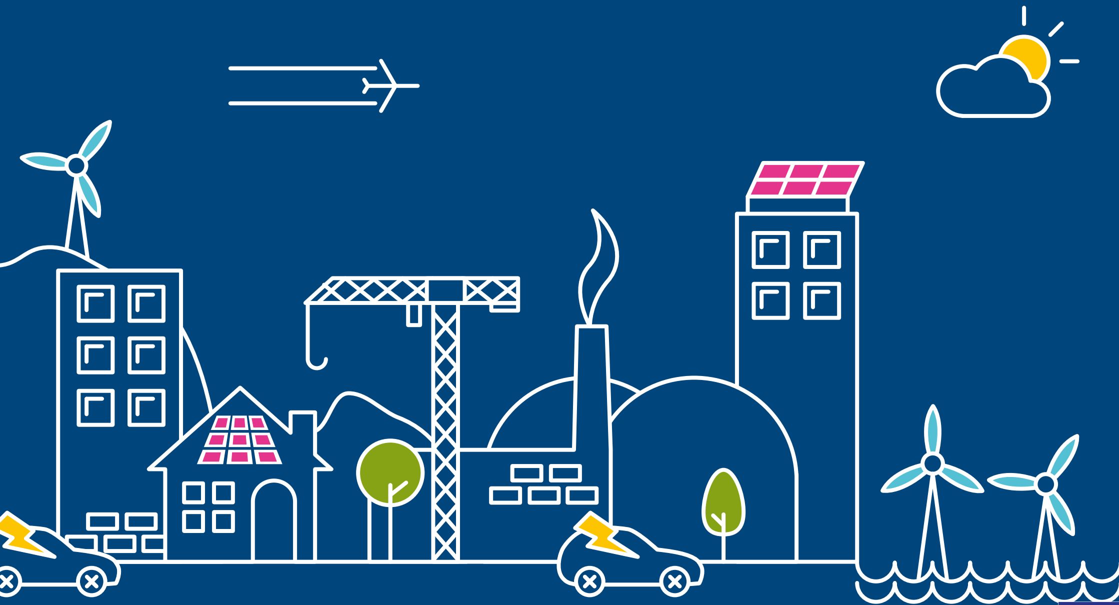
nationalgrid

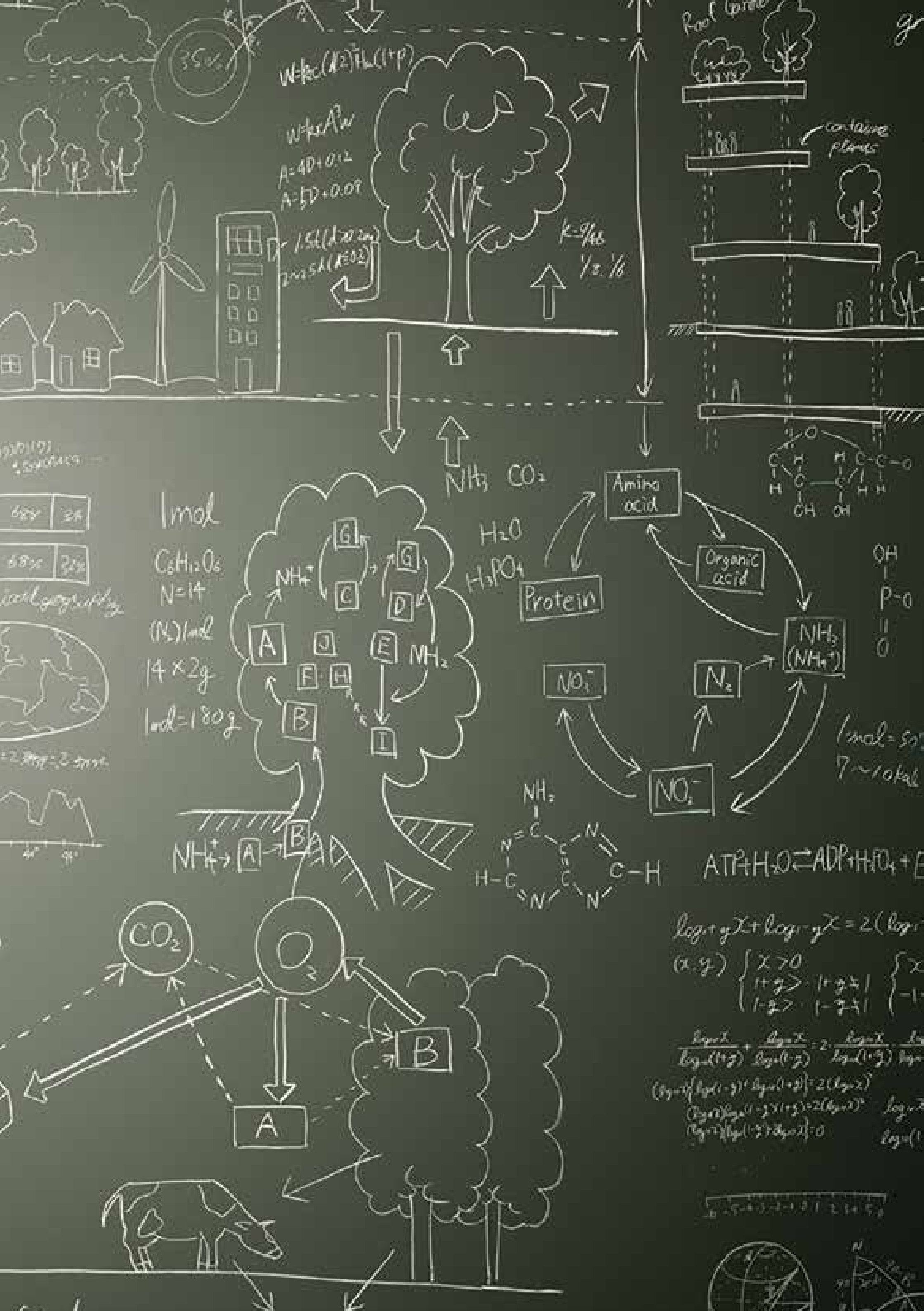
Future Energy Scenarios

UK gas and electricity transmission



Chapter **seven**

JULY 2015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How to use this document

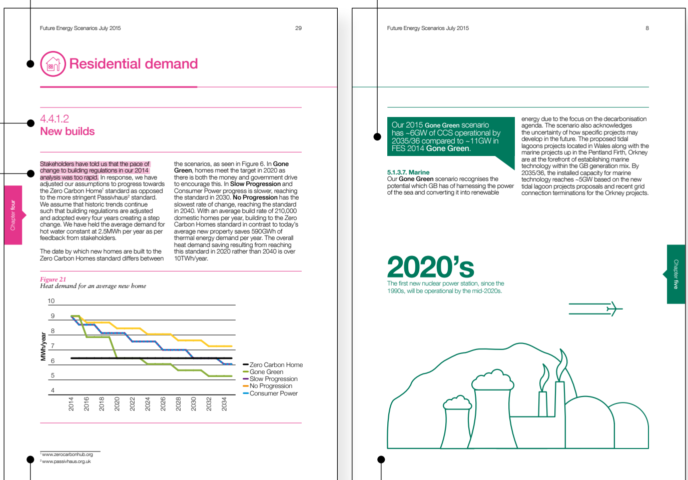
This document has been designed to present information in easily digestible sections, with the subject matter clearly defined in colour-coded chapters.

Heading and icon introduce the main topic on the page.

Key pieces of information are highlighted in boxes.

The main text is divided into sections by subheadings.

We have highlighted specific areas where we have responded to stakeholder feedback.



Footnotes are used for citations and further commentary.

Key data is emphasised with an image.

Chapters are tabbed and colour coded to help you find the section you are looking for.

Chapter seven

Case studies

- Balancing
- Future of heat
- Security of supply
- Green lights for electricity storage

Balancing

7.1
Power balancing challenges

Future summers will see periods of low transmission demands due to the increasing amounts of generation embedded within the distribution networks; in particular solar photovoltaic (PV). These increases, without action, will create balancing challenges for the system operator (SO). This case study considers these challenges for a typical summer Sunday in 2020, using the Consumer Power scenario.

The analysis shows that with average solar output, transmission demand is being suppressed across a large part of the day, dropping to a minimum of 16.7 GW in 2020. There will still be a need to hold generation at part load to cater for unforeseen events on the system. Therefore total generation is likely to exceed demand.

Key statistics

- Minimum demand falls to 16.7 GW in July 2020 in **Consumer Power**
- Under high solar outputs, demand remains flat across the day
- Operability and balancing challenges impact all scenarios at different points in the future.

16.7 GW

Minimum demand falls to 16.7 GW in July 2020 in **Consumer Power**

Innovative solutions are likely to be required to address these challenges. For example, greater flexibility from existing sources of generation and demand, greater use of interconnection, more demand side response or the development of energy storage and new balancing products. National Grid's System Operability Framework (which is published in autumn each year) will be the process where we work with the industry to explore operability challenges and identify potential solutions.

Fact

- 11 August 2014, minimum demand fell to 19 GW, which led to 13 consecutive ½ hour periods of negative generation prices.

19 GW

11 August 2014, minimum demand fell to 19 GW, which led to 13 consecutive ½ hour periods of negative generation prices.

7.1.1 Introduction

Last year our stakeholders asked us to consider energy balancing in our scenarios and to consider the impacts and challenges from changing supply and demand patterns.

As SO, we must match demand for electricity with supply on a second-by-second basis. Historically, balancing the system has been maintained mostly by directing thermal power plants to increase or reduce output in line with changes in demand. Storage and interconnectors have also played a part, but a much smaller one. As the volume of intermittent generation on the system grows, we will balance the system by utilising both supply and demand resources.

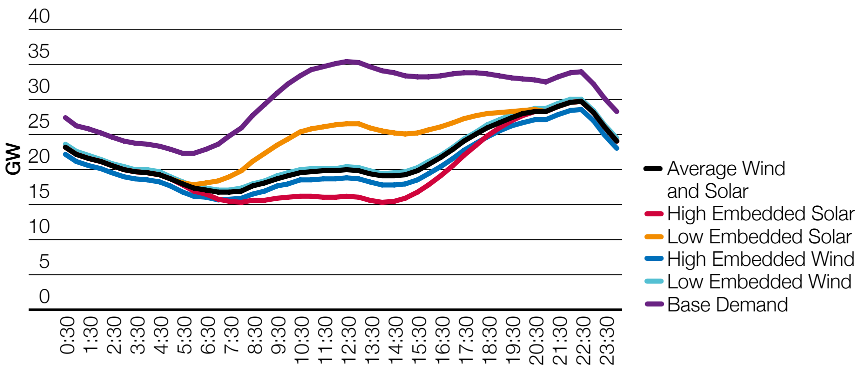
Managing periods of low electricity demand in the summer is just as important as managing the high demands we see in the winter. We have undertaken analysis to look at a typical summer Sunday with low demand using the **Consumer Power** scenario (due to its large volumes of intermittent distributed and micro generation).

Balancing

7.1.2
Distributed and micro generation impact on summer transmission demand

There is a direct correlation between the volumes of distributed and micro generation and low transmission demand. Historically, summer minimum demand was at 06:00hrs. This was reflected within the base demand value (which excludes distributed and micro generation) shown in Figure 95. However, as the amount of distributed and micro output increases on the system, this minimum demand shifts to 07:00hrs. The demand profile is also flattened as distributed and micro generation offsets the transmission demand.

