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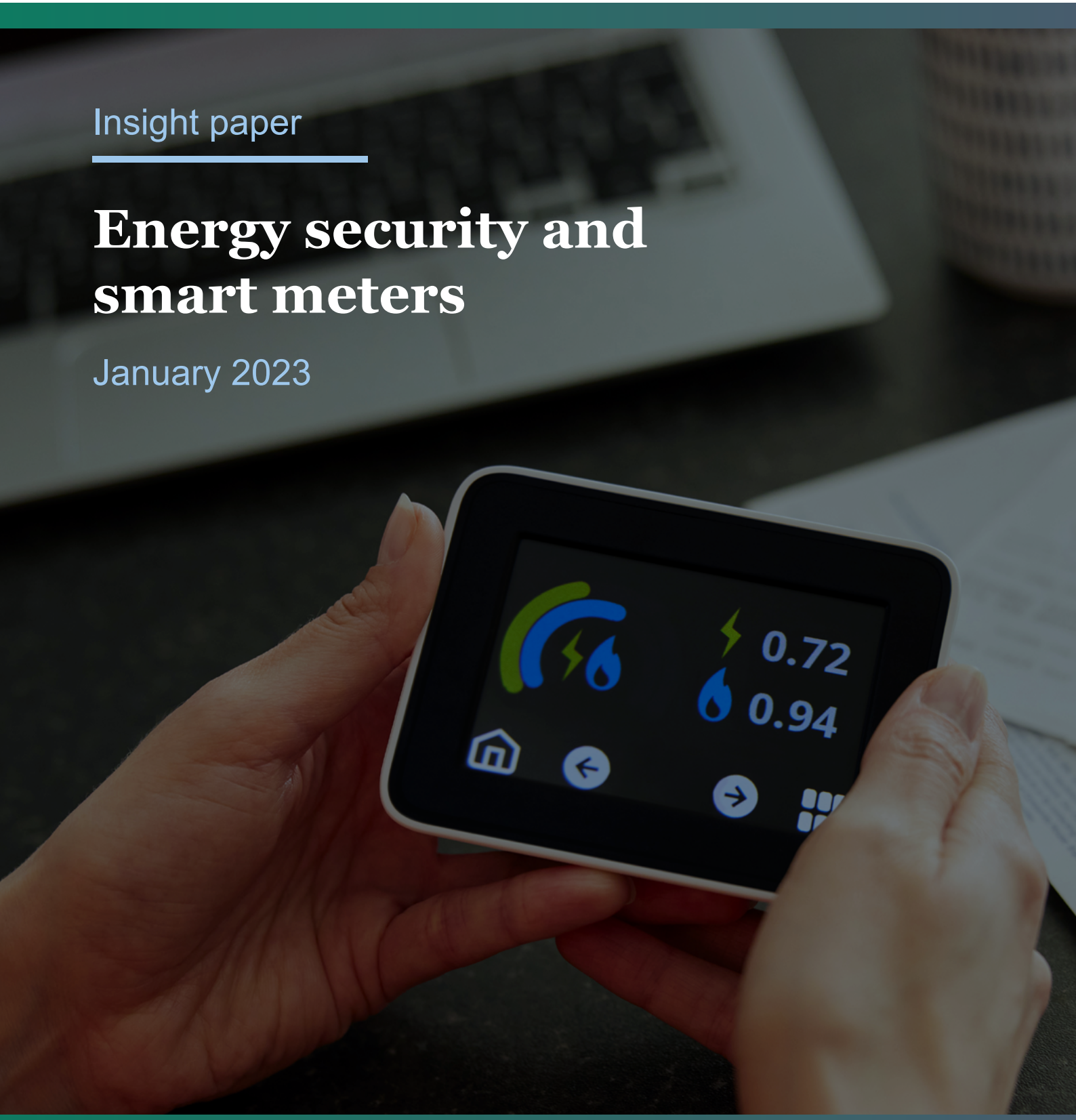
Insight paper

Energy security and smart meters

January 2023



www.smartenergygb.org

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About Cornwall Insight

Getting to grips with the intricacies embedded in energy and water markets can be a daunting task.

There is a wealth of information to help you keep up-to-date with the latest developments, but finding what you are looking for and understanding the impact for your business can be tough. That's where Cornwall Insight comes in, providing independent and objective expertise.

You can ensure your business stays ahead of the game by taking advantage of our:

- Publications – Covering the full breadth of the GB energy industry, our reports and publications will help you keep pace with the fast moving, complex and multi-faceted markets by collating all the "must-know" developments and breaking-down complex topics
- Market research and insight – Providing you with comprehensive appraisals of the energy landscape helping you track, understand and respond to industry developments; effectively budget for fluctuating costs and charges; and understand the best route to market for your power
- Training, events and forums – From new starters to industry veterans, our training courses will ensure your team has the right knowledge and skills to support your business growth ambitions
- Consultancy – Energy market knowledge and expertise utilised to provide you with a deep insight to help you prove your business strategies are viable
- Research – Creating new knowledge and insight in markets that are rapidly evolving, leveraging our in-depth knowledge and expertise in the energy sector to design thought leadership campaigns to suit your needs.

For more information about us and our services contact us at 01603 604400 or enquiries@cornwall-insight.com

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1. About the report

This paper is independent research commissioned by Smart Energy GB and undertaken by Cornwall Insight. It explores the role of smart meters in supporting energy security in Great Britain (GB). The report is intended to support Smart Energy GB's broader campaign to help consumers understand the benefits of smart meters for people and the environment.

The publicly available data sources used to develop this report reference the energy markets in both the UK and in Great Britain. As noted above, the analytical scope of this report is specific to the GB market, with references to other geographic markets reflecting the segmentations used in the available underlying data sets.

