nationalgrid

Future Energy Scenarios 2017

FAQs

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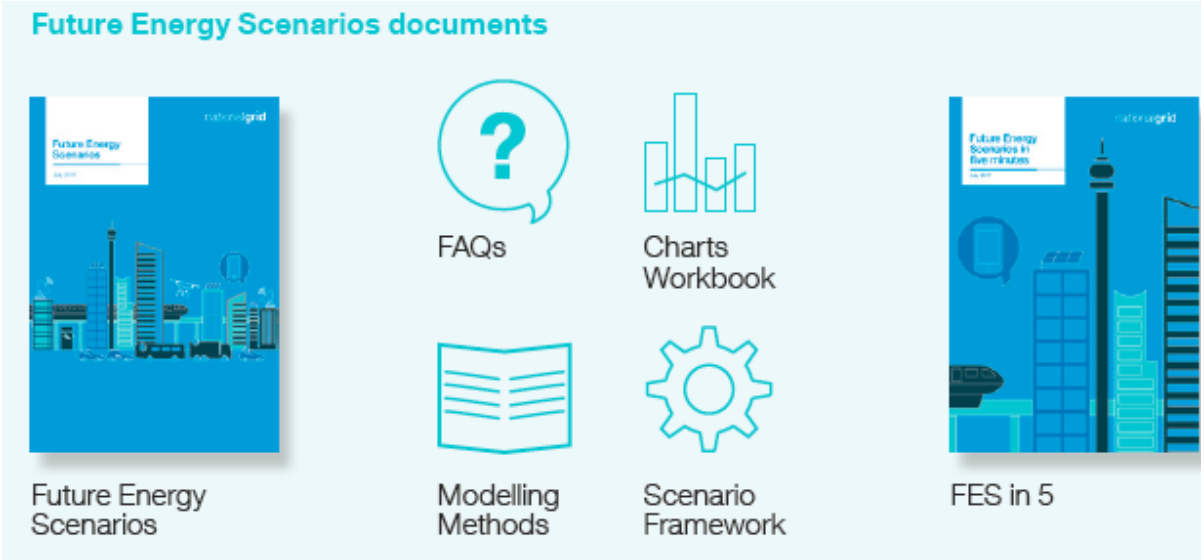
Our **Frequently Asked Questions** (FAQs) publication is just one of a suite of documents we produce as part of our Future Energy Scenarios (FES) process. A huge amount of work - including modelling, analysis and interpretation - goes into the production of the main document. For ease of use we only highlight significant changes to our modelling methods in the main **FES** document. Alongside this publication we have the **Scenario Framework** that details all the assumptions and levers that are used as input into our models. Our **Charts Workbook** contains all the outputs from the numerous models: the detailed tables, graphs and charts. We also publish a summary document, **FES in 5,** and our **Modelling Methods**. For more information and to view each of these documents visit our website: www.fes.nationalgrid.com



This document seeks to answer the main questions we receive as we publish the **FES**. This document has now been updated (v2.0) to address the questions we received on the day of the FES conference itself, as well as some frequent questions sent to us after the event. We will continue to update this document, ensuring the latest question and answers are shared. As with our other FES documents we welcome your feedback, please contact us at: transmission.ukfes@nationalgrid.com

Contents

General questions

Q: How do I ask questions or seek further information about the Future Energy Scenarios (FES)?

A: Please send questions via email to transmission.ukfes@nationalgrid.com . We will answer your questions as soon as we can.

Q: FES looks different this year compared to last year. What has changed?

A: The main FES document is just one of a suite of documents we produce as part of our FES process. A huge amount of work, including modelling, analysis and interpretation, goes into the production of the main document. For ease of use we have not included all of that data in the main FES document.

Alongside it we have the **Scenario Framework** that details the assumptions and levers that are used as inputs into our models. Our **Charts Workbook** contains the outputs from the numerous models: the detailed tables, graphs and charts. We also publish information on our **Modelling Methods**, a summary document **FES in 5** and these **FAQs**. For more information and to view each of these documents visit: http://fes.nationalgrid.com/

Q: Where can I find further information about the modelling used for FES?