Figure 95
2020 Summer transmission demand profiles for Consumer Power



7.1.3
Impacts of solar PV

The technology that has the single most significant impact on transmission demand is distributed and micro solar PV which is illustrated by the red line in Figure 95. Transmission demand is supressed to 15GW by 07:00hrs. This level of demand is maintained to 14:00hrs as increasing solar output offsets transmission demand. Between 14:00hrs and 20:00hrs transmission demand climbs as output from distributed and micro solar PV reduces.

Solar capacity has already had a rapid rise from 0.9GW in 2011 to 5.2GW in 2014. This rate is expected to increase to reach an installed capacity of 18GW in 2020.

We have considered three load factor sensitivities for solar output at 14:00hrs: high (84%), average (63%) and low (26%). The difference in transmission demand between high and low output could be a swing of up to 10GW. Focusing only on average solar conditions during July, demand is supressed to a minimum of 16.7GW (at 07:00hrs).

7.1.4
Is this just an issue for Consumer Power?

Whilst the case study focuses on **Consumer Power** (due to its high distributed and micro generation capacity levels) we have analysed the opposite scenario **Slow Progression**. We explored the summer demand profiles for **Slow Progression** in five year intervals to discover when this scenario would face the same challenges as **Consumer Power**.

> **Slow Progression** has slow economic growth and high emphasis on sustainability; the opposite environment of **Consumer Power**.

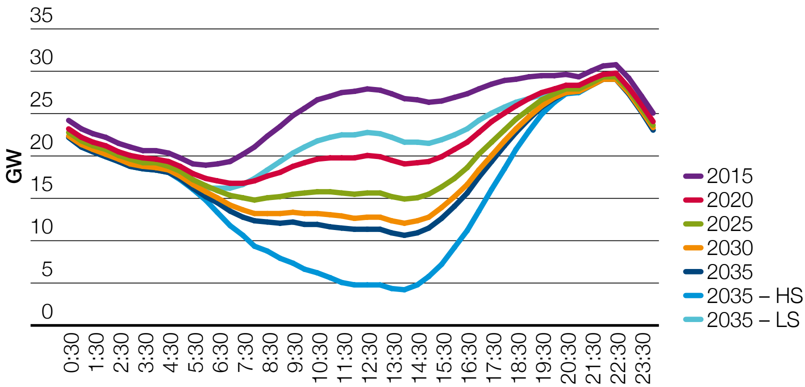
Analysis shows that by 2035 afternoon minimum demands are at similar levels to **Consumer Power** in 2020. This highlights that across all four scenarios we will experience balancing and operability challenges at some point from 2020 onwards.

In continuation we explored **Consumer Power** over the same period. In Figure 96 we can see that by 2035 the pattern of transmission demand has significantly changed. There is no longer any increase in transmission demand in the first half of the day as it falls continually from midnight until 14:00. This produces a steeper ramp rate in evening demand which is very pronounced by 2035 under **Consumer Power**; producing a 16GW rise in 6 hours.

Figure 96 shows the demands under both high (HS) and low solar (LS) output conditions for 2035 for **Consumer Power** are highlighted, showing that transmission demand could swing by 17GW within-day solely due to a change in cloud cover.

Balancing

Figure 96
Consumer Power summer transmission demand across years



7.1.5
Balancing and cash-out

Balancing the system during low transmission demand periods is a challenge. At all times there must be sufficient generation plant operating to allow output to decrease without any generator going below its minimum output level and disconnecting from the system in case of demand forecast error or loss of demand on the system; this is known as foot room. At the same time, there must be sufficient generation part loaded, ready to pick up for a generation loss; known as headroom.

Low transmission demand can also have an effect on cash-out pricing. On Monday 11 August 2014 minimum transmission demand was 19GW and led to 13 consecutive ½ hour periods of negative generation prices (settlement periods 01:00 to 07:30), as we constrained excess wind generation off the system.

Historically in low demand periods we have constrained generation and interconnector imports to maintain system security. With a growing proportion of summer generation coming from distributed and micro generation, especially from uncontrolled intermittent sources such as solar and wind, the balancing challenges are likely to increase.

7.1.6
The way forward

To address the balancing challenge we need to undertake further analysis and work alongside the industry to develop solutions. These solutions may include the provision of greater flexibility from existing sources of generation and demand. This could be achieved if such resources had the capabilities to start and stop multiple times per day and start up with short notice from a zero or low electricity operating level.

Greater use of interconnection may also play a part, mindful of the fact that the ability to export power depends on the needs of neighbouring countries. The development of energy storage, new balancing products and services, greater visibility and/or control of all generation or even a more fundamental reform could also form part of the solution.

Some of these issues are already being considered via various projects within the industry and we wish to use this information to develop our analysis. National Grid's System Operability Framework will address the operability issues in detail later this year. Going forward we would welcome your views on this case study and suggestions for further development for next year's analysis.

Although in its infancy, demand side response is already a reality.

power responsive

The ability for businesses and consumers to increase, decrease or shift their pattern of electricity consumption allows them the opportunity to save on energy costs, reduce their carbon footprint and help address these balancing challenges. Power Responsive is an ongoing framework to facilitate demand side response.

Find out more at www.powerresponsive.com and join the debate on LinkedIn

Balancing

Method

An average Sunday demand profile for July is derived from the data for 2005-2008/09. The base demand profile does not include distributed and micro generation impacts. This profile is then scaled against the summer minimum demand values for 06:00hrs for the appropriate scenario and year; again excluding any distributed and micro generation effects to produce a base demand daily profile.

We used distributed and micro generation capacity by technology type and exclude distributed and micro solar and wind which were dealt with separately. These capacities are specific to the appropriate scenario and year which is then profiled over the day based upon the 06:00hrs and 14:00hrs summer generation load factors. For example distributed combined cycle gas turbine (CCGT) was profiled to a 06:00hrs value of 26% and a 14:00hrs value of 40.5%.

We used average July daily load profiles for both wind and solar generation. These were used to scale the distributed and micro solar and wind capacities. For the sensitivities for both solar and wind the daily load profile was scaled from the average. For example the average solar was scaled from a 62% load at 14:00hrs to the 84% power supply summer 14:00hrs load factor.

The resultant distributed and micro generation was removed from the base demand to produce a transmission demand profile; including sensitivities for high and low solar and wind.

We utilised the quarterly (summer quarter) power supply output values for the **Consumer Power** scenario. These were converted into average generation outputs for the settlement period.

Future of heat

7.2
Future of heat

Energy used in heating demand is currently very carbon intensive and accounts for a significant proportion of GB's carbon emissions. If the carbon targets are to be met, there must be a step change in how our homes and businesses are heated. There are many solutions coming to market that aim to facilitate this change. We see a need for a combination of these solutions, with enabling technologies, to decarbonise heat at the most efficient cost to consumers and we see gas continuing to have a key role.

Key statistics

- Almost half (46%) of the final energy consumed in GB is used to provide heat, around 700 TWh/year
- Around 80% of heat demand is currently met with natural gas
- Heat is responsible for around a third of GB's greenhouse gas emissions.[6]

Heat is responsible for around a third of GB's greenhouse gas emissions1

[6] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf

Future of heat

7.2.1
Why is heat a problem?

Heating buildings accounts for around 700 TWh/year of energy demand in GB, around half of the total demand. Most of the energy demand is for domestic space heating and is satisfied with natural gas boilers in homes throughout the country. However, residential and industrial sectors are responsible for roughly equal emissions due to industry needing higher temperature heat, which is provided by more carbon-intensive fuels. Space heating resulted in the emission of approximately 100 mega-tonnes of carbon dioxide equivalent ($MtCO_2e$) into the atmosphere in 2008, 18% of the total carbon emissions including industry, power stations and transport. Total heat demand, including industry, contributed 182 $MtCO_2e$, bringing the total to 32%.

To meet the government's legally binding carbon targets (80% reduction in carbon emissions against 1990 level by 2050), the energy used in heating must be decarbonised by reducing the amount used and focusing on using cleaner sources. The industry is starting to address this via a range of potential solutions.

7.2.2
Potential solutions

Heat pumps

The first place to start with reducing the carbon intensity of heat is to consider alternatives to traditional gas boilers. Gas boilers convert gas to thermal energy with an efficiency factor of approximately 90% before distributing the heat around buildings with a wet system (water in radiators) or a dry one (hot air in vents).

Replacing gas boilers with a different appliance, such as a heat pump, could be an effective solution. Heat pumps are designed to be far more efficient, taking advantage of the latent heat that exists in the air, the ground or in bodies of water. This means that there is potential to get two or three units of thermal energy for every one unit of electrical energy. Therefore, heat pumps have no carbon emissions at the point of use and also use less energy for the same thermal output: a win-win.

Heat pumps don't provide a perfect solution though as the implications of installing heat pumps across the country are significant. The cost of electrifying heating is significant, ranging from the network costs to more generation assets. These costs are passed on to the consumer through higher electricity prices. Heat pumps are also more expensive to install than gas boilers and need different heat distribution systems in homes to gas boilers, adding to their cost.

Heat pumps can be used in hybrid systems, where gas is used to 'top up' and meet heat demands at peak when the heat pump is running at its lowest efficiency. This setup avoids requiring an electricity system built to meet peak demand and the high associated costs. Using gas at peak utilises assets that already exist; without gas, meeting peak demand would be considerably more expensive.

The electricity still has to be generated in a clean way to see any carbon benefits (the carbon intensity of electricity from the grid is currently around 400-450 gCO_2/kWh), which means either more renewable generation or carbon capture and storage (CCS) must be built to reduce carbon emissions from thermal generation.

Industrial and commercial heat pumps can take advantage of waste heat from other processes. Refrigerators and freezers vent heat as part of their cooling system and this heat can be recycled, using heat pumps, at high efficiency to effectively move heat from places that need to be cooled to places that need to be warmed. These solutions can be bespoke for a particular building but still use off-the-shelf equipment.

Future of heat

Heat networks

Heat networks centralise the task of changing primary energy into thermal energy and remove the need for each individual building to have a heating appliance. This can take advantage of thermal economies of scale before circulating the heat into buildings via insulated hot water pipes.

Installing a new heat network is costly and disruptive: new pipes must be laid in streets and residents must support the scheme. To maximise heat networks' success, everyone in the catchment area needs to sign up to spread the initial investment costs. This requires residents relinquishing control of their heating systems, a prominent cultural change. Heat networks are most efficient in high density areas, allowing for shorter pipework and more participants and thereby keeping costs as low as possible.

Many of these setup issues can be addressed by installing the heat network in a new housing estate. This avoids the cost of digging up roads, required in a retrofit, because the work can be integrated into the build, avoiding some costs, and new residents will have the heating already installed without needing to make a conscious decision to become greener. This, however, leaves the developer with a legacy problem of who will own, run and maintain the asset as well as hold any associated liability if it breaks down.

There are a range of possible heat sources, but the most effective would be to use waste heat from a power station or factory. This heat would usually be low grade (a lower temperature than required) but could be upgraded to a useful temperature and therefore make the heating appliances installed more efficient. This puts a second constraint on the location of an effective heat network: being close to a heat source.