Through this report, we have explored two key ways households and their smart meters can support GB's energy security:

- By reducing overall energy consumption where they are able to do so
- By increasing flexibility to manage electricity consumption through the day, shifting some usage to times where demand is lower and times when more renewable generation can be used

We have also addressed some of the market enablers that will support the transition to a smarter, more flexible electricity system, including smart meters and Time of Use tariffs.

2. Summary

The International Energy Agency (IEA) defines energy security as "the uninterrupted availability of energy sources at an affordable price"[1]. This means having access to uninterrupted and continuous energy provision, which is unaffected by, or able to respond to short-term changes in supply and demand. When the national energy supply is not secure, it can be impacted by international disruptions and shortages, leading to price hikes and an increased possibility for blackouts and gas shortages. Smart meters have the potential to play a critical role in energy security, providing near real-time information and empowering consumers to change how much and when they use energy. If consumers reduce or shift their energy consumption, this in turn supports energy security through reducing reliance on imports and facilitating more renewable generation.

Currently, a large share of the energy consumed in Great Britain comes from fossil fuels imported from other countries. While just under 40% of electricity generated in GB comes from renewable sources, just over 40% is generated using gas[2]. More than half of the gas used in Britain is imported. The largest proportion of gas comes from Norway, delivered by pipeline connecting the Britain to Norwegian gas fields in the North Sea[3]. Around one fifth is delivered in the form of Liquified Natural Gas (LNG), which in 2021 came mostly from Qatar (38.8%) and the USA (26.5%)[4].

Households directly consume around a third of all gas used each year[5]. Gas is the primary fuel used for heating and cooking for the majority of consumers, with around 80% of homes connected to the mains gas network. Gas is also used to generate electricity, representing around 30% of all gas used each year[6].

Similarly, households use around a third of GB's electricity each year. They contribute to the daily peaks in electricity demand, which occur on weekdays, usually between 4pm and 7pm when there is a crossover between industrial, commercial and household usage. Times of peak demand are often linked to an increase in fossil fuel generated electricity. As these fuels are more expensive than others, this increases the cost of wholesale electricity at peak times, which is factored into the price set by the energy supplier.

Smart meters are likely to be a key enabling tool for helping customers to move their consumption away from times of peak demand. Using the half hourly data from smart meters, customers can be rewarded for reducing their use of electricity and gas at certain times, in a way that would not be possible with a traditional meter.

By reducing overall consumption of electricity and gas (where possible), consumers can support energy security by reducing the need to operate some of the country's most carbon-intensive generating stations. In the round, lower demand for gas will reduce our reliance on imported gas for our heating, and for the gas used to generate electricity.

1 IEA, Energy Security
2 BEIS, DUKES data
3 National Grid ESO, Future Energy Scenarios data
4 BEIS, DUKES data
5 BEIS, Energy Trends data
6 BEIS, Energy Trends data

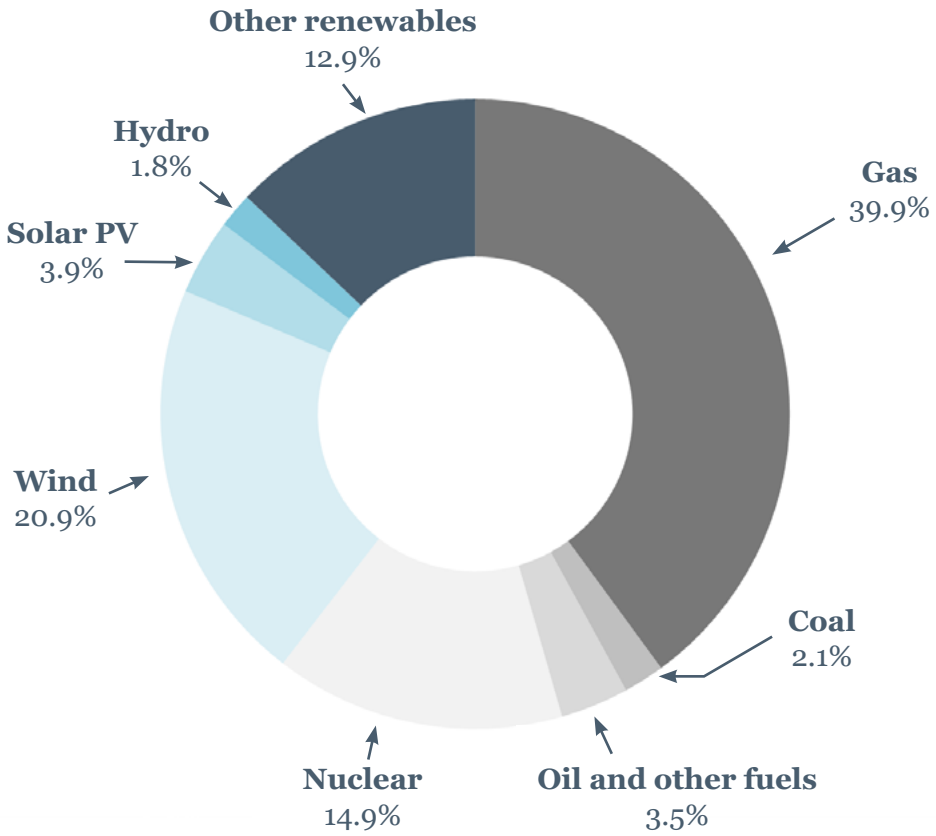
To understand a real-time view of their own energy consumption and costs, households can refer to the visual in-home display (IHD) on their smart meter. Consumers can use this information to manage their energy costs, by taking action to reduce their overall consumption or by moving their energy use to different times of day. This may enable consumers to save money, reduce emissions, and reduce reliance on imported energy, which means that households can play a vital role in delivering energy security.