A: Alongside FES 2017 we have the **Scenario Framework** that details all the assumptions and levers that are used as input into our models. We also publish information on our **Modelling Methods** in a separate document. For more information and to view each of these documents visit: www.fes.nationalgrid.com

Q: Where can I find the data published in the FES?

A: The FES charts and the associated data tables are available in the **Charts Workbook**, which can be accessed on our website http://fes.nationalgrid.com/fes-document/. The charts are labelled as they are in the main document (e.g. Figure 3.1).

We have also published additional datasets in the **Charts Workbook**, containing data that supports the FES analysis. The **Charts Workbook** uses the following abbreviations:

CP: Commodity Prices
GD: Gas Demand
PD: Peak Demand
HT: Heating Technologies
TD: Transport Demand
ES: Electricity Supply
GS: Gas Supply

Q: What is the date format in the Charts Workbook?

A: All gas charts are in calendar years, with the exception of gas peak demand, which is in gas years. This runs from 1 October to 30 September. All electricity charts are in financial years, with the exception of Figure 3.11 (Rollout of electricity smart meters, installations per year), which is in calendar years.

About the scenarios

Q: Can the scenarios be translated to a regional level?

A: FES Scenario information is fed into the Electricity and Gas Ten Year Statements (ETYS & GTYS) processes at a regional level. The ETYS and GTYS documents (with data tables included as an annex) are published in November and will be available at: http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

Q: Do we still have an energy trilemma? FES includes flexing green ambition and economic outlook, but does not flex security of supply. Is it now a dilemma?

A: All of our scenarios are designed to meet security of supply standards for electricity and gas. We flex the level of prosperity and green ambition - see page 10 of the main FES document for further details about our scenario matrix.

Q: You talk of partnership working – how will you work with local government?

A: We hope to work with local government in a number of different ways in the future. We invite a number of council energy managers to our FES workshops, as well as engaging with councils on a bilateral basis on specific areas - for example district heating schemes. National Grid has also just launched a £150m Warm Homes Fund to help councils and housing associations install affordable heating systems for households hit by fuel poverty (https://www.affordablewarmthsolutions.org.uk/warm-homes-fund/overview).

Q: There's a risk stakeholder feedback is based on aspiration rather than based on true projections. How is that mitigated when putting together the Future Energy Scenarios?

A: The production of our scenarios is part of an annual development process that has three key stages: stakeholder engagement, data and intelligence gathering, and analysis. At each stage we apply our expertise and judgement to ensure we create plausible and credible scenarios. Feedback from our stakeholders, such as industry experts, is an essential part of the development of FES. This feedback is one of a number of inputs that inform our analysis, making sure our scenarios are independent, well-informed and up to date.

Q: What is your view on the availability of financing (debt and equity), and the likely returns to investors? How do you incorporate this into your analysis?

A: Availability of financing and likely returns to investors are considered in some of our gas and electricity capacity work when making assumptions about particular projects. However, at a macro scale this aspect is captured more generally within the FES framework economic assumptions across the different scenarios.

Decarbonisation

Q: Significant progress has been made in advancing the electricity decarbonisation agenda. Is the Steady State scenario even realistic?

A: Steady State looks at progress as it is now, and extrapolates that rate of development into the future. We continually review our scenarios and scenario framework, based on our own analysis and stakeholder feedback, to determine if any changes are appropriate for FES 2018. Any changes will be shared as part of our Stakeholder Feedback Document 2018.

Q: Is Slow Progression most analogous to the current and likely future UK situation? If so what does this mean for climate targets? If you had to predict the future, which would be the most probable scenario?

A: FES is designed to provide a longer-term view of the range of potential energy landscapes, not to analyse where we are right now. We are not "in" any of the scenarios. The four scenarios we've outlined are based upon pathways beginning today.

Across our industry there is a great degree of uncertainty about the future, including the political, economic, social and technological landscapes. Scenarios are a powerful tool for understanding uncertainty. By providing a range of credible futures, we can be confident that the reality will be captured somewhere within that range. There is too much uncertainty in the future for a credible single view of the future in the timeframe that FES considers (out to 2050).

