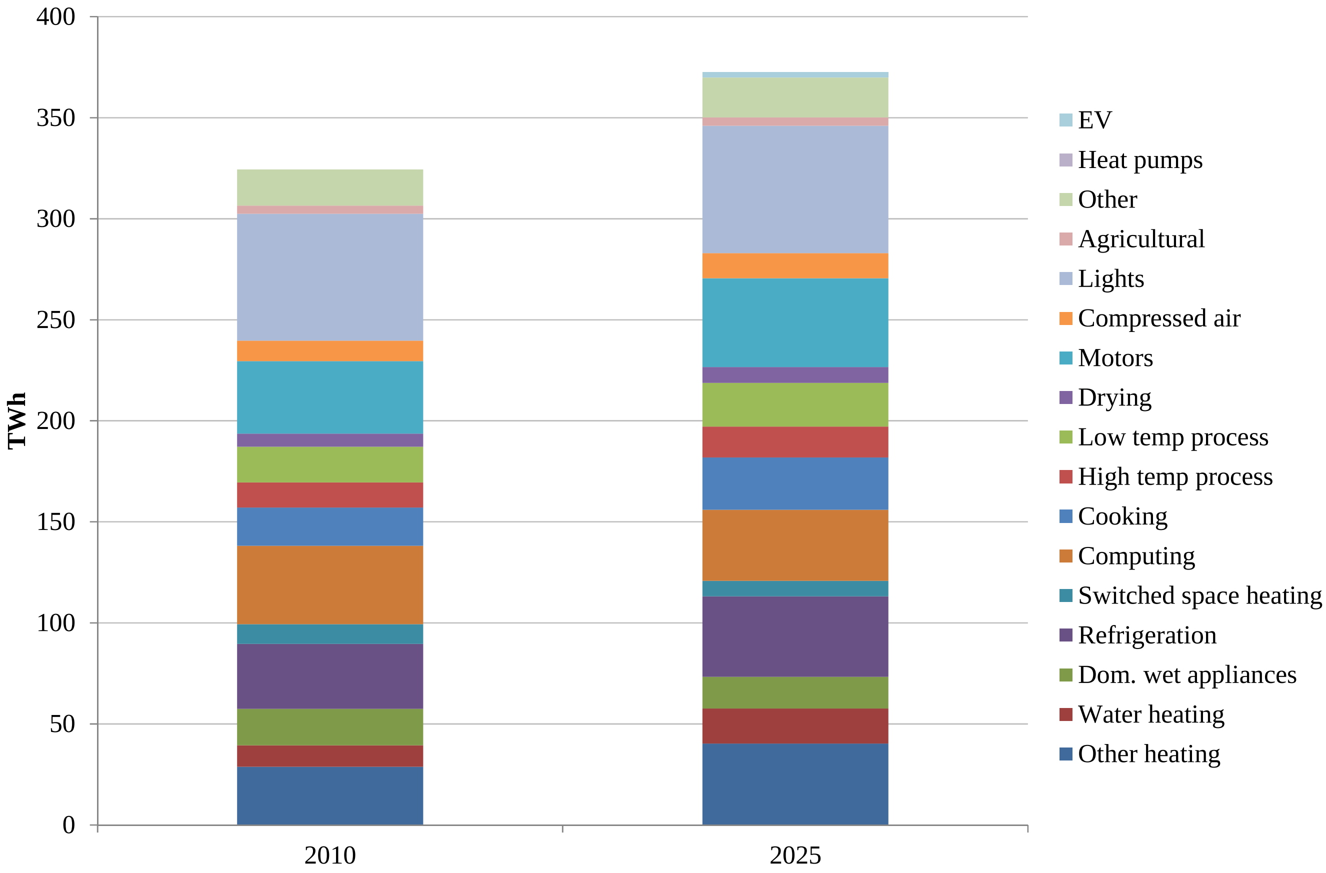

Figure 26: Electrical end use breakdown in 2025 under scenario 1

10.11 **Scenario 2 (Greenest)** is illustrated in Figure 27 and Figure 28 below and indicates**:**

- Annual demand decreases marginally (against 2010) to 320 TWh due to green policies. Shares of electricity consumed by the domestic, commercial and industry sectors remain unchanged.
- Some significant EV load – more than in Scenario 1; considerable uptake of Heat Pumps. In addition, the scenario assumes a widespread uptake of direct acting electric space and water heating in the domestic sector.
- Lower electricity end-use for lighting and appliances (due to higher efficiencies).