3. Where does our energy come from?

3.1 Where is our electricity from?

In the UK, electricity is primarily sourced from four different generation sources – gas, renewables and nuclear, as shown in Figures 1 and 2. The use of these fuels is determined by several factors, including price (influenced by fuel costs, global markets, and the balance of supply and demand amongst other drivers),weather (influences ability to generate and level of demand), and policy (some of our policies drive us towards low-carbon fuels for electricity generation).

Figure 1: UK's Electricity Generation Fuels in 2021, by volume



Source: Cornwall Insight from DUKES data

Figure 2: Overview of electricity generation types in the UK

Gas

With 40 power plants in operation in the UK today, gas is the main fuel source used for our electricity generation, accounting for roughly 40% of the mix. The UK obtains most of its gas from the UK continental shelf (UKCS) and natural gas imports from Norway via pipelines. We discuss gas sources further in section 3.2.

Renewables

Renewable electricity sources are natural resources which have an infinite supply – such as the wind and the sun – and can be utilised to generate electricity. Renewables account for a similar amount of our electricity fuel mix as gas at just under 40%. More than half of this comes from offshore and onshore wind turbines which harness the wind to produce electricity. 14.4% comes collectively from solar photovoltaics, which convert light energy into electricity, and hydroelectric power assets which use the movement of water for electricity.

Nuclear

Electricity produced by nuclear-powered generators accounts for around 15% of the generation mix. There are currently nine reactors operating across four sites in Great Britain at Hartlepool, Heysham and Sizewell in England, and Torness in Scotland. There are also two reactors in the process of construction at Hinkley Point in Somerset, and two planned at Sizewell in Suffolk, which could support the government's ambition to increase nuclear generation to roughly 25% of GB's electricity fuel mix by 2050.[7]

Coal, oil, and other fuels

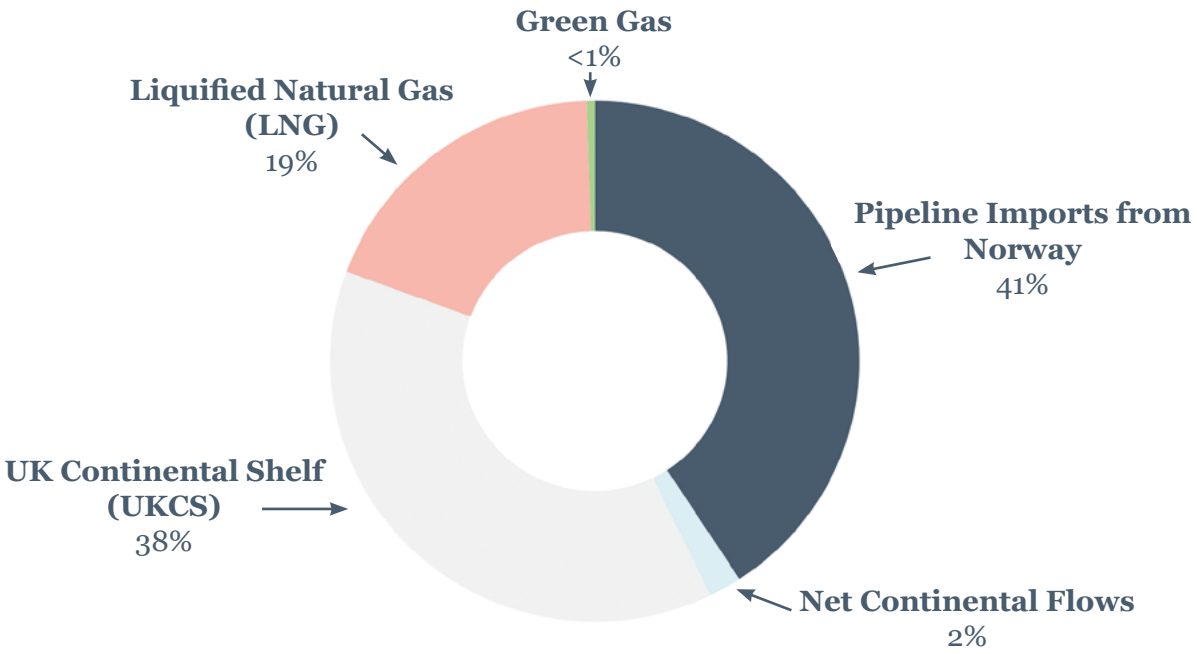
Coal, oil, and other fuels, including electricity generated from pumped storage, accounts for roughly 7% of the UK's electricity generation. There are three main coal-powered sites which remain in operation in the UK, although coal is typically used very little. These sites are due to close by the end of 2024, in line with the UK's ambition to decarbonise the electricity sector. However, through the winter of 2022 additional contracts have been put in place with GB-based coal-fired generators to ensure security of supply. A new coal mine has also been approved in Cumbria to support steel making.

7 BEIS, British Energy Security Strategy

3.2 Where is our gas from?

The UK is a major user of gas, with most homes heated by mains gas supply. Gas also fuels over a third of the UK's electricity generation[8]. Our gas comes from five main sources (see Figure 5), the largest of which are pipeline imports from Norway and Europe, the UK Continental Shelf (UKCS) and liquid natural gas (LNG) imports, as shown in Figure 3.

Figure 3: UK's Gas Supply Sources in 2021



Source: Cornwall Insight from National Grid ESO Future Energy Scenarios data

Figure 4: Breakdown of UK's Liquified Natural Gas Sources in 2021

Source: Cornwall Insight from DUKES data

8 National Grid ESO Future Emission Scenarios, FES 2022 Workbook,(2022)

Figure 5: Overview of UK gas sources

Pipeline imports

The UK's gas system is physically linked to Norway, the Netherlands, and Belgium.