Q: All of these scenarios fall short, three of them significantly, for 1.5 degree centigrade **global commitment. Should FES 2017's focus not be on options for achieving what is needed?**

A: Two Degrees meets the 2050 decarbonisation target, in line with the Paris Agreement and the Climate Change Act. This represents the action necessary to hold the increase in global temperatures to less than 2 degrees centigrade. We have not considered carbon reductions beyond this target.

Q: In which scenarios are we meeting the 2050 decarbonisation targets and what are the key enablers?

A: Two Degrees meets the 2050 decarbonisation target, driven in particular by renewables and nuclear, as well as decarbonised gas and Carbon Capture and Storage (CCS). Three of the sensitivities in FES 2017 show other possible futures that also meet the 2050 decarbonisation target.

Q: For the Two Degrees scenario what are the three most significant assumptions that would affect the results?

A: Two Degrees assumes the highest level of prosperity to allow investment in low-carbon technologies, and high levels of green ambition in terms of both consumer behaviour and government policy. Under these assumptions there are numerous factors that create the Two Degrees scenario. See our Scenario Framework document for more information.

Q: Isn't your max renewable generation prediction of just 67% by 2050 quite unambitious?

A: Our scenarios have a range of renewable generation, and across our scenarios we have a diverse range of generation. For our Two Degrees scenario this includes other forms of low-carbon generation, such as nuclear and CCS, and as such meets the 2050 carbon reduction target.

Brexit and Europe

Q: How have you changed your scenarios / modelling to reflect Brexit? (Why is Two Degrees more affluent than Consumer Power)?

A: In order to address the uncertainty of the UK leaving the European Union in our modelling, this year we have used a wider range of economic growth scenarios, up from two in FES 2016 to four in FES 2017. Given the uncertainty on future trading arrangements, our current analysis assumes electricity interconnection will maintain tariff free access to European markets under all scenarios. Should further information on future European energy trading arrangements become available, we will consider how any such changes impact our analysis.

Q: What is National Grid's view on the Winter Package (unbundling, market access, regional TSOs, etc.)? Or is this now not relevant due to Brexit?

A: The Clean Energy Package (formerly known as the Winter Package) is arguably the most significant EU legislative development since the Third Energy Package. It contains several thousand pages of draft legislation, covering a great deal of issues affecting all parts of the electricity system. Crucially for National Grid, it features a full review of the existing EU electricity market design legislation (Electricity Directive; Electricity Regulation; ACER Regulation; and a new 'Risk Preparedness Regulation').

This work is still relevant, even in the context of Brexit, as GB will remain interconnected with continental Europe. While nothing is certain at this stage around the outcomes of the Brexit negotiations or our Post-Brexit energy relationship with the EU, it is important that we engage in this opportunity to influence and negotiate on the package to ensure the best possible legislation, as regardless of outcomes of Brexit negotiations on energy and the nature of the future GB-EU relationship, the package will largely govern how our trading partners organise their electricity markets.

Q: Do the FES scenarios consider the lessons and innovations of both developed and developing nations as they are meeting their Paris Climate change targets?

A: We use a range of international data sources in modelling the scenarios, including tracking technological developments. In addition, we work closely with our System Operator European teams who monitor developments in Europe and the impacts they will have on the GB market, in particular the impact on interconnection.

Demand

Q: What are your economic growth scenarios?

A: We used Oxford Economics data to feed into our Industrial and Commercial demand model. In this year's FES we have used four economic conditions that have differing growth rates of Gross Domestic Product (GDP). We believe that these four economic pathways provide enough flexibility to model the potential consequences of the UK leaving the EU. The average GDP growth rates over the FES period are shown in Table 3.1 of the main FES document (see below).

FES Table 3.1: GDP average annual growth rate for each scenario

	Two Degrees	Slow Progression	Steady State	Consumer Power
Growth	2.1%	1.3%	1.0%	1.8%

Q: What definition of electricity demand do you use in FES?

A: In FES we consider underlying demand. That is end-consumer demand, regardless of where (transmission, distribution or on site) that electricity is generated, plus network losses. Demand is weather corrected to seasonal normal for annual and average cold spell (ACS) for peak. For clarity it does not include interconnector exports, station demand, pumping station demand or other forms of storage demand.

Q: How does this definition of electricity demand differ from other National Grid publications?