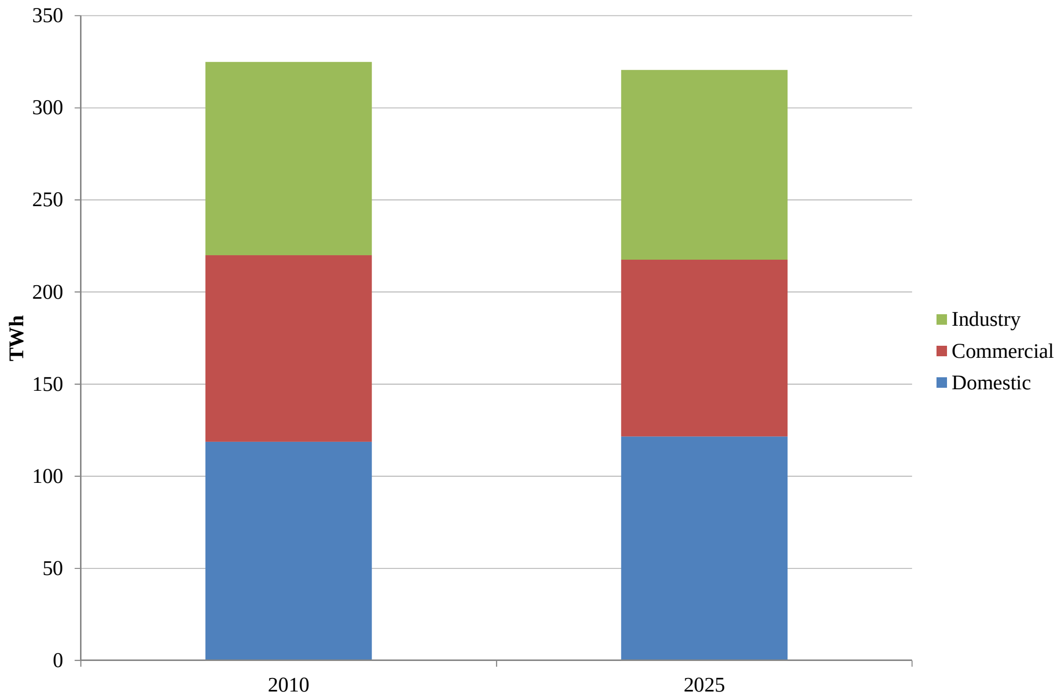

Figure 27: Change in sectoral electricity demand by 2025 under scenario 2

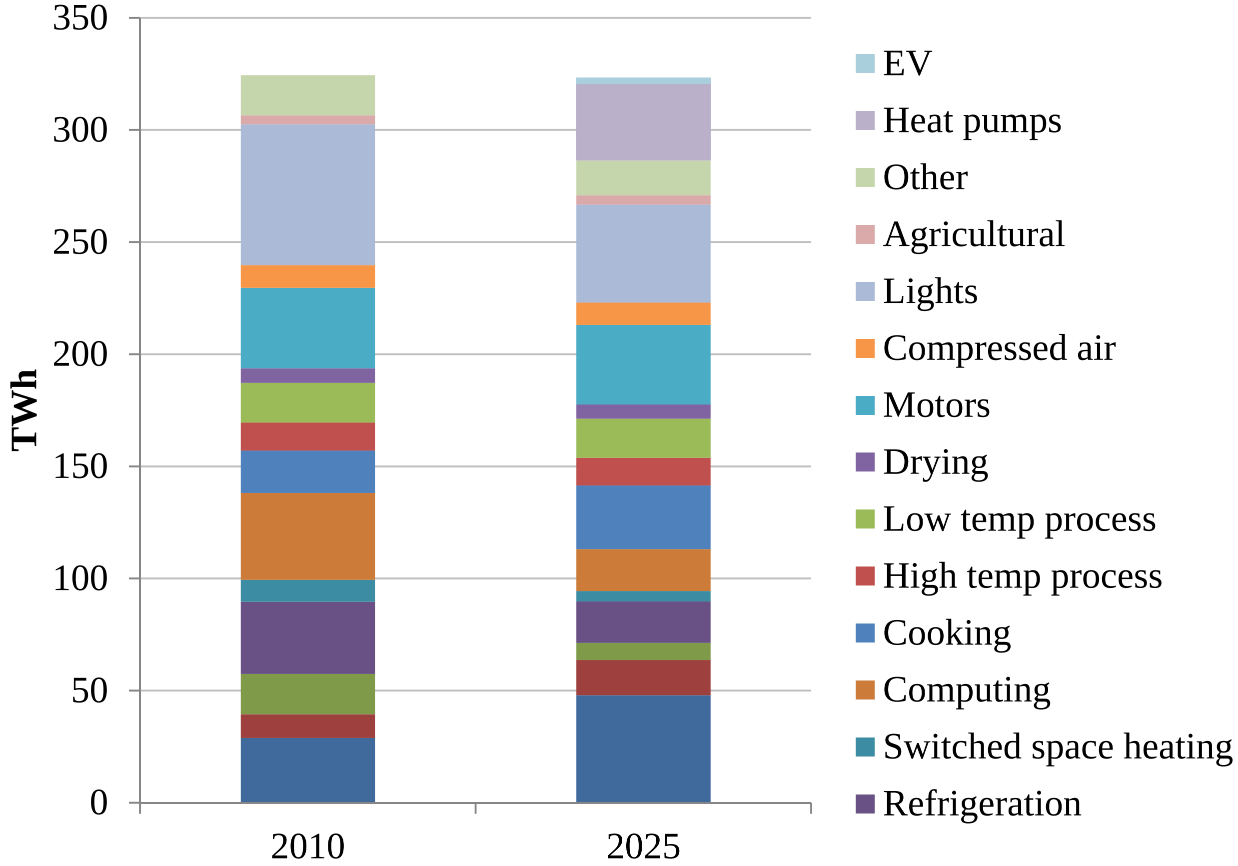

Figure 28: Electrical end use breakdown in 2025 under scenario 2

Winter weekday load curves disaggregated by end-use in 2025

10.12 For each 2025 scenario (BAU, Greenest), the model can then generate a possible electricity system load curve for a 24-hour period on a typical January weekday (i.e. a period of high system demand) – disaggregated by individual load profiles for each electricity end-use.

10.13 **Scenario 1 (BAU): winter weekday load-curve disaggregated by end-use in 2025 –**Figure 29 below shows:

- A high winter evening peak of 67 GW (10 GW higher than in 2010).
- Overnight off-peak heat.
- A significant amount of 'other' space heating.
- A pronounced morning increase – rising to 50 GW.
- A very small amount of EV load – evident only at evening peak.