From Norway
Imports of natural gas from Norway account for around 40% of gas supply, the largest proportion in our fuel mix. The Langeled pipeline (also known as Britpipe) is the main pipeline for transporting Norwegian natural gas. There are also four other pipelines which connect the UK to Norwegian gas fields in the North Sea.

Other Continental Flows
Smaller quantities of natural gas are derived from continental flow imports via pipelines, principally from Belgium and the Netherlands. Another key pipeline runs between Scotland and Northern Ireland (NI) which transports gas between GB and NI.

UK Continental Shelf (UKCS)

The UKCS provides around 38% of gas consumed in GB, coming from a section of water surrounding the UK where mineral rights are claimed. The region comprises parts of the North Sea, North Atlantic, Irish Sea and English Channel. Five further pipelines serve the UK from the UKCS including the CATS and SEAL pipelines to England and the Frigg UK System (FUKA), Fulmar Gas Line and the Vesterled pipelines to Scotland. The UKCS is mature, since much of its resources have been used, creating the expectation of an increase in the UK's reliance on gas imports in the future.

Liquified Natural Gas (LNG)

Liquefying gas enables the fuel to be easily transported across larger distances by ship, and accounts for roughly one fifth of our gas supply. Last year the UK sourced its LNG from nine countries[9], primarily from Qatar with smaller volumes from the USA and Russia as shown in Figure 4. The UK has since ceased imports of Russian LNG, with the last cargo arriving in March 2022[10]. Instead, the UK has increased imports of LNG from other countries and provided gas via pipeline to continental Europe.

Gas Storage

Gas is a commodity that can be kept and stored for indefinite periods, often held in underground gas storage facilities. Gas is typically stored when the price is low and withdrawn at times of high price and/or high demand. Compared to other European nations, the UK has a relatively small capacity to store gas following the closure of its largest gas facility Rough storage in 2017. However, this facility has been partially reopened since October 2022 to boost the UK's gas supply over winter 2022-23.

9 BEIS DUKES, Dukes 4.5: Natural Gas Imports and Exports, (July 2022)
10 BEIS, Energy Trends: April to July 2022, (September 2022)

4. Where is energy consumed?

4.1 Sector consumption of electricity and gas

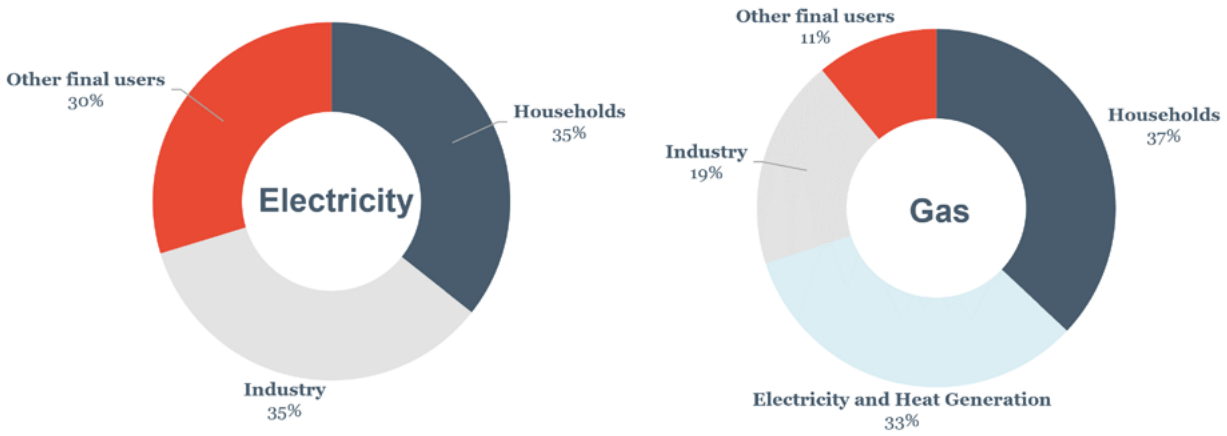
Figure 6 shows that households consume around 36% of electricity used across the UK. Similar proportions of electricity are used by the industrial sector and other final users, in office and commercial settings, with a small amount used by the transport sector. Around 37% of gas consumed in the UK is used by households[11], with 23 million homes heated by mains gas supply[12]. The rest of the UK's gas is used for heat and electricity generation, or consumed by industry and other final users, including commercial and office use, and transport.

Since 2010, household consumption of electricity and gas has decreased by similar proportions, falling by 13.9% and 11.5% respectively[13]. This decrease reflects a number of changes, including improved energy efficiency in appliances, lighting and heating, as well as price responses where consumers have used less energy in the face of rising costs.

Our future electricity consumption is set to shift direction again as we take steps to meet the country's Net Zero target by 2050. Many of the options for decarbonisation involve electrification, for example electric vehicles for transport or heat pumps for domestic heating.

Reducing consumption from today's baseline will support the transition to decarbonisation, making it more likely that new renewable generation assets built in GB are sufficient to meet rising demand from new electricity use cases. Household engagement in demand flexibility, enabled by smart meters and Time of Use tariffs, could be important to help mitigate the increase in peak residential electricity demand.