A: Other National Grid publications (the Electricity Ten Year Statement (ETYS), System Operability Framework (SOF), Network Options Assessment (NOA) and our Outlook documents) consider transmission demand, as they look at future development of the transmission system and year-ahead system security of supply.

Q: What definition of gas demand do you use in FES?

A: In FES we consider end-consumer demand, regardless of whether customers are connected to the distribution or transmission network. FES shows annual totals, so we do not include gas injected into storage as gas flows into and out of storage will net to zero over a year. Demand is corrected to seasonal normal weather. In the demand and sensitivity chapters we include demand within GB; exports to Ireland and continental Europe are excluded. When matching gas supply to demand we include gas for export, losses on the distribution and transmission networks, and gas used in the operation of the system.

Q: Does gas demand in FES include gas used as a feedstock for electricity generation (required as a result of industrial and commercial (I&C) electrical demand)?

A: I&C electricity and gas demands are modelled in a standalone econometric model. Any electricity consumption that comes out of the I&C model feeds through into a forecast of electricity demands, with these demands then being met using an economic generation dispatch model. So, while gas as a feedstock doesn't directly feed through to the I&C gas demand numbers, it does feed through to gas demands through gas used for power generation.

Q: In all National Grid's projections, electricity demand is seen going up while in reality we have seen trend in opposite direction in recent years. How do you explain that?

A: We have observed falling transmission demand (i.e. demand observed at the transmission level) over the last few years due to the rapid increase in distributed generation, energy efficiency and a shifting economy. In the longer term, we assume at least partial electrification of heat and transport in all scenarios, as well as continued economic growth. These are the main causes of increased FES demands, which are an assessment of underlying demand. Whether or not demand grows on the transmission system is subject to how the generation market develops.

Q: Could you shed some light on what is driving short term peak demand growth?

A: We weather correct our metered transmission system peak demands as a starting point. We then derive underlying demand from our assessment of non-transmission generation capacity and peak generation factors. These two points are the cause of differences in numbers when comparing other sources. Therefore as data sources change or we learn more, our assessment of underlying peak will change over time.

This year we have an increase in non-transmission generation and we have revised our peak generation factors: this is the majority of the increase. Also our economic projections this year show a more optimistic assessment of commercial demand compared to last year, and residential demand is slightly higher than we thought following updated data. Industrial demand continues to decline, however.

Q: In a world of distributed generation and pro-sumers, how will consumers still justify standing charges for grid connections, and how does the grid react?

A: We are seeing significant changes in the behaviours of network users and the service they value from the system. The system of open governance is designed to support network charging arrangements evolving to reflect these changes in network usage. The development of network charging will also be supported going forwards by the Charging Futures forum announced by Ofgem, supporting the Targeted Charging Review (TCR).

Q: What are your assumptions behind charging infrastructure for Electric Vehicles (EVs) and their charging profile?

A: Our assumptions around charging infrastructure are that all new EVs charged in a domestic location would utilise a 7kW charger rather than a 3kW charger. For the charging profile, we used the information from the Low Carbon Networks & Innovation (LCNI) project 'My electric avenue' to determine the diversification of charging at different times during the day and seasons. One of the major factors that influences peak domestic EV charging is how engaged the consumers are. Those most engaged consumers utilise smart charging to move their demand to an off-peak period.

Q: How does rail play in fleet efficiency? Especially now that coal is not on the rail, capacity is greater.

A: We model electricity demand from rail transport at a high level only. We assume 1.5% growth (the historic rate of demand growth) in our low-electrification scenarios, Steady State and Consumer Power. In our high-electrification scenarios (Two Degrees and Slow Progression) we assume 2.5% demand growth in (aiming towards a long-term ambition of electrifying most rail transport, where economic, by 2050).

Q: Do your models indicate the sensitivity of having periods of low, close-to-nil wholesale power price? Perhaps similar to the situation in Germany?

A: The dispatch model we use in our analysis does cater for the possibly negative wholesale power prices both in the GB market and more widely across Europe. In fact, we have seen negligible or slightly negative wholesale prices for some European countries (e.g. Germany) in our modelling.

Q: Given the small emissions savings for natural gas and the high demand for biomethane in other sectors, are gas heavy goods vehicles (HGVs) 'worth it'?