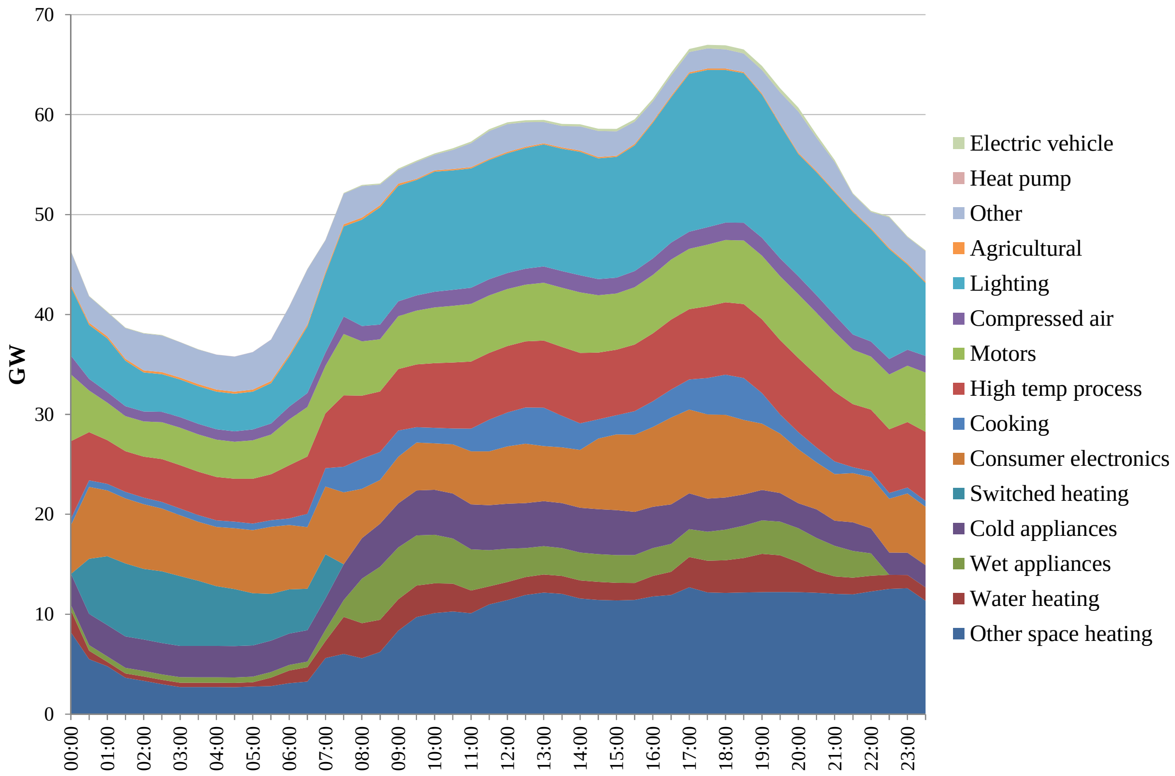

Figure 29: Estimated average daily GB demand breakdown on January weekdays in 2025 under scenario 1

10.14 **Scenario 2 (Greenest) – winter weekday load-curve disaggregated by end-use in 2025** - Figure 30 below shows:

- A winter evening peak of 58 GW (comparable to 2010).
- Reduced off-peak heat - in contrast with Scenario 1 above – creating a new and notable night-time valley (potentially leading to increased over-night costs in winter in system balancing).
- A significant amount of 'other' electric space heating – plus a reasonable amount of constant heat-pump load.
- Much less of a morning peak than in scenario 1.
- A reduction in lighting load - both in absolute and percentage terms.
- A definite EV load, spread out across the day - not all at evening peak

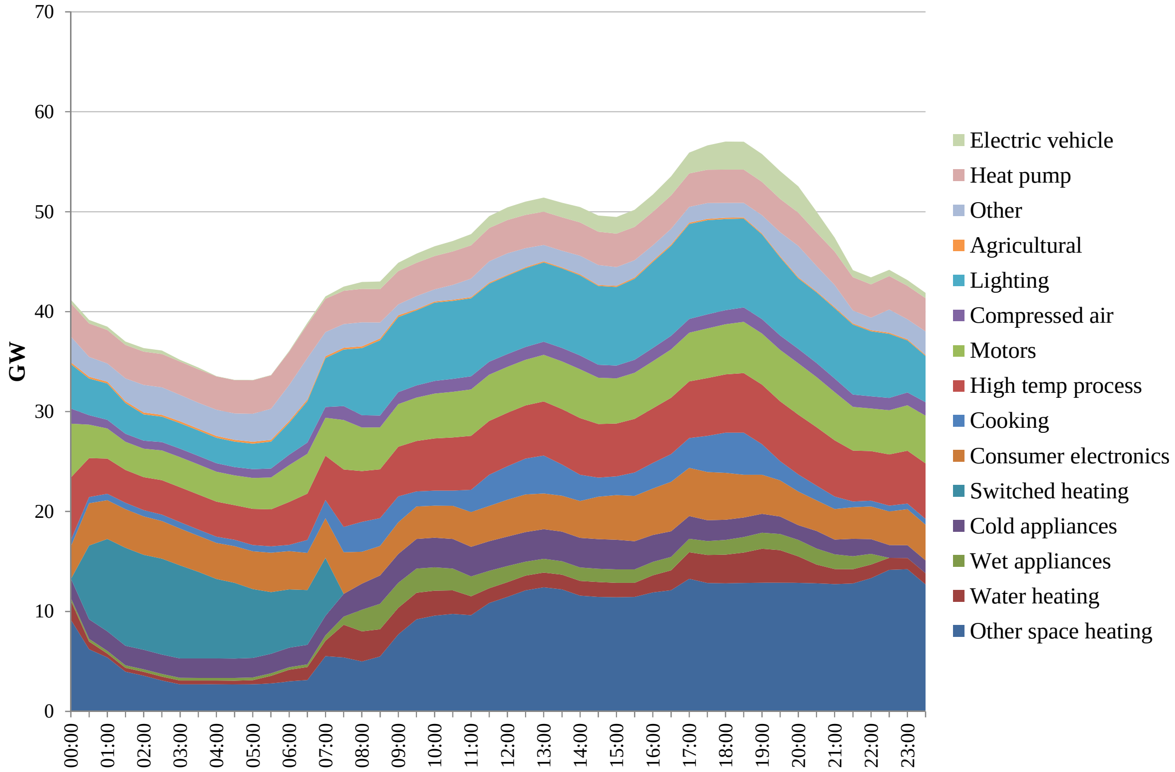

Figure 30: Estimated average daily GB demand breakdown on January weekdays in 2025 under scenario 2

Summer weekend system load curves disaggregated by end-use in 2025

10.15 For each 2025 scenario (BAU, Greenest), the model then illustrates a possible system load curve for a 24-hour period on a typical August weekend (i.e. a period of low system demand) – disaggregated by individual load profiles for each electricity end-use.