Figure 6: UK's Electricity and Gas Consumption by Sector in 2021, excluding losses



Source: Cornwall Insight from BEIS data

Source: Cornwall Insight from BEIS data

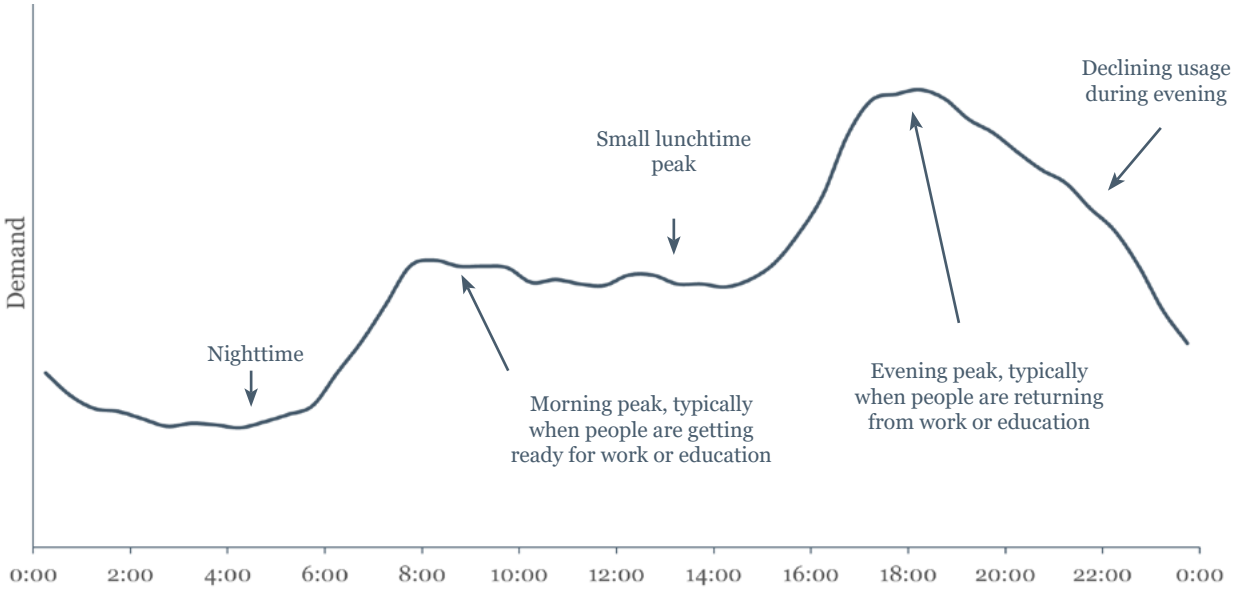
11 BEIS DUKES, Dukes 4.1: Natural Gas commodity balances, (July 2022)
12 Committee on Climate Change, Annex 2: Heat in UK buildings today, (January 2017)
13 BEIS, Energy Follow Up Survey: Household Energy Consumption & Affordability, (2021)

5. The role of smart meters in supporting energy security

5.1 The benefits of flexibility

Electricity use is usually highest during the evening, with the peak typically occurring between 4pm and 7pm. This is typically when large numbers of people are returning home and starting to use electricity, while there is some crossover with continuing commercial use. Looking specifically at the household consumption, Figure 7 shows an example of the pattern of electricity consumption over the course of a day for a typical household[14].

Figure 7: Illustrative view of typical daily household electricity usage for a dual fuel household



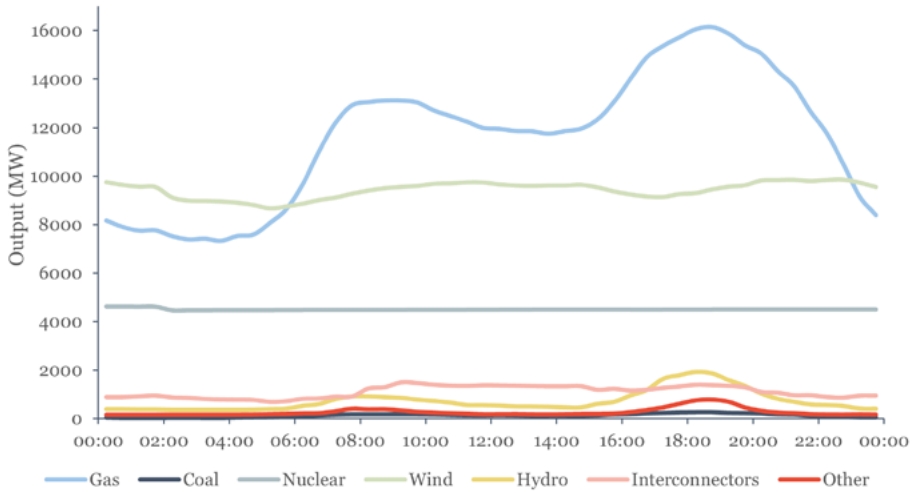
Source: adapted from Elexon

Meeting peak demand often requires the increased use of fossil fuelled generation. While renewables and low carbon generators have relatively low costs to run and usually operate when they can, other generators require fuel, meaning that the most expensive fuelled generators are only dispatched when needed to meet peak demand. Due to their reliance on a fuel, the costs of generating are impacted by global commodity costs. For example if the price of gas prises, the cost of generating electricity by burning gas also goes up.

In Britain, gas fired generation tends to be used to meet peak demand and when wind generation is low. Figure 8 shows the average mix of generation on the transmission network by time of day for October 2022. This shows gas-fired generation increasing during the day in line with consumption, with notable peaks during the morning and evening.

14 A typical household here is assumed to have a direct connection to the electricity network and direct connection to the gas network, with the latter used to meet heating requirements

Figure 8: Average transmission-connected generation output by fuel type, over October 2022



Note: Data does not include generation connected to the distribution network or generation without operational meters. As such renewables outturn values will be under reported.