A: Studies indicate that natural gas-fuelled HGVs produce lower greenhouse gas emissions than diesel, although the figures vary by study. While on an individual basis the savings per vehicle may not be substantial, on a fleet basis they provide a significant reduction. Also due to cost effectiveness and a general interest in air quality, this technology is still being pursued. We recognised that there is significant uncertainty around low-carbon transport for large / heavy vehicles.

Q: How much of a role does energy efficiency play in your modelling of heat demand?

A: Energy efficiency is a component of our modelling. Government intervention has played a major part in the last decade in reducing heating demand, through providing loft insulation and cavity wall insulation to millions of homes. We note there is significant debate as to how well insulated the GB housing stock should become by 2050 considering the current housing stock, which includes a significant number of low thermally efficient properties. In our highest insulation scenario (Two Degrees), there is approximately a 20% reduction in space heating demand by 2050, reflecting strong government intervention. Within other scenarios the impact is less.

Demand: Consumer engagement

Q: Do your scenarios consider the cost to the customer, and their willingness to pay and change their habits?

A: Our FES document aims to facilitate industry dialogue, presenting a range of plausible and credible pathways that can help our customers and stakeholders make informed decisions. We do not cost the scenarios. In general terms, Consumer Power and Two Degrees reflect a world of high prosperity where more money is available. Steady State and Slow Progression reflect a world where less money is available.

In FES 2017, we have applied different levels of consumer engagement regarding energy use. See page 38 of the main FES document.

Q: Do you ask consumer engagement questions to those outside the industry? Surely the average customer only considers energy for a few minutes each year?

A: Our modelling of consumer engagement has been drawn in part from the work carried out by Ofgem, which involved direct market research to inform a current position that we then extended in line with the different FES scenario framework assumptions. The Ofgem consumer engagement survey has been conducted annually since 2014, with around 6,000 consumers, to track engagement in the domestic energy market following Ofgem's Retail Market Review (RMR).

We applied engagement trends between 2014 and 2016 to analyse how consumer behaviours have changed over this period. We assumed different speeds of involvement of four consumer engagement sectors (SwitchedOn, TunedIn, StandBy and Unplugged) in our scenarios by applying engagement delay lags. We also took into consideration 'saturability ceilings' within the sectors for capping the maximum achievable level of engagement for each scenario. All these considerations allowed us to arrive at the results presented in FES 2017 whereby the implementation of the Smart Meters rollout will probably take more time than originally estimated (i.e. reaching the required goal only in the best case scenario where the government and big energy suppliers take a strong lead in marketing and realisation of the programme).

Q: With automation, how much consumer engagement is actually required beyond some sensible economic decisions? Are you assuming a 'dumb' smart system?!

A: Automation will clearly work as an important facilitating factor, helping the consumer to get easy access to information communication with the supplier. However, consumer engagement plays the leading role in achieving energy efficiency improvement and we assume consumer choice remains in the form of over-ride switches in smart technology. Sensible economic decisions in the form of innovative pricing schemes will be another consumer incentive provoking factor. We emphasise that the role of consumer engagement will only grow if marketing campaigns are actively run for educational purposes. Knowledge and understanding of the goal, and the ways how it could be achieved, should be communicated and clarified to the audience to achieve buy in.

Demand Technologies

Q: How have you selected low carbon technologies in your scenarios and not selected others?

A: We carefully assess all potential new technologies that are publically available. We use a number of criteria to test whether any given technology should be included within FES. This includes technology maturity, supply chain potential, commercial readiness, and support required, together with consumer and political interest. Each year we reassess the technologies to ensure that we capture innovation and we test this through engagement with stakeholders. This year's FES includes spotlights that focus on particular technologies that could have a significant impact with future markets.

Q: Where can I find your numbers for installations of low-carbon heating technologies?

A: In the charts workbook: Tabs HT1, HT2, HT3 and HT4 contain installations of the various technology types. GD11 counts the number of homes on district heating.

Q: Do you consider Vehicle to Grid (V2G)? What are your assumptions on the role of V2G and the use of smart / managed charging on mitigating peak demand?