10.16 **Scenario 1 (BAU) – summer weekend load curves disaggregated by end-use in 2025.** Figure 31 below shows:

- A maximum morning demand on the system of ~ 45 GW (higher than in 2010) – and thereafter generally flat across the day.
- Little overnight off-peak heat

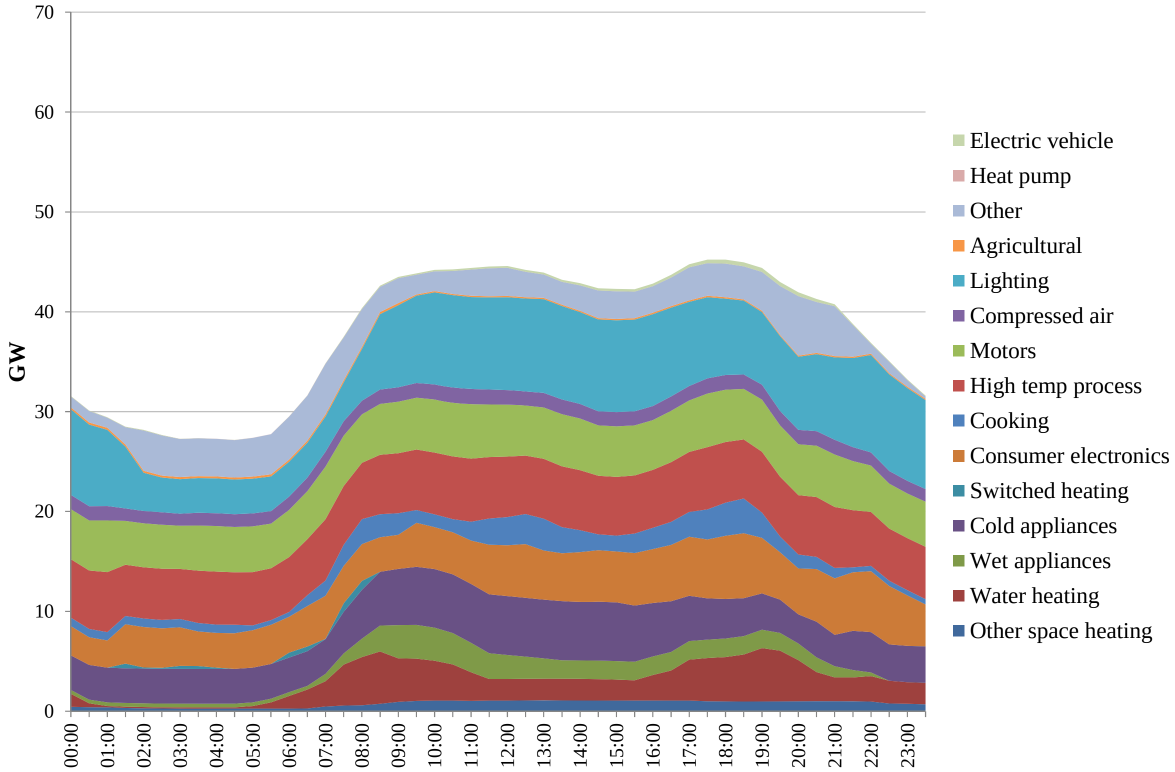

Figure 31: Estimated average daily GB demand breakdown on August weekends in 2025 under scenario 1

10.17 **Scenario 2 (Greenest) – summer weekend load curves disaggregated by end-use in 2025.** Figure 32 below shows:

- A more pronounced evening peak than in 2010 or in scenario 1, albeit that the maximum demand (at 37 GW) is lower than in 2010.
- Almost no overnight off-peak heat but some modest heat pump load providing hot water and a little heating
- Modest EV load across the day

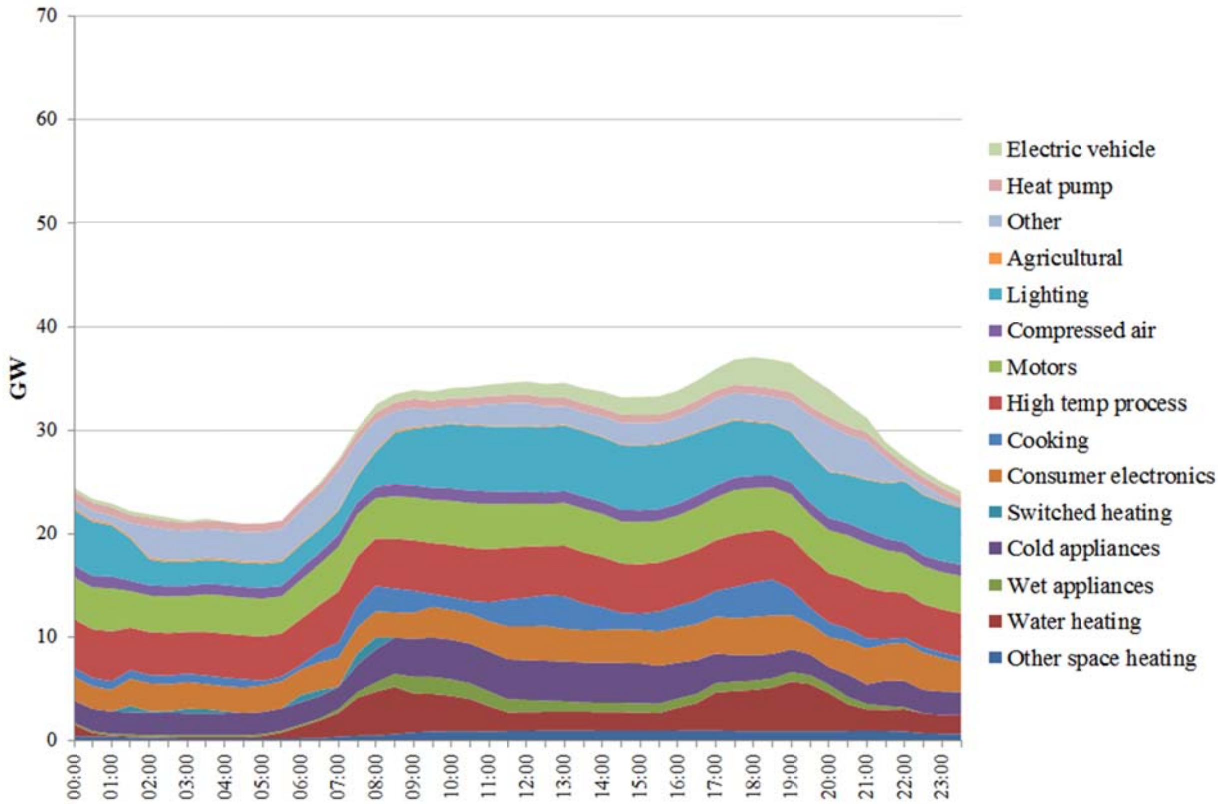

Figure 32: Estimated average daily GB demand breakdown on August weekends in 2025 under scenario 2

Total Demand Picture 2025

Scope for Reduction

10.18 Scope for electricity demand reduction in 2025 is highly dependent upon the impact of improved product efficiency. In the case of electric space heating and hot water improved end-use efficiency will also be shaped by the uptake of thermal insulation. Generally, the extent of electricity demand reduction overall will also be shaped by economic and demographic factors as well as the extent to which we find ourselves in a world more akin to the BAU Scenario or to the Greenest Scenario.

