Energy Policy 61 (2013) 301–305

Contents lists available at ScienceDirect

Energy Policy

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

Communication

# Historical daily gas and electrical energy flows through Great Britain's transmission networks and the decarbonisation of domestic heat ☆

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ARTICLE INFO

*Article history:*
Received 28 May 2012
Accepted 27 May 2013
Available online 20 June 2013

*Keywords:*
Energy system balancing
Heat storage
Electrification of heat

ABSTRACT

Publically available data is presented comparing recent historical daily energy flows through Great Britain's electrical and gas transmission networks with a focus on domestic heat and hot water. When this data is expressed graphically it illustrates important differences in the characteristics of the gas and electricity demand; these include the quantity of energy delivered through the networks on a daily basis, the scale of variability in the gas demand over multiple timescales (seasonal, weekly and daily) and the relative stability and predictability of the electrical demand. As the United Kingdom proceeds to migrate heating demands to the electrical network in its drive to cut carbon emissions, electrical demand will increase, but equally importantly the variability and uncertainty shown in the gas demand will also migrate to the electrical demand, which suggests both technical challenges and opportunities for management of future energy networks.



## 1. Introduction

This communication presents historical daily energy flows through Great Britain's electrical and gas transmission networks illustrating the significant differences in the demand characteristics of these two main energy vectors. Of particular note are the differences in temporal variability and magnitude. On a daily basis the total gas demand can be approximately four times the electrical demand in winter; gas demand also exhibits significantly higher volatility. Conversely, daily electrical demand is more predictable and less subject to seasonal variation. These differences have profound implications when considering the potential transfer of heat demands from the gas network to the electrical network in order to 'decarbonise heat' as envisaged in the UK Climate Change ACT (UKCCA, 2008). The data analysed spans the period from October 2010 to January 2013.

## 2. UK policy background

The UK Climate Change Act set forth legally binding targets to reduce UK greenhouse gas emissions to 20% of their 1990 levels by 2050. The 2011 Carbon Plan states 'By 2050, electricity supply will need to be almost completely decarbonised' (DECCa, 2011). It is anticipated that electrical supply decarbonisation will be achieved by deploying a wide range of low-carbon technologies such as renewables, sustainable biomass, nuclear, and fossil-fuels with carbon capture and storage. In parallel, the UK has also adopted a range of policies aimed at reducing energy demand, including a radical strengthening of building regulations (DCLG, 2012) and decarbonisation of the energy required for heating. The area of low-carbon heat is justly receiving increased attention, as evidenced by reports from the Department of Energy and Climate Change (DECCb, 2013) and the Royal Academy of Engineering (RAEng, 2012).

## 3. UK heating and hot water demand

UK energy consumption in 2011 for space heating and hot water for all sectors (domestic, service and industry) was provisionally 497 TWh (ECONUKa, 2012). Energy used for domestic space heating and hot water accounts for the majority of this total (354 TWh). By comparison, the overall final energy consumed for



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http://dx.doi.org/10.1016/j.enpol.2013.05.110