Source: Cornwall Insight from Elexon data

The UK government's 2021 Smart System and Flexibility Plan sets out how we will transition to a smart, flexible decarbonised energy system[15]. It highlights the numerous ways that greater flexibility, enabled for households via smart meters, drives forward our energy independence and decarbonisation:

"Flexibility is essential for cost-effective integration of renewable generation, while meeting increased demand from electrified heat and transport … Flexibility allows for generation and demand to be shifted to avoid curtailment and results in better utilisation of low carbon generation and less overbuilding of capacity. Flexibility also lowers the peak demand on the system, reducing network upgrade costs. … Without these low carbon flexibility assets, we risk either inadequate energy security or having to build more unabated gas in the same period. It will be very difficult to achieve the deep power sector decarbonisation needed to achieve the sixth Carbon Budget without significantly higher levels of system flexibility."

Household flexibility is enabled by smart meters, which are a key tool for helping customers to move their consumption away from times of peak demand. Using the half hourly data from smart meters, customers can be rewarded for reducing their use of electricity and gas at certain times, in a way that would not be possible with a traditional meter.

This kind of engagement in daily energy management is enabled by communication of pricing or energy trends. One way to realise this is through a Time of Use tariff. These offer different prices at different times of the day, in a similar manner to peak and off-peak transport tickets. With Time of Use tariffs, prices will typically be higher during the peak, and customers can be rewarded for shifting their demand to cheaper times. In practice, this could mean using appliances earlier or later in the day, in return for cheaper bills. Shifting or reducing electricity demand during peak times will also help to reduce the overall use of fossil fuels, as these generation sources are typically used to meet peak demand, when commercial, industrial, and household consumption occur at the same

15 BEIS, Smart Systems and Flexibility Plan

time. In the future, increased use of battery storage, electric vehicles, and automated controls could open up further opportunities, allowing consumers to store electricity or charge vehicles when prices are low and use the electricity when they rise.

While there are a limited number of these tariffs available to choose from today, smart meter data supports the creation of such a tariff by providing an energy supplier with a more granular level of information about electricity consumption patterns. Time of Use tariffs are voluntary, and customers will be able to move back to a more traditional tariff if they find it's not working for them, but savings should be available for those that can participate. While there is no obligation to move to a Time of Use tariff if you have a smart meter, customers won't be able to take advantage of the arrangements without one.

There are different types of Time of Use tariffs, including:

- Those with banded peak and off-peak rates that are fixed over the duration of the tariff, including:
  - Tariffs where the peak rate is typically close to, or not much more than a normal flat tariff rate, and the off-peak rate is lower
  - Tariffs where the peak rate is higher and the off-peak rate is significantly lower (typically aimed at those with flexible technologies like electric vehicles)
- Those with dynamic rates that change during the day and over the duration of the tariff
  - These typically track wholesale prices with peak rates and/or times set on the day before they come into effect

By facilitating customer flexibility via these Time of Use tariffs, smart meters could also be key to allowing customers to better align their consumption with generation from renewables. Currently, some wind farms are regularly paid to 'turn down' if they are producing more electricity than the national electricity network can transport to areas of high demand. Managing network constraints in this way is costly, combining the monetary payments made with the lost renewable electricity generation, which may have to be replaced with more carbon-intensive sources such as imported gas. Network constraints as a driver of generation turn down will likely reduce over time as additional network infrastructure is developed. But rapid rollout of renewables will instead mean there are times when, without flexibility, the amount of renewable generation available will exceed demand.

Smart meters are being used to incentivise customers to change their consumption patterns. This may involve increasing demand at times of high wind output, which could come from direct consumer actions, such as scheduling connected appliances, or by charging batteries or electric vehicles. This could reduce curtailment described above and increase utilisation, as well as allowing higher levels of renewable generation to be built and connected to the network by reducing imbalances in supply and demand that contribute to the network challenges faced.

Time of Use tariffs, enabled by smart meters, are also expected to unlock the benefits of other technologies such as solar panels, batteries, and electric vehicles. These include:

- Allowing customers to charge their vehicle or complete other more energy intensive

tasks, or be paid to charge via dynamic pricing and participation in flexibility services during cheaper times

- Selling back the electricity generated by their solar panels or stored in their batteries via products like the Smart Export Guarantee or dedicated flexibility services
- Coordinate their demand with local renewable generation to help more renewable electricity generation assets be built and used
- Being rewarded for reducing (or having a third-party manage) their electricity usage to support the wider network (see our case study below)

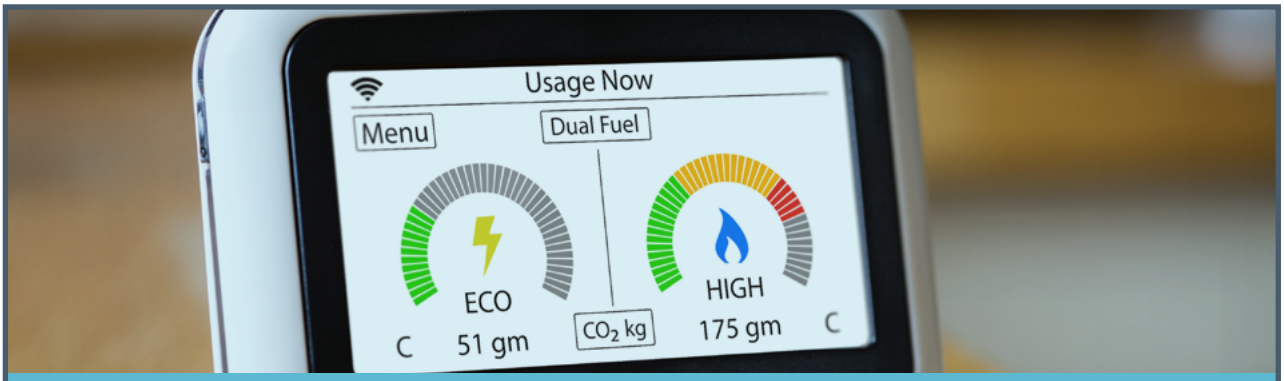
Many of the benefits above can be unlocked via smart meters by enabling products that do not need involvement of an energy supplier. For example, there are several apps available which can use the data collected from smart meters to offer additional insights into electricity consumption and the generation mix at the time. Both Time of Use tariff offerings and other products are expected to become more prevalent and diverse in the future. Many of these services are expected to utilise automation or pre-defined parameters that meet a customer's requirements, reducing or minimising involvement from the customer.