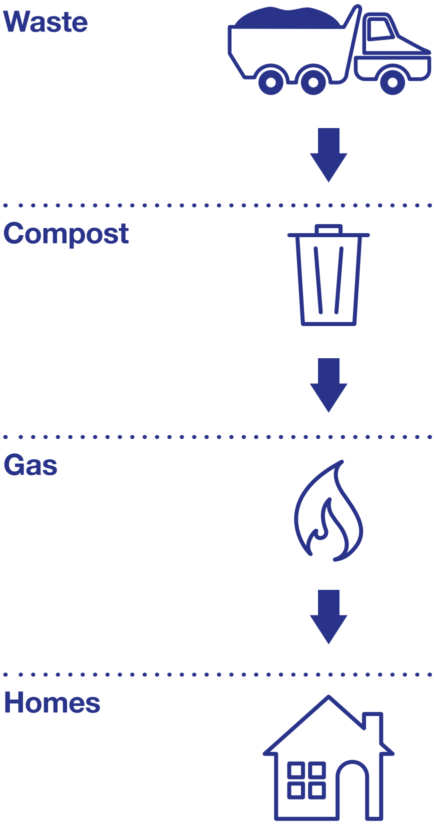
Another option would be to use gas combined heat and power (CHP) units to generate both electricity and heat. The heat can be pushed through the network and the electricity exported to the grid or used to power heat pumps. This is greener than using grid electricity and a gas boiler in the short term, but there is a tipping point as grid electricity becomes greener (this depends on CHP efficiencies but it's around 1.4 times the intensity of burning gas) where CHP is then more carbon intensive than the alternative. Once the heat network is in place, the heating system can be transferred to alternative heat sources with minimal problems or CCS can be added.

Biogas

Biogas can be produced using a technique called anaerobic digestion (AD). This is where organic waste material is broken down by micro-organisms which expel biogas as a by-product. This gas can be cleaned up so that it is suitable to be injected into the local distribution network and then burnt to produce heat, just the same as natural gas. AD occurs naturally when waste is left to rot and the resulting methane is vented into the atmosphere. Biomethane has a double counting effect on reducing carbon emissions (not venting in the first place and replacing natural gas); this is because methane's impact on climate change is equivalent to about 25 times[2] the impact of CO_2.

Biomethane is chemically identical to naturally occurring methane and so can be used as an alternative, greener, source of gas. A significant benefit over other heating solutions is that biogas utilises the existing distribution networks and incumbent gas boilers.

However, a great deal of waste is required to produce biogas in serious quantities. One tonne of waste can produce anywhere from 100 to 3,000 kWh of biogas depending on the quality of the organic material.[3] It has been estimated that it is possible to produce and inject into the distribution network around 20TWh/year of biogas by 2050[4], although this represents less than 3% of the current gas demand. Given these restrictions biogas can only ever represent part of a wider solution.



[2] http://epa.gov/climatechange/ghgemissions/gases/ch4.html

[3] http://www.afbini.gov.uk/afbi-ad-hillsborough-27-months-june-11.pdf

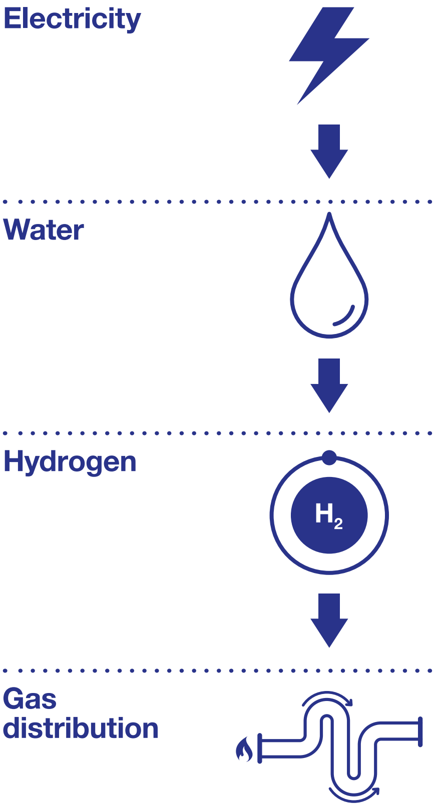
[4] 4.25
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf

Future of heat

Hydrogen
Hydrogen is often proposed as a clean solution for energy. There are several issues which need addressing before this potential can be realised, ranging from production to transportation and end use.

The vast majority (more than 90%) of hydrogen production is currently done by chemical reactions with fossil fuels, primarily methane. However, this only moves emissions to a different point in the process. Alternatively, hydrogen can be produced with electrolysis and could take advantage of excess supply from renewables like wind and solar. The electricity is used to convert water into hydrogen and oxygen. Currently, however, this is not a very economic use of this spare capacity.

Once made, the hydrogen could be injected into the current gas distribution system in small quantities (up to 2% by volume[5]) which would effectively lower the carbon intensity of the gas from the grid. However issues need to be addressed with appliances being adapted to utilise hydrogen effectively. In larger quantities a hydrogen gas grid could be built along with hydrogen boilers installed in buildings; clearly a great deal of investment would be required to make this worthwhile and competitive.



[5] http://www.gerg.eu/public/uploads/files/publications/GERGpapers/HIPS_-_the_paper_-_FINAL.pdf

Next steps

Each of these solutions requires investment into technologies and infrastructure as well as gaining buy-in and acceptance from the end customers who will ultimately see a change in their home or business. There are physical constraints for some, like heat networks, which prevent wholesale installation. These technologies lend themselves to a mixture of installations, each targeted to resolve the problem of decarbonising heat in their own focus area.

For thermal generation to be decarbonised, and included in the heat mix, CCS will need to be part of the solution. CCS, a system whereby carbon emissions are captured at source and then piped back into the ground, is expensive to implement and needs infrastructure external to the power stations (or industrials) to function. Therefore they are most economical in high-density clusters of industrial activity and near a carbon sink point – the North East of England and Scotland are obvious contenders that meet both of these requirements.

To further investigate heat networks we have commissioned a study with Buro Happold and University College London (UCL), aiming to inform our scenarios for 2016. The study will review existing heat networks, the location and potential scale of economic heat networks and, crucially, the sources of low carbon heat production that could support a future heat network. We intend to also review the plausible expansion of CCS networks and interaction with potential heat and gas networks.

Understanding the practicalities, deployment and potential geographical opportunities for CCS and heat networks will have a knock-on impact to our energy demand and supply scenarios. We aspire to a better understanding of the interaction with existing and potentially new energy infrastructure, with a view of further enhancing our Future Energy Scenarios for next year.

None of these solutions are completely new, but they will require a step change to make them competitive against the current preferred heating solutions. The government may have a part to play in investment or incentives, as will obtaining economies of scale from interested parties working together in partnership to utilise waste heat efficiently. It is clear that a mix of solutions will be required that suits the infrastructure that already exists, is cost effective, and returns significant carbon reductions for the required investment.

Security of supply

7.3
Security of supply

This case study looks at the outlook for security of supply for the coming winter. Margins, whilst narrow, continue to be manageable until 2018/19 when the capacity market delivers new sources of capacity and margin pressures ease. The purpose of this section is to look at the immediate outlook for security of supply and describe the solutions that are in place to ensure adequate generation and Demand Side Response is available to meet the security of supply standard.

7.3.1
Introduction

Security of supply is concerned with how much generation is available to meet peak demand across a number of market outlooks. The aim of this case study is to consider security of supply for winter 2015/16 in detail and to share our thinking and analysis with the industry as part of work to increase transparency. Security of supply is a key area of focus as the generation mix diversifies over time; the level of traditional thermal generation decreases and the level of more intermittent renewable generation increases. This case study looks at the loss of load expectation (LOLE) in each of the scenarios for winter 2015/16 and sets out the actions taken in order to inform the market to support best planning.

LOLE is used to describe electricity security of supply. It is an approach based on probability and is measured in hours per year (hours/year). It measures the risk, across the whole winter, of demand exceeding supply under normal operation.

This does not mean there will be loss of supply for X hours/year. It gives an indication of the amount of time, across the whole winter, which the system operator (SO) will need to call on balancing tools such as voltage reduction, maximum generation or emergency assistance from interconnectors. In most cases, loss of load would be managed without significant impact on end consumers. The standard for Great Britain is set by the government at 3 hours/year LOLE. This assumes average conditions so the analysis considers a range of credible and plausible sensitivities to deliver security of supply across a range of outcomes.

For winter 2015/16 the SO has taken action by procuring new balancing services through a tender process. The tender process resulted in this additional generation being procured at a competitive price to deliver value for end consumers. This reduces the LOLE across the scenarios and these details are discussed later in the case study. Although the SO has taken action to improve the outlook for the coming winter, we believe the security of supply for winter 15/16 is manageable. We will continually review the latest position and remain vigilant regarding security of supply as we approach winter.

Security of supply

7.3.2
Approach to security of supply modelling

This case study focuses on the demand, generation and interconnector backgrounds in FES 2015. However, it is useful to consider how this has changed from the analysis presented in FES 2014 to understand the impact of updated market intelligence and modelling over the year.

Generation – The starting point is the generation backgrounds in FES 2014. These have been updated to reflect changes at a generator level in line with the latest market intelligence. These changes typically include generator closures and openings and Transmission Entry Capacity (TEC) increases or decreases that have been made since the previous year. This has resulted in an overall reduction of 2.2 GW of installed capacity for 2015/16 when compared with FES 2014.

Interconnectors – All of the scenarios assume 1 GW of net imports to GB from interconnectors for winter 2015/16. This net position is made up of 1.8 GW of imports from Europe and 0.8 GW of exports to Ireland. FES 2014 assumed a position of GB net float, where all imports were matched by exports. This increase in imports is assumed because we recognise that the tightening margins over the next few years will prompt responses from the market, one of which would be increased imports.

Demand – Is largely flat across the scenarios for the coming winter showing only a 0.1 GW difference across the scenarios.

LOLE – The government set the reliability standard for security of supply at 3 hours/year LOLE. The approach taken to calculate security of supply is to firstly examine demand and the generation which is available to meet that demand in line with the 3 hour LOLE standard. We alter assumptions relating to specific generation assets to reflect the uncertainty in the market and provide some meaningful variation across the scenarios.

Supplemental balancing reserve (SBR) and demand side balancing reserve (DSBR)[1] – For winter 2014/15, the SO contracted a total volume of 1.1 GW additional de-rated capability comprising of 1 GW SBR and 0.1 GW DSBR. This was not reflected in the generation backgrounds in FES 2014. The SO has already contracted 2.5 GW of additional capability comprising of 2.3 GW of SBR and 0.2 GW of DSBR for winter 2015/16. In this case study, we present the LOLE values for the scenarios both pre and post-procurement of SBR and DSBR. We have done this to show the most up-to-date view of the short-term outlook, highlighting why it was prudent to procure additional generation and demand side support when offered at a competitive cost.

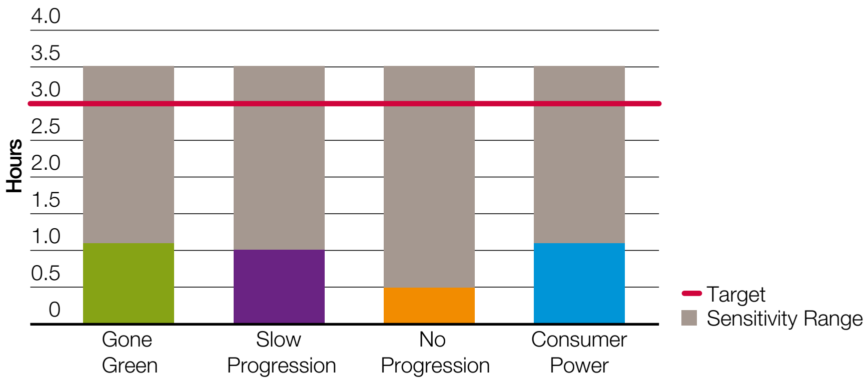
[1] http://www.nationalgridconnecting.com/balancing-act/

7.3.3
Winter 2015/16 LOLE results

Figure 97 shows LOLE across the four scenarios for winter 2014/15 and 2015/16, these figures include capacity contracted via SBR and DSBR for the periods covered.