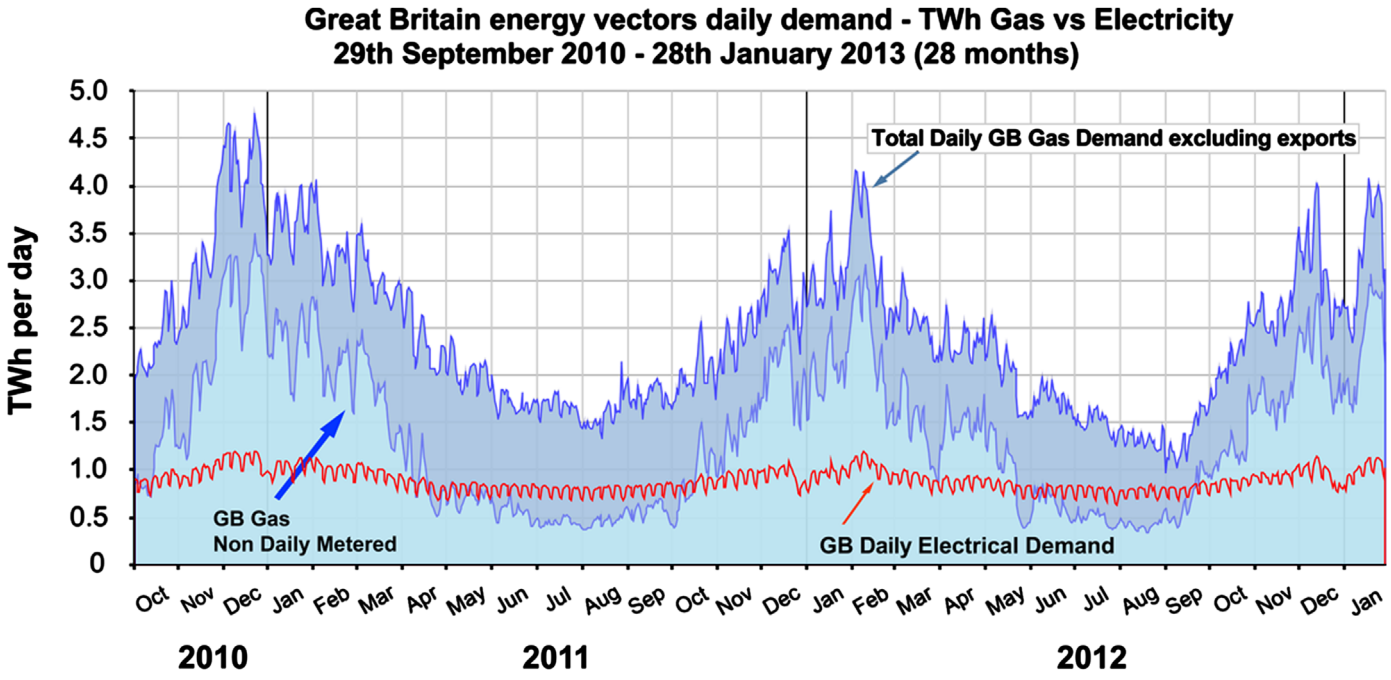


**Fig. 1.** Daily GB Gas and Electricity Demands (TWh). Data sourced from National Grid website (NGDIE, 2013; MHHED, 2013).

ALL sectors for electricity in 2011 was 318 TWh (ECONUKb, 2012). The vast bulk of the energy needed to meet UK domestic space heating and hot water demands is provided by the combustion of natural gas (286 TWh), with the balance met using electricity (20 TWh), heating oil (31 TWh), solid fuels (9 TWh), bioenergy and waste (7 TWh), heat sold (1 TWh), solar thermal or indeed a combination of these (ECONUKa, 2012).

Tackling overall energy use and emissions associated with domestic heating and hot water therefore has to be an integral part of the UK's decarbonisation strategy. Effectively, decarbonisation of domestic heating requires that a major part of space and water heating energy demands be transferred over from the natural gas network to the electrical network.

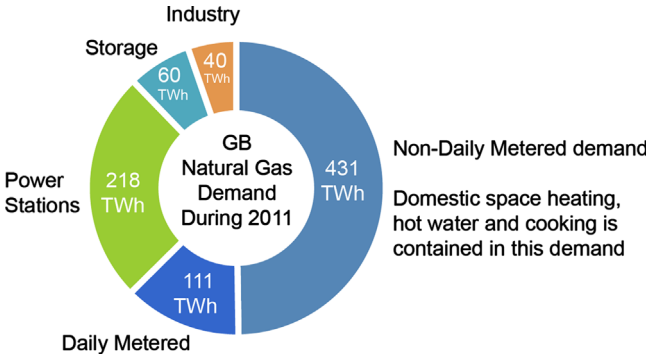


**Fig. 2.** Breakdown of 2011 UK gas total demand by component (excluding exports). Data sourced from National Grid website.

## 4. Daily gas and electrical demand

In order to explore the variation in gas demands over time, gas data from the National Grid's data explorer (NGDIE, 2013) was chosen due to its public availability and granularity of a single day.

Fig. 1 uses this data to show Great Britain's (GB) daily gas demand in Terawatt hours for natural gas through the national transmission system. This TWh/day total includes gas to power stations, industry, storage and the daily and non-daily metered demands, but excludes exports.

Fig. 1 also shows the non-daily metered (NDM) component of this total daily gas demand, and the total amount of energy delivered through the UK's electrical system over the same period [1].

The non-daily metered (NDM) component of the total GB gas demand is comprised of gas meters that are not measured on a daily basis, *e.g.* domestic, small business, and a proportion of commercial, public administration, agricultural and even some industrial facilities. However, gas for domestic space heating, hot water and cooking is the major part of the NDM component.

Fig. 1 shows the very different characteristics of gas and electricity demand. In winter, the NDM gas demand alone can be up to three times the total electrical demand, whilst dropping below electricity in summer. In addition to seasonal variability, the gas demand also shows striking shorter-term daily and weekly volatility linked to weather conditions and the resulting requirement for heat. The NDM component is the largest source of the seasonal variation of the total gas demand, *e.g.* the 2011 daily values ranged between 0.368 TWh/day and 3.49 TWh/day. In contrast, the daily electrical demand shows a seasonal variation between 0.675 TWh/day and 1.2 TWh/day. It is also noteworthy that over two contrasting winters of 2010 and 2011 covered by Fig. 1, which were cold and mild respectively, the peak values were broadly similar although their timing was not.

It is important to note that NDM gas flows are not constant throughout a day but are instead concentrated in the morning and evening, when space heating and hot water demands are highest (Buswell et al., 2013; Sansom, 2013). Analysis of sub-daily gas demand data would show even greater variability of the gas demand than shown in Fig. 1, and it would prove useful to further compare and contrast with sub-daily electrical data. However, national sub-daily gas demand data are not readily available for the UK.

[1] The daily electrical data is aggregated from the half hourly demand data (termed IO14_TGSD) also from National Grid (MHHED, 2013).