Case study: Scottish Power Energy Networks Flexibility Demand Shift Trial

In 2022 Scottish Power Energy Networks (SPEN) undertook the first trial of domestic demand shifting to support local network capabilities. The trial took place in Dumfries & Galloway and Ayrshire, an area of the distribution network that has a high level of constraints. The trial saw SPEN notifying Octopus Energy of six two-hour periods across six weeks where high generation output was forecast. Octopus Energy then notified around 2,500 participating customers the day before the period. Electricity usage from each household was monitored using their smart meter. Households that managed to increase their usage by more than 10% received all the electricity used during the period for free, with those using more than double their normal usage receiving additional money. Overall, the participating households managed to use 20MWh more electricity across the six two-hour periods, being rewarded with an average of £5 worth of free electricity and reducing constraints across the local distribution network.

Real-time electricity consumption management can also support National Grid Electricity System Operator (NG ESO) in managing supply and demand. Currently services to help NG ESO balance the system are primarily provided by fossil fuelled generation. However, as the electricity system decarbonises the need for flexibility

from other sources, potentially including households, will significantly increase. The government's Smart Systems and Flexibility Plan 2021[16] sets out a vision of the mid-2020s where domestic consumers will be able to choose from a variety of innovative products such as smart tariffs, with interoperable and secure smart appliances being widely available. From the 2030s, the government sees consumer flexibility becoming normalised, with "energy smart" products and services being commonplace. Rather than increasing the generation coming onto the electricity system, NG ESO can instead contract with consumers to reduce the volume of electricity they are using. Facilitated by power suppliers, this has historically been used with large business consumers. More recently, NG ESO has begun to explore the opportunity that could arise for households to participate in this type of arrangement. Smart meters will be a key enabler to unlocking this domestic flexibility. Without domestic flexibility, there is a risk that we would need to maintain or build more fossil fuelled assets into the 2030s.



Case study: National Grid ESO Demand Flexibility Service

National Grid Electricity System Operator has developed a Demand Flexibility Service to allow it to access additional flexibility in real-time during peak winter days when demand is high. The service was designed rapidly to support energy security over winter 2022-23. The service forms part of a range of tools that NG ESO uses to manage the electricity system, and is available to consumers with smart meters and supplied by a participating supplier. The service is designed to incentivise businesses and households to voluntarily flex the time they use electricity in response to market signals. Smart meters are used to record typical electricity consumption, and this is compared with usage during turn down events.

One supplier, Octopus Energy, that has participated in the scheme, has released results of its November participation event where over 200,000 households reduced their electricity demand. Collectively, they achieved a reduction of 108MW over the hour[17].

Octopus Energy reported that typical bill payers received over £1 for one hour's shift, as well as saving on their electricity bills. The top 5% of participants earned an average of £4.27.

NG ESO is working with other suppliers and aggregators as part of this national service for this winter, expected to add around 1.5GW of extra flexibility to the grid.

5.2 Reducing overall electricity consumption

Consumers can also support energy security by acting on smart meter information to reduce their electricity consumption (where possible). Using less electricity overall should reduce the need to run some of the generators that are either less efficient or

16 BEIS/Ofgem, Smart Systems and Flexibility Plan 2021
17 Octopus Energy, Octopus Energy Saving Session

use the most expensive fossil fuels. As consumption increases, the wholesale price of electricity faced by suppliers also tends to increase. This is largely due to the marginal pricing model used to determine the wholesale prices that suppliers pay when buying power on short-term markets. Under this model, the cheapest available power stations capable of meeting demand generate at any given time, with prices driven by the most expensive plant needed to meet demand.

The marginal generator is usually a gas fired power station. This has driven the high prices seen recently, with high gas prices following the invasion of Ukraine contributing to elevated electricity prices despite the large and growing presence of low-cost renewable generation on the grid.

5.3 Reducing gas imports

Given the key role of gas in household consumption, and in setting the electricity price paid for consumers across the market, lowering reliance on typically higher priced imported gas can provide energy security and cost benefits. One of the ways of doing this is to reduce overall consumption of gas.