Scope for Flexibility

10.19 The model indicates a possible ‘maximum’ for technical flexibility for each scenario in 2025. It is important to note that the model offers no insight into the likely commercial value of demand-side flexibility or what will, in practical and commercial terms, prove feasible. That will depend on many other factors not incorporated into this model, including: supply side developments; customer acceptance and participation; technical potential for length of interruption / delay (latency) in response; appliance innovation and development (e.g. storage for electric heat etc.).

10.20 The model assumes that the same categories of appliance end-use will have a potential to shift / to be flexible in 2025 as were identified for 2010 (para. 9.6). These were:

- **‘Other’ heating;**
- **Water Heating;**
- **Refrigeration;**
- **Domestic Wet appliances, and**
- **Compressed air.**

10.21 In 2010, the model suggested that these end-uses could potentially provide 18 GW of demand that is technically shiftable at the evening peak during winter weekdays - and 10 GW of demand that is technically shiftable during summer weekends. By 2025, these figures change to:

- **Scenario 1 (BAU)**: 23 GW for winter weekdays and 13 GW for summer weekends.
- **Scenario 2 (Greenest)**: 20 GW for winter weekdays and 19 GW for summer weekends.

10.22 Electric Vehicle Load - By 2025, it is assumed that new load from plug-in electric vehicles (EV) will be on the system. **It is important to note that in both scenarios, we have assumed that EV load will occur *mainly during on-peak hours* – and we have not assumed specific incentives to shift EV load to off-peak (although that**

will in the end be likely). In addition, by contrast with other types of load identified in para. 10.18 above, EV load may potentially shift for a greater number of hours – over-night for example.

10.23 The modelling also produces some very preliminary outcomes, as illustrated by Table 11 and Figure 33 below. These suggest that potentially shiftable electricity demand at evening peak is likely to increase irrespective of whether demand follows a BAU or Green scenario. Shiftable load under the BAU case (scenario 1) comes from greater potential from the same end-uses identified for 2010 in para. 9.6. Under the Greenest case (scenario 2) those sources of shiftable load decline in relative terms. However, this reduction in currently potentially shiftable load is more than offset by new shiftable load created from the uptake of Electric Vehicles.

	January weekdays			August weekends		
	Scen 1	Scen 2	2010	Scen 1	Scen 2	2010
Potentially shiftable load	24	23	18	13	12	10
Maximum demand	67	57	56	45	37	36
Breakdwon						
Domestic	50%	48%	50%	49%	40%	63%
Commercial	32%	28%	28%	35%	31%	16%
Industrial	17%	16%	23%	14%	14%	21%
EV	1%	8%		2%	15%	

Table 11: Summary of estimated potentially shiftable load over the evening peak

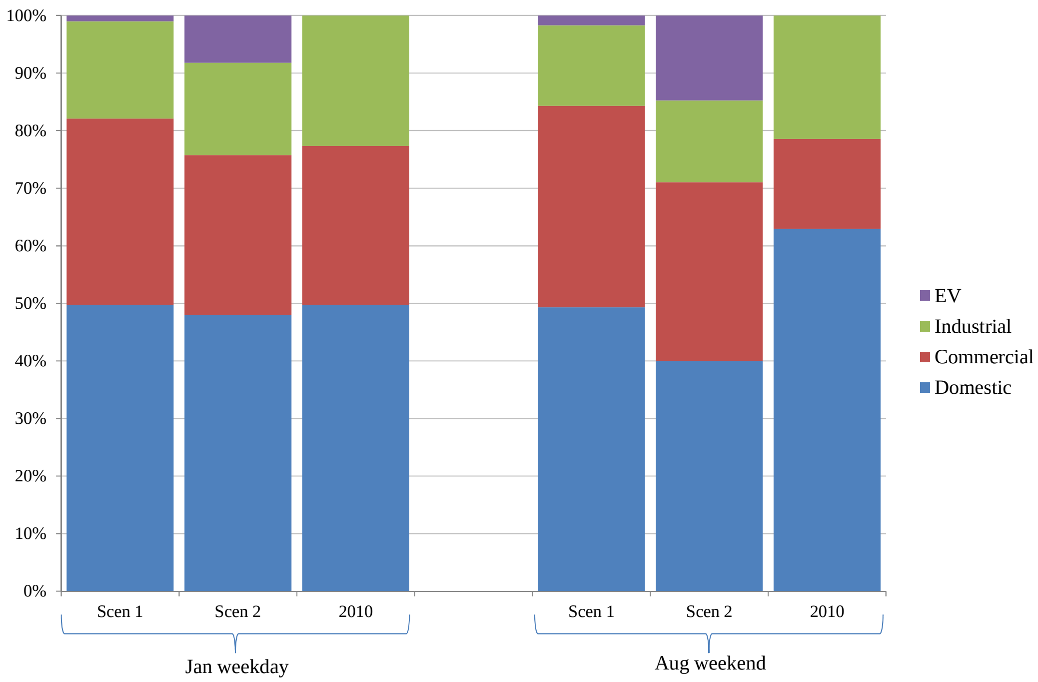

Figure 33: Breakdown of potentially shiftable demand during the evening peak (16:00-19:00h)

Key similarities and differences – 2010 and 2025

10.24 **Key similarities - 2010 and 2025**. Many end-uses and associated end-use load-profiles are assumed to stay unchanged.

10.25 **Key differences - 2010 and 2025**. It is reasonable to assume that some product efficiency standards – in particular those required by the Eco-Design Framework Directive - may make a material difference to volumes of demand in 2025 across all economic sectors e.g. lighting, computing, motors, refrigeration[37]. Efficiency and product standards will also to some extent be driven by Scenario outcomes (BAU, Greenest). Heat Pump and Electric Vehicle (EV) uptake will also be driven by Scenario outcomes. As noted, the model assumes that EVs charge on peak, but that will in the end depend on incentives to shift load and on Scenario outcome.