The supporting narrative begins by looking at the outlook post-procurement of additional capacity. It then explores the position pre-procurement and why it action has been taken.

Figure 97
LOLE chart winter 2015/16 (post-procurement)



The outlook for winter 2015/16 is that in all four scenarios the level of LOLE is below the 3 hour target. This is a slight increase in LOLE from last winter where the LOLE across the scenarios was 0.47hours/year.

For procurement of SBR and DSBR we consider a base case scenario. The base case is FES 2015 **Slow Progression**. We include sensitivities to cover a wide range of credible cases. The selection process determines the optimal volume to procure taking account of this range of credible outcomes and price. This is set out in the Volume Methodology[2] that was approved by Ofgem[3].

Chapter seven

[2] http://www2.nationalgrid.com/UK/Services/Balancing-services/System-security/Contingency-balancing-reserve/Methodologies/

[3] https://www.ofgem.gov.uk/ofgem-publications/94680/nbsmethodologyapprovaldecisionletter-pdf

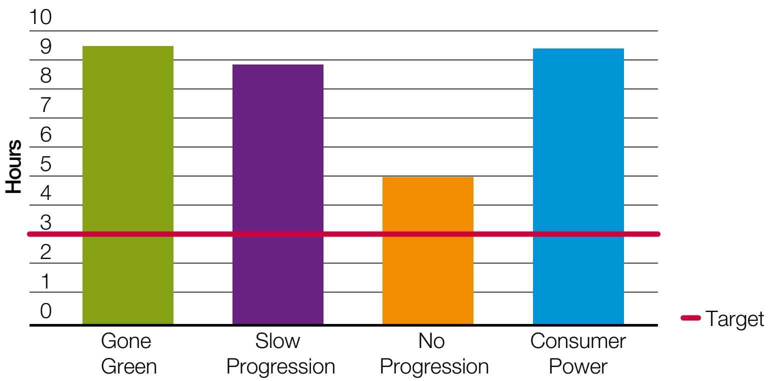
Security of supply

LOLE for winter 2015/16 was higher than than 3 hours/year as shown in Figure 98. Based on analysis of all the credible cases for 2015/16, the optimal procurement volume was determined as 2.5GW of additional de-rated capability. Additional capacity in the form of SBR and DSBR was procured via a tender process. The first tender round was held in December 2014, securing 600MW of SBR and 65MW of DSBR. A second tender round secured an additional 1,784MW of SBR and 112MW of DSBR.

Figure 97 shows the impact of the additional generation obtained through SBR and DSBR contracts on the analysis. All four scenarios show LOLE below the 3 hours/year. When considering the credible cases for 2015/16, the LOLE values range from 0.1–3.5 hours/year. This is shown by the shaded area in Figure 97. This can be compared to the range of LOLE values for winter 2014/15 which was 0–4.3 hours/year.

For the base case scenario pre-procurement LOLE was 8.9hrs which equates to a de-rated margin figure of 1.2%. Following procurement of SBR and DSBR the LOLE in the base case reduces to 1 hour which corresponds to a de-rated margin figure to 5.1%.

Figure 98
LOLE chart winter 2015/16 (pre-procurement)



LOLE values before contracting SRB and DSBR range from 5.1 hours/year in **No Progression** to 9.5 hours/year in **Gone Green**: this is shown in Figure 98. The high levels of LOLE are largely due to a reduction in de-rated generation capacity. The majority of this is thermal plant closing in line with current environmental legislation including the Large Combustion Plant Directive (LCPD)[4] and the Industrial Emissions Directive (IED)[5]. Current market conditions have resulted in a number of CCGT generators closing and mothballing.

The differences between the scenarios are either caused by variations in demand or the underlying assumptions on the level of available generation. For example, **No Progression** assumes an additional 0.8GW of de-rated capacity in 2015/16 in comparison to the other scenarios. **No Progression** and **Slow Progression** have the lowest demand.

[4] https://www.gov.uk/government/publications/environmental-permitting-guidance-the-large-combustion-plants-directive

[5] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/367365/statutory_security_of_supply_report.pdf – Pages 19 and 20

Security of supply

7.3.4 Summary

We have procured balancing services for winter 2015/16 to ensure we have the tools in place to help us balance the system. This is in line with actions taken for 2014/15. The capacity from generation and these tools shows margins of 5.1% and an LOLE of 1.1 hours/year. The unit cost of these services was lower than the previous winter and represents good value for consumers due to competitive tender prices.

We expect the upcoming winter to be manageable. Procurement of the additional generation at this point has removed uncertainty from the market. It has put us in a much stronger position in the run up to winter 2015/16.

Looking forward to 2018/19, the first delivery year of the capacity market, it is important that we continue to monitor security of supply. We are positioned to identify potential reductions in security of supply. We continue to work closely with Ofgem, government and stakeholders across the energy industry to explore options and products to resolve any gap in a timely and cost effective manner.

The SO is not currently licensed to procure SBR and DSBR services beyond winter 2015/16. We will therefore be consulting with the industry during July 2015. This will consider whether the SBR and DSBR arrangements should be extended, whether changes are required or whether an alternative solution should or could be developed in an appropriate timescale.

Green lights for electricity storage

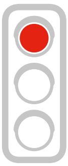
7.4
Electricity storage

Electricity storage could be significant for the future balancing toolkit. It has the potential to offer valuable services to the SO, broader industry, and ultimately the end consumer. Using a traffic light system, this case study explores the developments that could improve the commercial viability of electricity storage in GB. The findings will inform how electricity storage is captured in future years of the FES using an evidenced-based approach. We have considered four areas where progress would be beneficial:

- policy and regulatory developments
- system needs
- commercial developments
- technological developments.

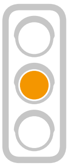
For each area, we explore the current status for GB (**red**, **amber**, **green**). We explain what progress, or '**green**', may look like for GB and consider international examples. Issue resolution, or a '**green**' status, is not necessary for all four areas for storage to be commercially viable; a change in just one or two areas could unlock the potential.

We would like to use this case study as an opportunity to engage with the energy industry. What do you see as the main changes required to improve the commercial viability of electricity storage?



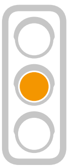
1

Policy and regulatory developments is red



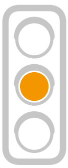
3

Commercial developments is amber



2

System need is amber



4

Technological developments is amber

Green lights for electricity storage

7.4.1
Policy and regulatory developments

The first of the potential areas for development is policy and regulation. This section explores how the absence of a regulatory definition for storage impacts ownership and business models. We also look at the current level of support for storage in GB and internationally.

Current status for GB: red

Storage has been identified as one of the government's "eight great technologies", which are anticipated to propel the UK to future growth in light of their potential to save money and reduce emissions. To date, DECC's Innovation Programme has provided three routes to support the development of electrical energy storage, totalling £56 million.

Although the potential benefits of storage have been established, support remains focused on innovation funding and demonstration projects, rather than through a policy instrument such as incentives, due to the relative infancy of some storage technologies.

One of the challenges facing storage is the absence of a regulatory definition. Electricity storage is not recognised explicitly in EU legislation and is therefore treated as a subset of power generation. This legal uncertainty has implications for ownership and operation, and therefore business models for storage. As transmission system operators (TSOs) are prohibited from controlling generation, this restriction extends to storage. It also results in double charging, where storage is charged for both consuming (charging) and generating (discharging) energy, impacting on operating costs and therefore profit levels.

Greater regulatory clarity could improve the environment for storage, and more targeted support – for example, mandates and incentives – could provide certainty for early adopters in the short- to medium-term. This would be '**amber**' or '**green**'. There are parallels that can be drawn between the regulatory treatment of storage and interconnection. Interconnection was not initially defined within the legislative framework. However, its amended status as 'network' has resulted in cost reflective charging. This change was driven by recognition of the wider benefits interconnection could offer and it may be appropriate to conduct similar assessments for storage.

Practical applications: benefits of storage being treated as an independent asset class

In the US, storage has been identified as a solution to managing the variability of renewable generation, in addition to providing ancillary services and an economically viable alternative to gas peaking plants.

California has a target to procure 1.3GW of electricity and thermal storage by 2020. Along with orders introduced by the Federal Energy Regulatory Commission (FERC), these measures mean storage is no longer competing with conventional power generation, revenue is increased based on speed and accuracy, and connections for storage are fast-tracked. This is bridging the gap between the current relatively high cost of storage and the value to network operators, utilities and consumers.

1 https://www.gov.uk/government/speeches/energy-storage-innovation-showcase

2 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0092:EN:HTML

3 http://www.greenbiz.com/blog/2013/12/11/inside-california-energy-storage-mandate

7.4.2
System need

This section explores transmission system needs that could be addressed by storage. These relate to system operability (frequency, voltage, inertia) and constraint management. The impact of distributed solar PV and wind at times of low demand is pertinent. This topic is discussed in Commercial Developments and you can read more in the Balancing Challenges case study on pages 180–185.

Current status for GB: amber

As described in National Grid's 2014 System Operability Framework[4] (SOF), Summer Outlook Report[5] and the Balancing Challenges case study (page xx), future system requirements are evolving. The Balancing Challenges chapter shows how distributed generation exporting onto the grid at times of low demand has implications for energy balancing and system operability. These challenges arise as output is driven by fuel availability, for example sunshine, rather than market behaviour. Storage, both large scale and domestic, has the potential to alleviate this challenge and unlike interconnection, will not be impacted by European countries experiencing the same issue at similar times of day.

The 2014 SOF has identified other potential future requirements for system operability, which could be met by storage. For example, based upon FES 2014, enhanced frequency response is required at the earliest by 2019/20 in a **Gone Green** world and by 2029/30 at the latest for **No Progression**.

Rapid frequency response can be delivered by interconnectors, wind generators, DSR and energy storage. This suggests that, whilst most storage technologies excel in speed of response, storage is likely to be part of the toolkit in future, rather than the single solution.

Constraint management is required where there is congestion on the transmission system due to excess generation. Storage can be used to integrate large scale renewable generation by absorbing the excess generation and storing it until there is sufficient capacity on the system to release it. The cost of storage is a barrier to this application. In addition, the relationship with incentives for wind generation may dampen the demand for storage. At present, renewable electricity is not eligible for incentives if it is used to charge storage before it enters the electricity system.

For this section, the question is not whether there is a system need, but rather whether storage can provide a cost-effective solution to that need. Whilst storage technologies have the potential to assist with system operability and constraint management, services must be met by the most economic option. Therefore, '**green**' for system need cannot be achieved in isolation. As future system challenges and requirements become clearer, progress will be required in other areas to enable storage to provide services at competitive prices and realise its potential.

Practical applications: SO-owned storage provides solution to requirements

The Italian SO (Terna) has installed a series of batteries to increase the safety of the grid on islands and reduce grid congestion on the mainland. In light of EU legislation, Terna was given authorisation by the Regulatory Authority for Electricity and Gas. Transmission infrastructure was considered. However, due to the risk of over-investment, battery storage was identified as the best short-term solution.