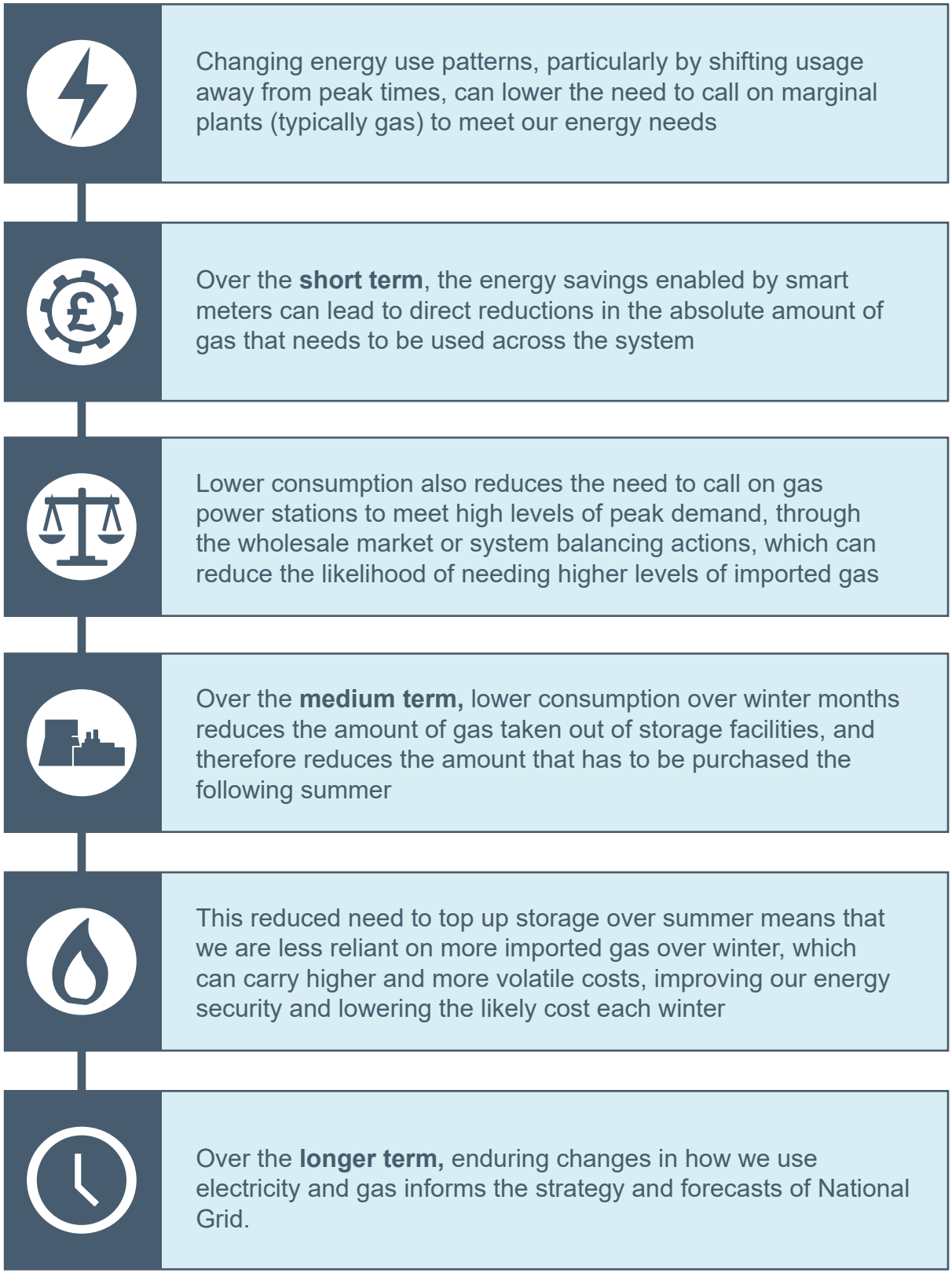
Of the sources of gas used to meet our energy demand, LNG is typically one of the most expensive, reflecting its higher level of processing (regasification) and distance to travel. Gas from the UK continental shelf tends to be the cheapest, with less distance to travel. The average gas price in GB is typically ~30% below the average continental gas price since the start of 2022. As well as importing gas to meet demand, the UK also uses gas storage facilities to help meet demand over winter. These stores are usually refilled during the summer months, when gas is traditionally cheaper to purchase and less is needed to meet people's heating needs.

Smart meters increase visibility and awareness of gas consumption within the home, with the latest government figures assuming an average household reduction of 2.2% for credit customers[18]. At the aggregate level, this reduction in demand can provide direct reductions in the absolute level of gas used.

Figure 9 sets out the potential impacts that smart metering infrastructure can facilitate on our demand for gas, and the implications this has on overall energy security.

18 BEIS, 2019 Smart Metering Cost Benefit Analysis

Figure 9: Smart metering and gas imports



Source: Cornwall Insight

6. Market enablers

Smart meters support numerous enablers of a smarter and more flexible electricity system and a more secure GB energy market. These are included in Figure 10.

Figure 10: Market enablers

More granular information

A smart meter measures how much electricity and gas a consumer uses every half hour. The visual display shows energy usage in near-real time for electricity and updates every 30 minutes for gas, alongside the associated cost. Consumers can use this information to manage their energy costs, by taking action to reduce their overall consumption. Smart meter information supports the creation of Time of Use tariffs. This may enable consumers to save money, reduce emissions and to reduce reliance on imported energy. There are strict data protection policies in place to protect customers (the Data Access and Privacy Framework).

Time of Use pricing

Time of Use tariffs are electricity tariffs where the prices vary at different times of the day. These are designed to encourage people to use energy outside of peak times when costs are typically higher. This shift away from concentrated peak-time consumption means that it is less likely the UK will have to use fossil fueled power stations to meet demand. Moving demand into other periods of the day, such as overnight when wind generation is typically higher, means that renewable energy can be utilised more.

Communicating energy costs

Communication of energy prices is a key component towards encouraging energy saving behaviours. If consumers have more visibility over the price they are paying for energy, this helps to take actions where possible to save money on energy. If linked to Time of Use tariffs, this can also help alleviate electricity system pressures.

Improving system visibility

Improved visibility of demand throughout the day will help NG ESO and local network operators to better plan and manage the system. Flexibility services play a key role in this system management and smart meters help households to participate in these. For example, NG ESO has estimated that there is 1.5GW of capacity available to participate in the Demand Flexibility Service this winter.

Source: Cornwall Insight

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