How efficiency improvements could shape flexibility in 2025

10.26 Figure 34 below compares daily load curves for potentially 'shiftable' load / demand (i.e. up to 25 GW. The maximum in any half-hourly period is nearly 25 GW, the average over the evening peak is 23 GW as identified in paragraphs 10.17 and 10.18 for:

- **2010** - a typical winter weekday and a typical summer weekend.
- **2025** - potential load-curves for a winter weekday and a summer weekend for both scenarios (BAU, Greenest).

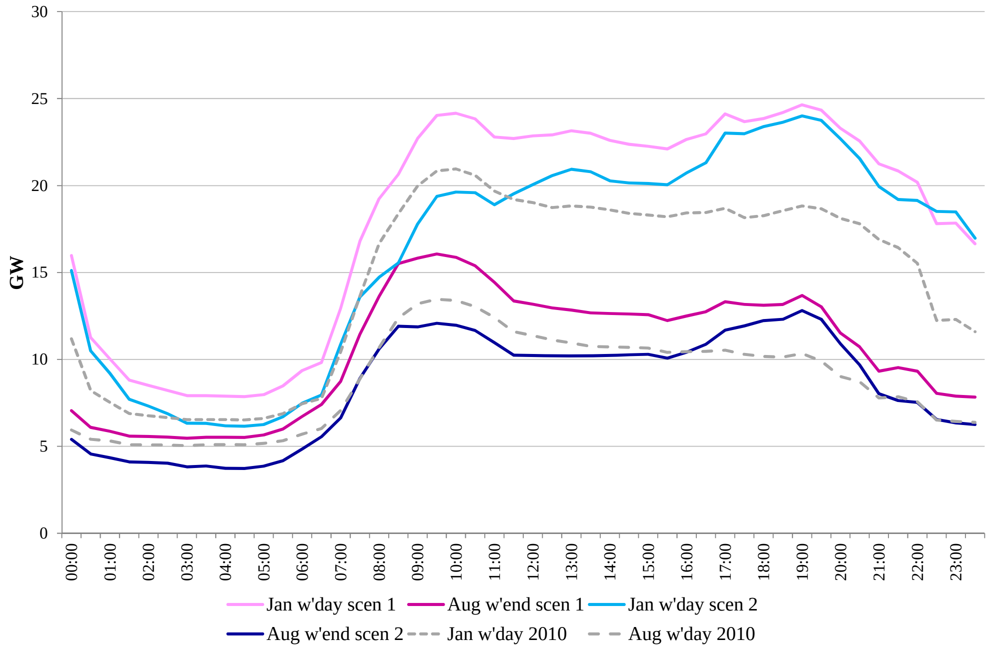

Figure 34: Potentially shiftable load in 2025

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[37] Sustainability First. GB Electricity Demand project. Paper 1. October 2011. p.16.

10.27 **Over the evening peak** - differences between the two 2025 scenarios are not large and scope for demand shifting is significantly higher than in 2010.

10.28 **Around the morning peak** - which may have increasing significance in system balancing terms by 2025 should this coincide with lower wind periods as suggested by Poyry (2011) [38] - the potentially shiftable load differs between the scenarios by around 4 GW. Scenario 2 (Greenest) implies less shiftable load than scenario 1 (BAU) - largely due to higher uptake of Heat Pumps in scenario 2. This in turn may reduce the level of potentially shiftable space and water heating load (based on our model assumptions). This assumed reduction in the potential for shiftable load, together with generally lower levels of electricity demand overall due to increased efficiency, means that in the Greenest scenario, (at times outside evening peak when EV load might shift), the potential for shiftable load could be static or decrease.

[38] See paragraph 9.10 above

Part 4 - Conclusions and Next steps

11 Initial Conclusions

11.1 An initial electricity demand-side model has been developed by the Brattle Group as a resource to the Sustainability First GB Electricity Demand project.

11.2 **Model aims –** the model has sought to:

- Build-up a quantitative picture of current GB electricity demand and customer-use.

- Consider current potential for:
  - electricity demand reduction.
  - demand-shifting at peak.
  - more general demand-shifting at other times of day.

- Use current electricity demand as a base-line to look ahead to 2025 - and to explore in a very initial way, the potential for demand reduction and demand shifting in 2025.

11.3 **Model data -** there is a significant issue regarding the lack of available published data at a worthwhile level of disaggregation with respect to GB electricity end-use today - across each of the domestic, commercial and industry sectors. The position may improve to some extent during the course of the project in the light of new quantitative analysis by Ofgem and DECC on I&C demand, or through completion of LCNF projects, new university projects including projects supported by the Research Councils or the Technology Strategy Board.

11.4 **Model Methodology -** the model methodology therefore entails a number of judgements about how electricity is used by householders, business and industry today – and equally so in looking forward to 2025.

11.5 **Model Results – 2010.** The modelling results suggest immediate technical scope for:

- **Demand reduction** - through forthcoming efficiency improvements – for example especially in respect of lighting (in particular commercial but also domestic) industrial motors and compressors.

- **Demand shifting –** not just at winter peak - but also at morning peak. In particular, by shifting day-time electric heat; water heating; and domestic wet appliances.

11.6 **Model Results – 2025.** The modelling results for 2025 - under a 'business-as-usual' scenario and a 'green' scenario – suggest that:

- **New load** – highly dependent upon developments in: heat; electric vehicles; economic growth and demographic factors.

- **Demand reduction 2025** - will continue to be driven by product regulation – and that the policy priority accorded to energy efficiency will be a central driver. The difference in overall demand between scenario 1 and scenario 2 illustrates the likely impact that demand reduction policies might achieve i.e. up to 50 TWh – i.e. up to one-sixth of all 2010 demand.

- **Demand shifting 2025** – at evening peak under either scenario, the main sources of flexibility to offer technical scope for load-shifting are likely to remain those already identified for 2010. A significant new source of demand-side flexibility at evening peak may be from Electric Vehicles – particularly under a high-efficiency scenario – and will depend upon incentives to shift. In a high efficiency scenario, if heat pumps replace other forms of electrical space and water heating to any major extent, and given assumptions made for this model about possible heat pump operation, then the potential for demand shifting from the domestic and commercial sectors at other times of the day outside the evening peak (including at morning peak) could be static or reduce.