[4] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

[5] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/summer-outlook/

Green lights for electricity storage

7.4.3
Commercial developments

This section considers barriers to accessing multiple, or stacking, revenue streams and the possibility that storage could receive additional revenue from the provision of a unique service. We also explore how installing storage with distributed generation can increase self-consumption and that price signals are likely to be required to make this worthwhile for consumers.

Current status for GB: amber

The potential revenue streams for storage in GB include providing ancillary services to the SO, deferral of both transmission and distribution network reinforcement, and integrating large scale renewable generation. Stacking revenue streams improves the commercial viability of storage. However, there are a number of barriers to overcome, some of which are being explored by industry groups and innovation projects.

Storage has valuable characteristics, such as speed of energy delivery or absorption, and could therefore provide frequency response services to the SO. Due to the fundamental importance of these services to real-time system security, they must often be provided exclusively so the SO has certainty that a provider will be available when needed. This is often seen as a barrier to stacking revenue streams. Currently some storage providers in GB overcome this by separating their storage into individual units to provide separate services. However, this is not possible for all technologies, and does not fully address the underlying issue of providing more than one service from the same storage volume.

Although commercial changes could enable stacking revenue streams, this may also benefit other market participants in addition to storage providers and, as a result, counteract the advantage storage stands to gain. Therefore, if storage were able to provide a unique and valuable service, such as speed of response, this would be an effective way to enhance its commercial viability.

Storage is used in Italy by the SO to defer transmission network reinforcement. There is not currently a business model to enable storage to access revenue from this service in GB. However, resolving the classification issues raised in policy and regulation could allow storage to provide a cost-effective alternative to traditional reinforcement under the new network options assessment process of the Integrated Transmission Planning and Regulation (ITPR) project.

In addition, UK Power Networks' Low Carbon Network Fund (LCNF) Smarter Network Storage project is investigating how a battery could provide an alternative to traditional distribution network reinforcement and is exploring potential business models and regulatory implications. The battery will also be used to provide ancillary services to the SO and energy services to the wholesale market.

In addition to storage connected to the transmission and distribution networks, we have considered the commercial developments that may be required for smaller scale storage. Installing storage alongside distributed generation enables consumers to be responsive to price signals and can increase self-consumption by decoupling the timing of generation and usage. This reduces the need to buy electricity from the grid at times of peak demand and helps to smooth the daily demand profile. Solar PV can reduce the amount of electricity required from the grid by approximately 30% for a household.

If a battery is added, this reduction is increased to 70-80%[6].

This system has economic benefits when the cost of purchasing electricity exceeds the cost of installing a solar PV and storage system. Bloomberg New Energy Finance (BNEF) suggests that, without dramatic cost reductions in storage technology, the value for storage is in the price differential between peak and off-peak prices.[7] This price differential is unlikely to exist without time of use tariffs (TOUTs) and, at present, the most economic option is a PV system without storage.

Developments for in-home storage

In April 2015, Tesla announced the launch of its new in-home battery. Powerwall is a rechargeable lithium-ion battery designed to store energy at domestic level. It has the potential to be used for load shifting, backup power, and pairing with solar power generation to enable self-consumption. The product is available in two sizes: 7kWh and 10kWh. To provide context, the average daily consumption for a UK household is approximately 11kWh.

Powerwall will be on sale in the US from this summer and 38,000 units have already been reserved by US residents. Due to the unexpected low cost in relation to similar systems, this could be a significant development for storage.

There are currently no plans to sell the product in the UK. However, the balancing challenges discussed earlier in this chapter will require a solution in the very near future and pairing storage with solar generation is therefore a potential growth area within GB.

In the UK, Moixa's Maslow battery is available, as either a 2kWh or 3kWh system. This is a smart energy storage system for residential and commercial applications, which charges during off-peak hours when energy prices are lower or directly from on-site renewables, such as solar generation. Moixa has deployed 0.5MWh across 250 sites under a DECC-funded 2013 demonstration project.

In-home storage will need to make economic sense to most, if not all, of those who purchase devices like Tesla's. However, the media attention the launch of the Powerwall has received suggests desirability could be an increasingly influential factor in the uptake of such products.

38,000

Number of units reserved by US residents for the Powerwall battery

[6] Bloomberg New Energy Finance (BNEF) "European end-user storage: a battery in every home."

[7] BNEF – US residential PV & storage: case against grid defection

Green lights for electricity storage

Although Tesla have been selling residential storage since 2011 under California's Self Generation Incentive Programme, their recently announced Powerwall home battery provides the technology for a far lower cost than many expected, which could drive competition in the market.

Considering these factors, '**green**' will involve changes that overcome the barriers to stacking revenue streams or ensuring that the existing revenue streams are sufficiently attractive in isolation. This could involve changes to service parameters or the introduction of specific markets that value the unique attributes of storage projects. The emergence of a business model, possibly as a result of regulatory change, for storage to provide an alternative to traditional network reinforcement could also represent a '**green**' light. For solar and storage as a model, the introduction of TOUTs and smart meters would sharpen the price differential between peak and off-peak prices, encouraging self-consumption. Our projections for the smart meter roll-out in GB are shown in Figure 40.

Practical applications: investigating how to optimise services from storage and support for domestic generation with storage
At the Dietikon Power Plant, Switzerland, a 1MW battery has been installed and is expected to benefit from multiple revenue streams. This is possible as the battery is integrated with an energy conversion system allowing it to operate in five modes. Peak shaving, frequency control, PV smoothing and voltage control can be achieved from the same asset. The project will shed light on how to develop algorithms that optimise the operation of the storage system.

Subsidies for residential battery systems were introduced in Germany in May 2013. In the first year of the subsidy, over 4,000 new solar and storage systems were installed. Although there are questions over whether this is the most sustainable way to grow the market, this may be a short-term solution to support early adopters.

7.4.4
Technological developments

This section captures improvements in cost, efficiency and lifespan of existing technologies, and the emergence of new technologies.

Current status for GB: amber

The cost of storage is often referred to as a significant barrier. In terms of levelised cost of electricity (LCoE), which represents an "all-in" cost, pumped hydro is currently the most attractive electricity storage technology for delivery of short bursts of energy. The LCoE of compressed air and liquid air energy storage is marginally higher than pumped hydro, and the LCoE for batteries is significantly greater. However it is suggested that the cost of lithium-ion batteries could largely rival that of mechanical storage for power-intensive applications (short bursts) by 2030, with further cost reductions anticipated as deployment increases.

Examples of efficiency improvements include adiabatic systems, where waste heat is stored and reused during the power recovery process, removing the need for fossil fuels. RWE's ADELE project[8] (Germany) is exploring this approach for compressed air energy storage and aims to increase efficiency from around 50% to 70%.

Flywheels are highly efficient and fast responding storage technologies. Whilst they are sometimes used for uninterruptable power supplies (UPS) at data centres in GB, the 20MW flywheel due to be built in County Offaly, Ireland, will be Europe's first grid connected hybrid system. The project is due to launch commercially in 2017[9].

These are promising efficiency improvements and cost projections for existing energy storage technologies. There is also the possibility of the emergence of new technologies that could offer significant enhancements to the storage industry – for example, metal-air batteries. Considering these factors, a strong indicator of '**green**' would be a reduction in LCoE to the point where storage is cost competitive with alternative solutions for the application in question. Examples of these alternatives include interconnection for energy balancing, thermal generation or DSR for ancillary services, and traditional reinforcement for upgrade deferral.

Chapter seven

[8] http://www.rwe.com/web/cms/mediablob/en/391748/data/364260/1/rwe-power-ag/innovations/Brochure-ADELE.pdf

[9] http://www.theguardian.com/environment/2015/apr/08/new-energy-storage-plant-could-revolutionise-renewable-sector

Green lights for electricity storage

7.4.5
Conclusions

The commercial viability of storage is strongly linked to cost competitiveness. This could be achieved through a number of routes, including capital cost reductions, incentives or stacking of revenue streams. **Therefore, only one or two of the developments listed below may be needed to unlock the potential of electricity storage and trigger the inclusion of storage within the FES:**

- legislation that recognises electricity storage as a separate entity
- additional targeted policy support, in addition for innovation funding, such as an incentive or mandate for early adopters
- a business model for storage to provide an alternative to traditional network reinforcement
- the introduction of time of use tariffs and smart meters to encourage self-consumption
- the development of frameworks that enable storage providers to provide services to multiple parties
- the continued trend of cost reductions.

We will continue to assess the role of storage in the scenarios and welcome your feedback through stakeholder workshops and bilateral meetings. The successful applications of storage internationally and emerging requirements nationally highlight the opportunities for storage in GB and the potential value that storage could deliver to the energy industry and end consumers.

Chapter eight

Appendix 1
Government policy

CRC Energy Efficiency Scheme (CRC)

The Carbon Reduction Commitment (CRC) Energy Efficiency Scheme[1] is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large public and private sector organisations. The scheme features a range of reputational, behavioural and financial drivers, which aim to encourage organisations to develop energy management strategies that promote a better understanding and more efficient use of energy.

Electricity Market Reform (EMR)

Electricity Market Reform[2] includes the introduction of new long-term contracts: Contracts for Difference (CfDs) for new low carbon generation projects, a Carbon Price Floor[3] (in place since April 2013) and a Capacity Market, to include demand response, interconnectors and generation. EMR also includes an Emissions Performance Standard (EPS), set at 450gCO_2/kWh, to reinforce the requirement that no new coal-fired power stations are built without carbon capture and storage (CCS) and to ensure necessary investment in gas can take place. The Energy Act of 2013 gave the Secretary of State for Energy and Climate Change the power to introduce these elements of EMR (to work alongside the Carbon Price Floor[1]).

National Grid as the National Electricity Transmission System Operator (NETSO) has been appointed as the Delivery Body for EMR. This involves administering the Capacity Market and CfDs on behalf of DECC, as well as providing key analysis to inform decision making.

Our analysis of EMR is ongoing. We have taken account of the main themes in deriving our power supply backgrounds, shown in chapter 5. We assume that the mechanisms will play a part in maintaining adequate plant margins and will ensure that there is sufficient renewable and low carbon generation to meet the renewable and carbon targets in the **Gone Green** scenario.

Feed-In Tariffs scheme (FIT)

The Feed-In Tariffs scheme[4] aims to encourage small scale renewable and low carbon electricity generation by paying users for each unit of electricity generated, as well as a payment for each unit exported to the grid. The scheme is applicable to a number of technologies (solar PV, wind, hydro, and anaerobic digestion) up to a maximum capacity of 5MW of total installed capacity (TIC). Micro combined heat and power (mCHP) plants are also eligible up to 2kW.

Green Deal Energy Company Obligation (ECO)

Green Deal[5] replaces the Carbon Emissions Reduction Target[6] (CERT). It allows individuals and businesses to make energy efficiency improvements to their buildings at no upfront cost through access to the finance needed for the improvements with repayment, in instalments, attached to the electricity bill. Research conducted by GfK NOP showed that in November 2013, 23% of consumers were aware of the Green Deal[7]. It is estimated that 26 million homes could be eligible for Green Deal financing. By the end of March 2015, over 530,000 Green Deal assessments had been carried out, 184 authorised Green Deal providers had been registered and 2,258 organisations were signed up to carry out installations[8].