12 Next steps

12.1 As the GB Electricity Demand project proceeds, we hope that it will be possible to develop and improve upon both the model methodology and model inputs, including further inputs from:

- The project Sponsor Group and Smart Demand Forum members.
- The DECC/Ofgem Smart Grids Forum scenario analysis – due spring 2012.

12.2 Responsibility for the model and its initial results rests with the Brattle Group and Sustainability First. Feedback on the initial modelling approach, inputs and assumptions are sought - serena.hesmondhalgh@brattle.co.uk.

12.3 In making this initial model available for wider use, we hope that this will help (1) to further critique and inform the methodology and thereby help improve the model and (2) enable those with an interest to develop and adapt the model for their own purposes.

Improving model inputs

12.4 Sustainability First and Brattle anticipate that in the year to come, model inputs will be developed and improved by additional material which is currently work in progress as follows:

- Household data – Sustainability First; EST Home Electricity Study; LCNF projects; Research Councils' projects.
- Commercial data – Ofgem.
- Industry data – Sustainability First; DECC.
- Incorporating new 2025 projections – based on DECC 4th Carbon Plan; Smart Grids Forum scenarios analysis (due Spring 2012).

The Brattle Group
Sustainability First

February 2012

Annex 1: Further details of the key data sources.

This annex draws from a separate note produced for Sustainability First on DECC Electricity Data Sources by Richard Hoggett [39].

A1.1. An outline of the information found on data sources for this model is as follows:

- **DECC DUKES data on electricity consumption across sectors.** The high-level split between industry, services, domestic and 'other' is based on actual survey returns from Major Power Producers and Electricity Suppliers to DECC.

- **DECC DUKES data on industry electricity use.** Based on annual sales information provided by electricity suppliers to DECC, DUKES provides information on electricity consumption by industry subsector across 12 subsectors[40].

- **Energy Consumption in the UK (ECUK)** provides electricity consumption data at a more disaggregated level (at 2-digit Standard Industry Classification code, for 26 subsector categories). This is based on secondary analysis of DUKES data and historic data from the Office for National Statistics Purchase Inquiry.

- Historically (until 2006) the Office for National Statistics as part of its Annual Business Inquiry carried out a Purchase Inquiry survey, sampling around 6,000 firms regarding the amounts spent on different fuels. The data from this was re-scaled to reflect estimated levels of expenditure on energy at the UK level by re-weighting the sample by the number of enterprises operating within each of the relevant SIC sectors. This allowed DECC to provide disaggregated electricity consumption data at the 4-digit (more disaggregated) SIC level.

  However, the ONS Purchase Inquiry was last carried out in 2006. The 2006 ONS PI data was used with 2007 overall recorded data, but has not been used since (due to changes in economic circumstances it was not considered appropriate to use 2006 ONS PI data with 2008 & 2009 overall data). Since then DECC have provided data at the higher level 2 digit SIC code-level, offering a more generalised picture of UK industry electricity consumption than before[41].

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[39] 'DECC Electricity Data Sources' (2012) Richard Hoggett, Associate Research Fellow, Energy Policy Group, University of Exeter. Available from: http://www.sustainabilityfirst.org.uk/gbelec_documents.html

[40] The subsectors are: Iron and steel; Non-ferrous metals; Mineral products; Chemicals; Mechanical engineering etc.; Electrical engineering etc.; Vehicles; Food, beverages etc.; Textiles & leather; Paper & printing Other industries; Construction.

[41] It is not clear however what data underlies / supports the analysis providing electricity consumption at the 2-digit SIC code, other than the information provided by Electricity Suppliers to DECC through monthly & annual surveys – data which is not disaggregated fully at the 2-digit SIC code level.

- **Energy Consumption in the UK also provides industry electricity consumption by end-use** (split across industry processes), based on secondary analysis of data from the ONS and BRE[42]- i.e. this is modelled rather than actual data.

- **Energy Trends Quarterly Updates.** High-level actual consumption data by key economic sector – industry, services, domestic and other. Additional end-use split by heat, lighting, appliances, process uses etc. – is modelled, based on end uses originating from historic survey information (further information pending). DECC have confirmed that all quarterly data, including Energy Trends Quarterly Updates is reconciled with Annual Data, and Annual Data takes precedence.

- **DECC DUKES data on commercial electricity use** (**e.g. broken down by public admin, commercial, agriculture, etc.).** Electricity consumption across the commercial sector is obtained from the annual returns from electricity suppliers.

- The following SIC headline codes are used for the service sector:
    - Wholesale and retail distribution (SIC codes 45 and 47).
    - Insurance, banks, offices (SIC codes).
    - Hotels and restaurants.
    - Combined domestic and commercial premises.

Other SIC codes of relevance to the service sector appear to include:
- Post and telecommunications.
- Agriculture.
- Public lighting sector.
- Public administration.
- Other sectors construction.

- **Commercial electricity consumption by end-use** is modelled based on BRE models[43].

- **Domestic Consumption –** DUKES July 2011. Consumption data is **actual data** derived from the annual survey that DECC carry out with Energy Suppliers. This feeds into tables 5.1 to 5.3 in DUKES. Table 5.3 splits domestic consumption by: standard; economy 7 and other off-peak; standard pre-payment; off-peak pre-payment.

- **Domestic Consumption by Appliance –** Disaggregated data by end-use within the domestic sector (space heating, water, cooking and lights/appliances) is **modelled data**, obtained from BRE, Market Transformation Programme (MTP) and Cambridge Architecture Research (CAR) models. (e.g. DECC. Energy Consumption in the UK. Domestic Data Tables 2011. Table 3.7, Table 3.10).

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[42] Unfortunately we have not been able to clarify with BRE the details regarding this historic survey information (date and contents of the survey).
[43] Unfortunately we have not been able to clarify with BRE the basis of the modelling carried out for DECC.