[1] https://www.gov.uk/crc-energy-efficiency-scheme-qualification-and-registration#overview
[2] https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform
[3] The carbon price floor was legislated for in the 2011 Finance Act
[4] https://www.gov.uk/feed-in-tariffs
[5] https://www.gov.uk/green-deal-energy-saving-measures
[6] http://webarchive.nationalarchives.gov.uk/20121217150421/www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx
[7] https://www.gov.uk/government/publications/green-deal-household-tracker-wave-3
[8] https://www.gov.uk/government/collections/green-deal-and-energy-company-obligation-eco-statistics

Energy Company Obligation (ECO)

The Energy Company Obligation (ECO) commenced in 2013 and will operate until March 2017. It places a legal obligation on energy suppliers to satisfy energy efficiency and fuel saving targets to households. ECO is primarily focused on households unable to achieve significant energy savings from Green Deal without an additional or different measure of support. ECO is directed towards vulnerable and low-income households, community schemes, and those living in harder to treat properties, such as those with solid walls.

Industrial Emissions Directive (IED)

The Industrial Emissions Directive[9] is a European Union directive which commits member states to control and reduce the impact of industrial emissions on the environment post-2015 when the Large Combustion Plant Directive (LCPD) expires.

Under the terms of the IED, affected plant can:

- Opt out and continue running under previous (LCPD) emission limits.
- Opt in under the Transitional National Plan (TNP), which will impose a cap on annual mass nitrogen oxide emissions and a decreasing cap on annual mass sulphur dioxide emissions on all plants operating under a country's TNP until mid-2020. At that point they will have to decide whether to fit appropriate emission-reducing equipment to comply with the directive, be limited to run a maximum of 1,500 hours a year or close.
- Opt in and comply fully from 1 January 2016. This will mean fitting selective catalytic reduction equipment or additional flue-gas de-sulphurisation technology for some plants.

Large Combustion Plant Directive (LCPD)

The Large Combustion Plant Directive[10] is a European Union directive which introduced measures to control the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant. Large power stations (installed capacity greater than 50MW) in the UK must comply with the LCPD. Plants that 'opt out' of meeting the new standards must close by 2015 or after 20,000 hours of operation.

Levy Control Framework (LCF)

The Levy Control Framework[11] caps the annual amount of money that can be levied on bills to support UK low carbon generation at £2.35bn in 2012/13, rising to £7.6bn in 2020/21. This covers Feed-in Tariffs (FITs), Renewables Obligation (RO) and Contracts for Difference.

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive[12] scheme provides payments for heat generated from renewable technologies including biomass boilers, solar thermal and heat pumps. There are three distinct phases of financial support:

- RHI Phase 1 – for commercial, industrial, public, not-for-profit and community generators of renewable heat
- RHI Phase 2 – a renewable heat premium payment (RHPP) to householders who have no access to the gas network and who generate renewable heat. Under RHPP householders receive a single payment for the installation of renewable heat technology
- RHI Phase 3 – for householders generating renewable heat. Householders will receive regular annual or quarterly payments for heat generated.

[9] http://www.official-documents.gov.uk/document/hc1012/hc16/1604/1604.pdf (page 12)

[10] https://www.gov.uk/government/publications/environmental-permitting-guidance-the-large-combustion-plants-directive

[11] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48244/3290-control-fwork-decc-levyfunded-spending.pdf

[12] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi

Appendix 1
Government policy

Renewables Obligation (RO)
The Renewables Obligation[13] (RO) is the main support mechanism for renewable electricity projects in the UK. Smaller scale generation is mainly supported through the Feed-in Tariff scheme (FITs).

The RO came into effect in 2002 in England and Wales, and Scotland, followed by Northern Ireland in 2005. It places an obligation on UK electricity suppliers to source an increasing proportion of the electricity they supply from renewable sources.

Renewables Obligation Certificates (ROCs) are green certificates issued to operators of accredited renewable generating stations for the eligible renewable electricity they generate. Operators can trade ROCs with other parties. ROCs are ultimately used by suppliers to demonstrate that they have met their obligation.

Where suppliers do not present a sufficient number of ROCs to meet their obligation, they must pay an equivalent amount into a buy-out fund. The administration cost of the scheme is recovered from the fund and the rest is distributed back to suppliers in proportion to the number of ROCs they produced in respect of their individual obligation.

Energy Saving Opportunities Scheme (ESOS)
The government established ESOS[14] to implement Article 8 (4-6) of the EU Energy Efficiency Directive (2012/27/EU). The ESOS Regulations 2014 give effect to the scheme.

ESOS is a mandatory energy assessment scheme for organisations in the UK that meet the qualification criteria. The Environment Agency is the UK scheme administrator.

Organisations that qualify for ESOS must carry out ESOS assessments every 4 years. These assessments are audits of the energy used by their buildings, industrial processes and transport to identify cost-effective energy saving measures.

Organisations must notify the Environment Agency by a set deadline that they have complied with their ESOS obligations, the first of which is 5 December 2014.

[13] https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro
[14] https://www.gov.uk/energy-savings-opportunity-scheme-esos

Appendix 2 – Meet the Energy, Strategy & Policy team

Balancing and Markets
We explore the future electricity balancing challenges and opportunities relating to changing generation and demand. We consider the role that technologies such as interconnectors, electricity storage, demand side response and other innovative solutions may play in the future balancing toolkit. Engagement with stakeholders is vital to the development of ourinterconnector scenarios and through industry groups and bilateral meetings we ensure all perspectives are taken into consideration. We welcome your views on balancing the electricity system over coming decades.

Emma Carr
Balancing and Markets Manager

Dave Wagstaff
EMR Network Cost Analyst

Iain Ashworth
Balancing Analyst

Matthew Speedy
Balancing Analyst

Rhiannon Grey
Balancing Analyst

EMR Modelling
Our team was set up to fulfil part of National Grid's obligations as Electricity Market Reform (EMR) Delivery Body. Our responsibilities include analysis used to recommend the capacity to procure in the Capacity Market that is published annually in our Electricity Capacity Reports and modelling to inform the setting of strike prices for Contracts for Difference (CfDs) as illustrated by our report for the EMR Delivery Plan. We also carry out related modelling work outside of our EMR responsibilities, for example to inform the volume of the new balancing services (SBR and DSBR) required in the mid-decade years.

Duncan Rimmer
EMR Modelling Manager

Ajay Pandey
EMR Senior Data Officer

Gareth Lloyd
EMR Analytical Manager

Simon Geen
EMR Analytical Manager

Gas Demand
As the gas demand team we project the usage of gas for both the Industrial and Commercial markets and the residential sector. We utilise various modelling tools and techniques to support our analysis alongside taking part in several industry discussion groups to balance our statistical analysis with innovative thinking on the future of gas. Heat forms a significant part of our analysis as this is currently dependent on gas in addition to transport which has the potential to become more reliant on gas. Amongst our stakeholders, we engage with gas providers and distribution networks to ensure we're using the most up to date information. If you can share any views on gas demand, please get in touch.

Iain Shepherd
Energy Demand Analyst

Phil Clough
Gas Demand Analyst

Rob Nickerson
Senior Gas Demand Analyst

Appendix 2 – **Meet the Energy, Strategy & Policy team**

Gas Supply
We take gas demand projections from our colleagues in the Gas Demand team and work out how much gas will have to come from different sources to meet the demand. Our work depends very much on detailed industry knowledge rather than complicated mathematical modelling, and is helped by the 70 years of industry experience that we have between us. During the year we talk to major industry players, producers, terminal operators, other network operators and potential developers. We also attend industry discussions, all to make sure that we are working with the best possible information when we come to make our supply to demand match. If you have anything that you think we should know about possible gas supplies we'd be very interested to hear from you.

Simon Durk
Gas Supply Manager

Nigel Bradbury
Primary Energy Analyst

Chris Thompson
Senior Gas Supply Analyst

Christian Parsons
Gas Supply Analyst

Market Outlook
We bring together expert thinking, market data, industry experts, stakeholder feedback and indepth analysis to create a rounded view of the future of energy. Our publications cover the short, medium and longer-term including the Winter and Summer Outlook Reports, the Winter Consultation, the Safety Monitors Report and, of course, the Future Energy Scenarios (FES). Our role is to extract the key messages from the inputs and analysis to give a clear direction to National Grid and the industry on energy trends, landscapes and the future energy challenges. We also produce the Stakeholder Feedback document that summarises views from interested parties on the FES document and provides a commentary of how these responses have been used to develop and progress the scenarios. We welcome your views on the content of all these documents.

Catherine Lange
Market Outlook Manager

Andy Dobbie
Energy Security Analyst

Caroline Kluyver
Content Officer

Chris Thackeray
Content Officer

Duncan Sluce
Energy Security Analyst

Faye Relton
Strategy Analyst

Power Demand
We spend much of our time striving to understand electricity usage once it's been generated. Our models are concerned with what people do with electricity in their day-to-day lives, from the home to the office and beyond, from an annual basis right down to an understanding of within day usage profiles. This considers the future landscape for transport, heating and lighting. To understand potential electricity usage, we engage with members of Britain's society, including homeowners, business people, academics and journalists. We also regularly attend a wide range of industry events and conferences along with reading a wide range of publications and annual reports. Please let us know your thoughts and opinions on power demand and how this may change into the future.

Russell Fowler
Power Demand Manager

Huw Thomas
Power Demand Analyst

Kein-Arn Ong
Senior Power Demand Analyst

Orlando Elmhirst
Senior Power Demand Analyst

Power Supply
We consider the sources of generation that will be used to meet power demand now and in the future. We consider all sources of generation (both established and emerging technologies) irrespective of where and how they are connected. We consider how the political ambition, environmental legislation, the economic climate, technological advancements and social engagement influence electricity generation. We look forward to discussing with you our power supply scenarios and will be delighted to hear from you if you have any information on power supply which could be included in our analysis.

Lilian MacLeod
Power Supply Manager

Dr Giuliano Bordignon
Senior Power Economics Analyst

Greg Hunt
Senior Power Supply Analyst

Janet Coley
Senior Power Supply Analyst

Luke Cutler
Power Supply Analyst

Mark Perry
Senior Power Supply Analyst

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Appendix 3
Glossary

Acronym	Word	Description
ACT	Advanced conversion technology	Gasification, pyrolysis or anaerobic digestion, or any combination of those.
ASHP	Air source heat pump	Air source heat pumps absorb heat from the outside air. This heat can then be used to produce hot water or space heating.
ARA	Amsterdam Rotterdam and Antwerp (Coal Price)	The cost of coal in the major NW Europe coal importing ports of Amsterdam/Rotterdam/Antwerp (ARA). http://www.worldcoal.org/resources/coal-statistics/shipping-terms-glossary/
AD	Anaerobic digestion	Bacterial fermentation of organic material in the absence of free oxygen.
	Ancillary services	Services procured by a system operator to balance demand and supply and to ensure the security and quality of electricity supply across the transmission system. These services include reserve, frequency control and voltage control. In GB these are known as balancing services and each service has different parameters that a provider must meet.
	Annual power demand	The electrical power demand in any one fiscal year. Different definitions of annual demand are used for different purposes.
ACS	Average cold spell	Average cold spell: defined as a particular combination of weather elements which gives rise to a level of winter peak demand which has a 50% chance of being exceeded as a result of weather variation alone. There are different definitions of ACS peak demand for different purposes.
BBL	Balgzand Bacton Line	A gas pipeline between Balgzand in the Netherlands and Bacton in the UK. http://www.bblcompany.com
	Baseload electricity price	The cost of wholesale electricity paid for baseload power.
bcm	billion cubic metres	Unit or measurement of volume, used in the gas industry. 1 bcm = 1,000,000,000 cubic metres
	Biogas	Biogas is a naturally occurring gas that is produced from organic material and has similar characteristics to natural gas.
	Biomethane	We use the term biomethane specifically for biogas that is of a suitable quality to be injected into distribution or transmission networks. http://www.biomethane.org.uk/
	Boil-off	A small amount of gas which continually boils off from LNG storage tanks. This helps to keep the tanks cold.
CM	Capacity Market	The Capacity Market is designed to ensure security of electricity supply. This is achieved by providing a payment for reliable sources of capacity, alongside their electricity revenues, ensuring they deliver energy when needed.
CCS	Carbon capture and storage	Carbon (CO_2) Capture and Storage (CCS) is a process by which the CO_2 produced in the combustion of fossil fuels is captured, transported to a storage location and isolated from the atmosphere. Capture of CO_2 can be applied to large emission sources like power plants used for electricity generation and industrial processes. The CO_2 is then compressed and transported for long-term storage in geological formations or for use in industrial processes.
CO_2	Carbon dioxide	Carbon dioxide (CO_2) is the main greenhouse gas and the vast majority of CO_2 emissions come from the burning of fossil fuels (coal, natural gas and oil).
CPF	Carbon price floor	A price paid by UK generators and large carbon intensive industries for CO_2 emissions.
CPS	Carbon price support	A price paid by UK generators and large carbon intensive industries in addition to the EU ETS to guarantee a minimum floor price for CO_2 emissions.
CRC	Carbon Reduction Commitment	See appendix on government policy. The Carbon Reduction Commitment is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large public sector and large private sector organisations.
	Cash out	Prices that are used to settle the difference between contracted generation or consumption and the amount that was actually generated or consumed in each half hour trading period

Acronym	Word	Description
	Climate change targets	Targets for share of energy use sourced from renewable sources. The 2020 UK targets are defined in the Directive 2009/28/EC of the European Parliament and of the Council of the European Union, see http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0028&from=EN#ntc1-L_2009140EN.01004601-E0001
CBM	Coal bed methane	Coal bed methane is methane that is extracted from un-mined coal seams by drilling wells directly into the seams to release the gas. http://www.worldcoal.org/coal/coal-seam-methane/coal-bed-methane/
COP	Coefficient of performance	The ratio of heating (or cooling) provided per electrical energy consumed.
CCGT	Combined cycle gas turbine	Gas turbine that uses the combustion of natural gas or diesel to drive a gas turbine generator to generate electricity. The residual heat from this process is used to produce steam in a heat recovery boiler which in turn, drives a steam turbine generator to generate more electricity.
CHP	Combined heat and power	A system whereby both heat and electricity are generated simultaneously as part of one process. Covers a range of technologies that achieve this.
CFL	Compact fluorescent light	A lighting technology introduced to replace traditional incandescent bulbs. Commonly referred to as energy saving bulbs.
CWV	Composite weather variable	A measure of weather incorporating the effects of both temperature and wind speed. We have adopted the new industry wide CWV equations that take effect on 1 October 2015.
CNG	Compressed natural gas	Compressed natural gas is made by compressing natural gas to less than 1 percent of the volume it occupies at standard atmospheric pressure.
CfD	Contract for Difference	See appendix on government policy. Contract between the Low Carbon Contracts Company (LCCC) and a low carbon electricity generator designed to reduce its exposure to volatile wholesale prices.
DBSR	Demand side balancing reserve	Demand side balancing reserve (DSBR) is a balancing service that has been developed to support National Grid in balancing the system during the mid-decade period when capacity margins are expected to be tight. DSBR is targeted at large energy users who volunteer to reduce their demand during winter week-day evenings between 4 and 8pm in return for a payment. Along with supplemental balancing reserve (SBR), this service will act as a safety net to protect consumers, only to be deployed in the event of there being insufficient capacity available in the market to meet demand.
DSR	Demand side response	A deliberate change to an industrial and commercial user's natural pattern of metered electricity or gas consumption, brought about by a signal from another party.
DECC	Department of Energy and Climate Change	A UK government department: The Department of Energy & Climate Change (DECC) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change.
	Deterministic	A modelling approach that produces a single view or outcome. This approach has no random elements as all outcomes and inputs are completely determined.
DUKES	Digest of UK Energy Statistics	A DECC publication which contains historic information on energy in the UK.
	Dispatch (aka economic dispatch)	The operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities.
	Distributed generation	Generation connected to the distributed networks which is equal or greater than 1 MW in size, up to onshore transmission areas' mandatory connection thresholds. The thresholds are 100 MW in NGET transmission area, 30 MW in Scottish Power (SP) transmission area and 10 MW in Scottish Hydro-Electric Transmission (SHET) transmission area.
	Distribution losses	Power losses that are caused by the electrical resistance of the distribution system.
DNO	Distribution network operator	Distribution network operators own and operate gas or electricity distribution networks.

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Acronym	Word	Description
EV	Electric vehicle	An electric vehicle has an electric motor to drive the vehicle. It can either be driven solely off a battery, as part of a hybrid system or have a generator that can recharge the battery but does not drive the wheels. We only consider EVs that can be plugged in to charge in this report.
EMR	Electricity Market Reform	See appendix on government policy. A government policy to incentivise investment in secure, low-carbon electricity, improve the security of Great Britain's electricity supply, and improve affordability for consumers.
ELSI	Electricity scenario illustrator	ELSI is a National Grid tool used to model network constraint costs and interconnector flows.
	Electricity storage technologies	Mechanical (for example, pumped hydro and compressed air), thermal (for example, molten salt), electrical (for example, supercapacitors), electrochemical (various battery types), chemical (for example, hydrogen). Each technology has different characteristics, such as speed and duration of response, scale and maturity status.
ETYS	Electricity Ten Year Statement	The ETYS illustrates the potential future development of the National Electricity Transmission System (NETS) over a ten year (minimum) period and is published on an annual basis.
ETL	Electricity Transmission Licence	A permit which allows transmission companies to own and operate electricity transmission assets. Conditions within the licence place rules on how holders can operate within their licence.
	Embedded generation	Power generating stations/units that don't have a contractual agreement with the National Electricity Transmission System Operator (NETSO). They reduce electricity demand on the National Electricity Transmission System.
ECO	Energy Company Obligation	See appendix on government policy. The scheme places a legal obligation on energy suppliers to help households meet energy efficiency and fuel savings targets.
ECUK	Energy Consumption in the UK	A UK government publication which reviews historic energy consumption and changes in efficiency, intensity and output since the 1970s.
ENA	Energy Networks Association	The Energy Networks Association is an industry association funded by gas or transmission and distribution licence holders.
ESOS	Energy Savings Opportunity Scheme	See appendix on government policy. The Energy Savings Opportunity Scheme is a mandatory energy assessment scheme for qualifying organisations in the UK.
	Error correcting model	A model with the characteristics that the deviation of the current state from its long-run relationship will be fed into its short-run dynamics.
EU ETS	EU Emissions Trading Scheme (EU ETS)	A European Union trading scheme that allows participants to buy and sell carbon emissions allowances. https://www.gov.uk/eu-ets-carbon-markets
ENTSO-E	European Network of Transmission System Operators – Electricity	ENTSO-E is an association of European electricity TSOs. ENTSO-E was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims at further liberalising electricity markets in the EU.
EU	European Union	A political and economic union of 28 member states that are located primarily in Europe.
FiT	Feed-in Tariffs	See appendix on government policy. Government programme designed to promote the uptake of a range of small-scale renewable and low-carbon electricity generation technologies
FIDER	Final Investment Decision Enabling for Renewables	Scheme to help developers of low carbon electricity projects make final investment decisions ahead of the Contract for Difference regime.
FFR	Firm Frequency Response	Firm Frequency Response (FFR) is the firm provision of Dynamic or Non-Dynamic Response to changes in Frequency. http://www2.nationalgrid.com/uk/services/balancing-services/frequency-response/firm-frequency-response/
	Foot room	The ability for a generation plant to allow output to decrease without going below its minimum output level and disconnecting from the system.

Acronym	Word	Description
	Frequency controlled demand management	Frequency control demand management (FCDM) provides frequency response through interruption of demand customers. The electricity demand is automatically interrupted when the system frequency transgresses the low frequency relay setting on site. http://www2.nationalgrid.com/uk/services/balancing-services/frequency-response/frequency-control-by-demand-management/
	Frequency response	An ancillary service procured by National Grid as system operator to help ensure system frequency is kept as close to 50Hz as possible. Also known as frequency control or frequency regulation.
FES	Future Energy Scenarios	The FES is a range of credible futures which has been developed in conjunction with the energy industry. They are a set of scenarios covering the period from now to 2050, and are used to frame discussions and perform stress tests. They form the starting point for all transmission network and investment planning, and are used to identify future operability challenges and potential solutions.
GTYS	Gas Ten Year Statement	The GTYS illustrates the potential future development of the (gas) National Transmission System (NTS) over a ten year period and is published on an annual basis.
GW	Gigawatt	1,000,000,000 watts, a measure of power
GWh	Gigawatt hour	1,000,000,000 watt hours, a unit of energy
gCO_2/kWh	Gram of carbon dioxide per kilowatt hour	Measurement of CO_2 equivalent emissions per kWh of energy used or produced
GB	Great Britain	A geographical, social and economic grouping of countries that contains England, Scotland and Wales.
	Green Deal	See appendix on government policy. A scheme that allows individuals and businesses to make energy efficiency improvements to their buildings.
GDHIF	Green Deal Home Improvement Fund	See appendix on government policy. A scheme that allows individuals to get financial support for qualifying energy efficiency improvements to homes.
GHG	Green house gases	A gas in the atmosphere that absorbs and emits radiation within the thermal infrared range.
GDP	Gross Domestic Product	An aggregate measure of production equal to the sum of the gross values added of all resident, institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs).
GVA	Gross Value Added	The value of goods and services produced in a sector of the economy
GSHP	Ground source heat pump	Ground source heat pumps absorb heat from the ground. This heat can then be used to produce hot water or space heating.
	Head Room	The operation of generation plant below its minimum output levels to allow output to increase at times of need.
	Heat pump	A heat pump is a device that provides heat energy from a source of heat to a destination called a "heat sink".
HGV	Heavy goods vehicle	A truck weighing over 3,500kg.
HHDI	Household disposable income	Household income minus tax.
IED	Industrial Emissions Directive	See appendix on government policy. The Industrial Emissions Directive is a European Union directive which commits member states to control and reduce the impact of industrial emissions on the environment post-2015 when the Large Combustion Plant Directive (LCPD) expires.
ITPR	Integrated Transmission Planning and Regulation	Ofgem's Integrated Transmission Planning and Regulation (ITPR) project examined the arrangements for planning and delivering the onshore, offshore and cross-border electricity transmission networks. Ofgem published the final conclusions in March 2015.
IUK	Interconnector (UK)	A bi-directional gas pipeline between Bacton in the UK and Zeebrugge Belgium. http://www.interconnector.com