- The Building Research Establishment appliance-stock / ownership models are the major data source on household electrical appliance ownership, likely usage (i.e. numbers of hours per week etc.). BRE data makes no estimates regarding usage at times-of-day or times-of-the year for household appliances. The BRE modelling feeds into the work of the Market Transformation Programme and into DECCs annual 'Energy Consumption in the UK'. Other than the Load Research Group, there is therefore very limited actual usage data available. Data from the Load Research Group is anyway historic (10-15 years old). In March 2012, EST, DECC and DEFRA may publish their Home Electricity Study 2010-11, which will include empirical data on electrical appliance use[44]. Until then, the BRE / MTP modelled data currently remains the best available GB data on household electricity end-use.

[44] The Elephant in the Living Room – how our appliances and gadgets are trampling the green dream'. Energy Saving Trust. September 2011. page.7 refers to a forthcoming joint EST, DECC and DEFRA study 'The Home Electricity Study 2010-11'. This is understood to be due for publication in March 2012.

The Home Electricity Study 'took detailed measurements of about 90% of the domestic energy use in 240 monitored households across the demographic spectrum. Of these, 60 were monitored for a year. The aim of the study was to provide reliable data on all electrical appliances in the home (including kitchen goods, lighting computers) – especially products, and consumption patterns that have significant impact on peak electricity demand – to enable more accurate projections of expected future use'.

Annex 2: Estimating off-peak demand in the commercial and domestic sectors.

A2.1 For the model, the percentage split between off-peak (midnight to 06.00h) and peak-time consumption for electric space heating was calculated as follows.

- The overall level of space heating in the domestic and commercial sectors was determined by applying the DUKES 2009 breakdowns by end-use, to the Energy Trends 2010/11 quarterly demand data – 117 TWh for domestic, 100 TWh for commercial (other final uses).

- An estimate for off-peak electricity-use for space heating was derived from:

  - The total sectoral electricity demand from Energy Trends.
  - The percentage of total annualised sectoral electricity demand data accounted for by the relevant Load Profile with switching.
  - An estimate of the percentage of demand in the switching Load Profiles accounted for by 'switched' demand (source - Elexon).

- By multiplying these three figures together, as shown in the table below, we estimated the total switched demand in the domestic and commercial sectors.

- To derive an estimate for the switched demand associated with space heating, we assumed that (a) the switched demand in August did not include any space heating and (b) that the level of demand for end uses other than space heating remains constant in each month. These assumptions enable us to deduct an allowance for other end uses from the switched demand estimate to arrive at an estimate for switched space heating demand.

			Domestic	Commercial
2010/11 sectoral demand (TWh)	[1]	Energy Trends	118,681	101,238
% sectoral demand in LP with switching	[2]	Elexon	25.26%	22.54%
% demand in LP switched	[3]	Elexon	35%	26%
Switched demand (TWh)	[4]	[1]x[2]x[3]	10,493	5,932
Switched demand in August (TWh)	[5]	Elexon	233	101
Assumed annual switched demand not for space heating (TWh)	[6]	[5]x365/31	2,741	1,191
Assumed switched space heating demand	[7]	[4]-[6]	7,752	4,742
Switched space heating demand as percentage sectoral demand	[8]	[7]/[1]	7%	5%

Table 12 Estimating total switched demand in domestic and industrial sectors

Annex 3: Details of 2025 scenario assumptions

End use	2010 modelled	Scen 1 2010	Scen 1 2025	Scen 2 2010	Scen 2 2025	Source (2050 Pathways calculator)
Domestic space heating and hot water		34	43	69	83	
Air source heat pump - heating					12	IXa 538/Ixa 136
Ground source heat pump - heating					5	IXa 539/Ixa 137
Resistive heating - heating		22	26	47	41	IXa 529/Ixa 131
Resistive heating - hot water		11	15	22	16	IXa 463/Ixa 149
Air source heat pump - hot water					7	IXa 468/Ixa 154
Ground source heat pump - hot water					2	IXa 469/Ixa 155
Cooling		0	2			IXa570
Domestic lighting, appliances, and cooking		87	93	70	60	
Cooking		14	14	14	16	Xa 71
Lighting and appliances		74	80	56	44	Xa 80
Domestic total		121	136	139	142	
Heat pumps		0%	0%	0%	18%	
Other heating	14%	18%	19%	34%	28%	
Other hot water	6%	9%	11%	16%	11%	
Cooking	5%	11%	10%	10%	11%	
Lighting and appliances	75%	61%	58%	40%	31%	
Cooling		0%	1%	0%	0%	
Check	100%	100%	100%	100%	100%	
Commercial heating and cooling		31	32	28	30	
Resistive - heating		15	13	15	10	IXc237/Ixc 97
Air source heat pump - heating					7	IXc242/Ixc 102
Ground source heat pump - heating					3	IXc243/Ixc 103
Resistive heating - hot water		3	3	3	2	IXc205/Ixc 115
Air source heat pump - hot water					2	IXc210/Ixc 120
Ground source heat pump - hot water					1	IXc211/Ixc 121
Cooling		13	17	10	6	IXc288
Commercial lighting, appliances, and catering		73	80	72	65	
Cooking		13	14	14.0	15.4	Xa 64
Lighting and appliances		60	66	58.4	49.2	Xa 71
Agriculture		4	4	4	4	VIa390
Commercial total		109	116	104	99	
Heat pumps		0%	0%	0%	13%	
Other heating	14%	14%	11%	14%	10%	
Other hot water	3%	3%	2%	3%	2%	
Cooking	13%	12%	12%	13%	16%	
Lighting and appliances	58%	55%	57%	56%	50%	
Cooling	9%	12%	14%	10%	6%	
Agriculture	4%	4%	4%	4%	4%	
Check	100%	100%	100%	100%	100%	
Industrial processes		118	144	115	113	Intermediate output 306
Domestic passenger transport		-	2.77	-	19.188	
Car ICE			2		12	XIIa 284
Car PHEV			0		7	XIIa 285
Bus EV					0	XIIa 290
Summary						
Domestic		121	136	139	142	
Commercial		109	116	104	99	
Industry		118	144	115	113	
Transport		-	3	-	19	

Table 13 Details of 2025 scenario assumptions. Source: DECC 2050 Pathways calculator

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.

 Its projects are developed by the trustees and a number of associates and consultants.

Sustainability *First*'s associates are: Gill Owen and Judith Ward. Maria Pooley is Sustainability *First*'s research officer.

Sustainability *First* is a registered charity number 107899.

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Sustainability *First*