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Acronym	Word	Description
	interconnector, gas	Gas interconnectors connect gas transmission systems from other countries to the National Transmission System (NTS) in England, Scotland and Wales. There are currently three gas interconnectors which connect to the NTS. These are: – IUK interconnector to Belgium – BBL to the Netherlands – Moffat to the Republic of Ireland, Northern Ireland and the Isle of Man.
	interconnector, power	Electricity interconnectors are transmission assets that connect the GB market to Europe and allow suppliers to trade electricity between markets.
IRR	Internal Rate of Return	The annualised rate of return, independent of inflation, for the net present value of an investment of zero in a given time frame.
IEA	International Energy Agency	The International Energy Agency is an intergovernmental organisation that acts as an energy policy advisor to member states.
LCPD	Large Combustion Plant Directive	See appendix on government policy. The Large Combustion Plant Directive is a European Union Directive which introduced measures to control the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant.
LCF	Levy Control Framework	See appendix on government policy. The Levy Control Framework caps the annual amount of money that can be levied on bills to support UK low carbon generation at £2.35bn in 2012/13, rising to £7.6bn in 2020/21. This covers Feed-in Tariffs (FITs), Renewables Obligation (RO) and Contracts for Difference.
LED	Light emitting diode	An energy efficient electronic lighting technology which is increasingly being adopted in UK homes and businesses.
LNG	Liquefied natural gas	LNG is formed by chilling gas to -161˚C so that it occupies 600 times less space than in its gaseous form. www2.nationalgrid.com/uk/Services/Grain-lng/what-is-lng/
	Load Factor	the average power output divided by the peak power output over a period of time.
LDZ	Local Distribution Zone	A gas distribution zone connecting end users to the (gas) National Transmission System.
LOLE	Loss of load expectation	LOLE is used to describe electricity security of supply. It is an approach based on probability and is measured in hours/year. It measures the risk, across the whole winter, of demand exceeding supply under normal operation. This does not mean there will be loss of supply for X hours/year. It gives an indication of the amount of time, across the whole winter, which the system operator (SO) will need to call on balancing tools such as voltage reduction, maximum generation or emergency assistance from interconnectors. In most cases, loss of load would be managed without significant impact on end consumers.
LCCC	Low Carbon Contracts Company	Private company owned by the Department of Energy and Climate Change (DECC) that manages the Contracts for Difference (CFD) scheme introduced by government as part of the EMR programme.
LCHT	Low carbon heating technology	A heating technology that has a lower carbon intensity for heating homes than an A rated condensing gas boiler
LCNF	Low Carbon Network Fund	A fund established by Ofgem to support projects sponsored by the distribution network operators (DNOs) to try out new technology, operating and commercial arrangements.
	Marine technologies	Tidal streams, tidal lagoons and energy from wave technologies (see http://www.emec.org.uk/)
	Medium range storage	These commercially operated sites have shorter injection/withdrawal times so can react more quickly to demand, injecting when demand or prices are lower and withdrawing when higher. http://www2.nationalgrid.com/UK/Our-company/Gas/Gas-Storage/
MWe	Megawatt (electrical)	1,000,000 Watts, a measure of power.
MWh	Megawatt hour	1,000,000 Watt hours, a measure of power usage or consumption in 1 hour.
	Merit Order	An ordered list of generators, sorted by the marginal cost of generation.
mCHP	Micro-Combined Heat and Power	A subset of CHP, designed for domestic use.

Acronym	Word	Description
	Micro generation	Defined within this document as generation units with an installed capacity of less than 1 MW.
mcm	Million cubic meters	Unit or measurement of volume, used in the gas industry. 1 mcm = 1,000,000 cubic metres.
Mte CO_2	Million tonnes of CO_2 equivalent	Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, 100 years).
	N-1	Refers to the European Commission security of supply test, where total supply minus the largest single loss is assessed against total peak demand. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:295:0001:0022:EN:PDF
NBP	National balancing point	The wholesale gas market in Britain has one price for gas irrespective of where the gas comes from. This is called the national balancing point (NBP) price of gas and is usually quoted in pence per therm of gas.
	National balancing point (NBP) gas price	Britain's wholesale NBP Gas price is derived from the buying and selling of natural gas in Britain after it has arrived from offshore production facilities. https://www.ofgem.gov.uk/gas/wholesale-market/gb-gas-wholesale-market
NETS	National Electricity Transmission System	It transmits high-voltage electricity from where it is produced to where it is needed throughout the country. The system is made up of high voltage electricity wires that extend across Britain and nearby offshore waters. It is owned and maintained by regional transmission companies, while the system as a whole is operated by a single system operator (SO).
NTS	National Transmission System	A high-pressure gas transportation system consisting of compressor stations, pipelines, multijunction sites and offtakes. NTS pipelines transport gas from terminals to NTS offtakes and are designed to operate up to pressures of 94 barg.
NGV	Natural gas vehicle	A vehicle which uses compressed or liquefied natural gas as an alternative to petrol of diesel.
NOx	Nitrous oxide	A group of chemical compounds, some of which are contributors to pollution, acid rain or are classified as green house gases.
OFGEM	Office of Gas and Electricity Markets	The UK's independent National Regulatory Authority, a non-ministerial government department. Their principal objective is to protect the interests of existing and future electricity and gas consumers.
	Oil & Gas UK	Oil & Gas UK is a representative body for the UK offshore oil and gas industry. It is a not-for-profit organisation, established in April 2007. http://www.oilandgasuk.co.uk
OCGT	Open Cycle Gas Turbine	Gas turbines in which air is first compressed in the compressor element before fuel is injected and burned in the combustor.
	Passivhaus	A Passivhaus is a building, for which thermal comfort can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air.
	Peak demand, electricity	The maximum power demand in any one fiscal year: Peak demand typically occurs at around 5:30pm on a week-day between December and February. Different definitions of peak demand are used for different purposes.
	Peak demand, gas	The 1-in-20 peak day demand is the level of demand that, in a long series of winters, with connected load held at levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.
pa	Per annum	per year.
PV	Photovoltaic	A method of converting solar energy into direct current electricity using semi-conducting materials.
PHEV	Plug-in hybrid electric vehicle	Has a battery which can be charged by plugging it in as well as a regular engine.
	Power supply background (aka Generation background)	The sources of generation across Great Britain to meet the power demand.

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Acronym	Word	Description
	Pumping demand	The power required by hydro-electric units to pump water into the reservoirs.
PEV	Pure electric vehicle	Has only a battery for energy storage.
RHI	Renewable Heat Incentive	See appendix on government policy. A payment incentive owned by Ofgem which pays owners of certain, renewable heating technologies per unit of heat produced. There is a domestic and a non-domestic version.
ROC	Renewable Obligation Certificate	See appendix on government policy. Green certificates issued to operators of accredited renewable generating stations for the eligible renewable electricity they generate. ROCs are ultimately used by suppliers to demonstrate that they have met their obligation.
RO	Renewables Obligation	See appendix on government policy. Main support mechanism for renewable electricity projects in the UK. It places an obligation on UK electricity suppliers to source an increasing proportion of the electricity they supply from renewable sources.
R&D	Research and development	A general term for activities which involve improvements to goods or processes, or research into new goods or processes.
	Seasonal storage or long-range storage	There is one long-range storage site on the national transmission system: Rough, situated off the Yorkshire coast. Rough is owned by Centrica and mainly puts gas into storage (called 'injection') in the summer and takes gas out of storage in the winter. http://www2.nationalgrid.com/UK/Our-company/Gas/Gas-Storage/
	Self-consumption	Where an end user consumes the electricity they generate, commonly from solar generation. This reduces the need to import electricity from grid but does not necessarily mean an end user is self-sufficient.
	Shale gas	Shale gas is natural gas that is found in shale rock. It is extracted by injecting water, sand and chemicals into the shale rock to create cracks or fractures so that the shale gas can be extracted. https://www.gov.uk/government/publications/about-shale-gas-and-hydraulic-fracturing-fracking
SRMC	Short run marginal cost	The instantaneous variable cost for a power plant to provide an additional unit of electricity. The short run marginal cost (SRMC) is derived from the cost of fuel, the cost of CO_2 emissions, the share of operating and maintenance (O&M) costs that varies with the plant electricity output and any income from incentives and the provision of heat associated to the plant electricity output.
STOR	Short term operating reserve	Short term operating reserve (STOR) is a service for the provision of additional active power from generation and/or demand reduction.
	Smart appliances	Residential power consuming goods which are able to reduce their power demand at defined times of the day either by reacting to a signal or by being programmed.
	Smart meter	New generation gas and electricity meters which have the ability to broadcast secure usage information to customers and energy suppliers, potentially facilitating energy efficiency savings and more accurate bills.
	Station demand	The onsite power station requirement, for example for systems or start up.
	Summer minimum	The minimum power demand off the transmission network in any one fiscal year: Minimum demand typically occurs at around 06:00am on a Sunday between May and September.
SBR	Supplemental balancing reserve	Supplemental balancing reserve (SBR) is a balancing service that has been developed to support National Grid in balancing the system during the mid-decade period when capacity margins are expected to be tight. SBR is targeted at keeping power stations in reserve that would otherwise be closed or mothballed. Along with demand side balancing reserve (DSBR), this service will act as a safety net to protect consumers, only to be deployed in the event of there being insufficient capacity available in the market to meet demand.
	System inertia	The property of the system that resists changes. This is provided largely by the rotating synchronous generator inertia that is a function of the rotor mass, diameter and speed of rotation. Low system inertia increases the risk of rapid system changes.
	System operability	The ability to maintain system stability and all of the asset ratings and operational parameters within pre-defined limits safely, economically and sustainably.

Acronym	Word	Description
SO	System operator	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure. Unlike a TSO, the SO may not necessarily own the assets concerned. For example, National Grid operates the electricity transmission system in Scotland, which is owned by Scottish Hydro Electricity Transmission and Scottish Power.
TWh	Terawatt hour	1,000,000,000,000 watt hours, a unit of energy
TOUT	Time Of Use Tariff	A charging system that is established in order to incentivise residential consumers to alter their consumption behaviour – usually away from high power demand times.
tCO^2	Tonne of carbon dioxide	A fixed unit of measurement commonly used when discussing carbon dioxide emissions.
TEC	Transmission entry capacity	The maximum amount of active power deliverable by a power station at its grid entry point (which can be either onshore or offshore). This will be the maximum power deliverable by all of the generating units within the power station, minus any auxiliary loads.
	Transmission losses	Power losses that are caused by the electrical resistance of the transmission system.
TSO	Transmission system operators	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure.
	Triad	Triad demand is measured as the average demand on the system over three half hours between November and February (inclusive) in a financial year. These three half hours comprise the half hour of system demand peak and the two other half hours of highest system demand which are separated from system demand peak and each other by at least ten days.
UKCS	UK Continental Shelf	The UK Continental Shelf (UKCS) comprises those areas of the sea bed and subsoil beyond the territorial sea over which the UK exercises sovereign rights of exploration and exploitation of natural resources.
UK	United Kingdom of Great Britain and Northern Ireland	A geographical, social and economic grouping of countries that contains England, Scotland, Wales and Northern Ireland.
UCL	University College London	A UK university based in London.
	Weather corrected	The actual demand figure that has been adjusted to take account of the difference between the actual weather and the seasonal normal weather.

Annual data in FES

Where a single year is referred to in FES, e.g. 2020, we are referring to that calendar year.

Where data is across split years, e.g. 2020/21, we are referring to power years. These run from 1 April to 31 March. For example, 2020/21 refers to 1 April 2020 to 31 March 2021.

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