A: V2G is not in the FES 2017 scenarios. We are well aware that V2G could be significant in providing demand side response (DSR) services (Two Degrees has 25 million electric vehicles by 2050). We will explore V2G further in an Energy Insights Thought Piece to be published in 2017. We will continue to reassess V2G against our criteria for new technology as it develops.

One of the major factors that influences peak domestic EV charging is how engaged consumers are. The most engaged consumers utilise smart charging to move their demand to an off-peak period. In Two Degrees, for example, we see high consumer engagement and a lower proportion of EV charging at peak. Smart charging has the potential to be very important in a mass EV world as it is likely to be a significant factor in the extent to which additional generation capacity and network reinforcements are required across the electricity system, to cater for demand caused by increased numbers of EV chargers.

Q: Do you have profiles for heat pump and EV usage?

A: Our profiles are informed by data from 'Low Carbon Network' projects, which were funded by Ofgem. The 'Customer Led Network Revolution' project library contains a wealth of information on different innovation project trials: http://www.networkrevolution.co.uk/resources/project-library/

Searching for 'Electric Vehicles' or 'Heat Pump' will find the following datasets, as well as a number of reports and summaries on trial design and findings. Data is also available for residential solar panels, micro Combined Heat and Power (CHP), and DSR trials.

CLNR-L078 Dataset TC6: Enhanced Profiling of Domestic Customers with Electric Vehicles CLNR-L075 Dataset TC3: Enhanced Profiling of Domestic Customers with Air Source Heat Pumps

Additional information is available from the 'My Electric Avenue', which trialled over 100 Nissan Leafs for 18 months: http://myelectricavenue.info/

Q: Do you include fuel cells in EV numbers? If not, why not – they are available now.

A: Vehicles powered by fuel cells are not included in the EV numbers. We note that there are some early stage developments happening in this area and we are looking to develop our low-carbon transport analysis for 2018 to consider these further.

Q: How do you account for DSR in FES?

A: Because we are interested in the underlying demand within our FES figures, we only count where the consumer has shifted their usage. We do not include where a consumer has switched to another power source – such as a generator or battery storage. This is not a demand shift as their demand is still the same it is just being sourced differently. This figure would be captured in the supply side and, if we were to include on the demand side, we would end up double counting the true generation that is available.

In FES we do not include I&C DSR within our definition of peak (our definition is an 'unrestricted' one), but we do incorporate residential demand shifts because of time of use tariffs, as these are considered a behavioural shift rather than economically derived.

Q: What are your assumptions around future air conditioning load and future summer temperatures?

A: We assume a residential portable air conditioning unit will be run for ~20 days each year, consuming ~500kWh. Average peak rating for portable air conditioning units is around 2.7kW. We assume that not all units will be running at the same time and assume around one third of units are running during peak, resulting in a diversified demand per unit of 1kW. In Consumer Power we assume the majority of city dwellers (~60% of the GB population) adopt air conditioning by 2050 due to rising temperatures. In Steady State, 33% of the GB population adopts air conditioning (low affordability). In Two Degrees and Slow Progression we assume a mix of climate-change avoidance, improved ventilation standards, greener consumer attitudes or low affordability mitigate the need for air conditioning. Penetration stays at ~1%.

We have published our assumptions for summer peak demand, annual demand and number of installations in the Charts Workbook (Sheet PD7). We have not modelled commercial air conditioning or industrial refrigeration at this time. As this work is in an early stage of development we would welcome feedback on this approach. You may also be interested to read our recent thought piece considering demand from air conditioning, available at http://fes.nationalgrid.com/insights

Q: What do you believe will be the largest change for consumers over the next decade? What will change in their day-to-day lives in terms of energy usage?

A: We see a number of important developments across all our scenarios in the next 10 years, but the pace and extent of this change will vary according to scenario. In terms of what consumers will experience directly, the growth of EVs, smart devices / meters and time of use tariffs are likely to be the areas most visible to consumers.

Q: Why could shared vehicles increase energy demand?

A: Currently privately owned cars, including EVs, are parked on average 95% of the time. Within the scenarios we have used shared autonomous vehicles, where an EV does not require a driver to move from place to place, and so can be easily utilised by multiple people. This increases the utilisation of the vehicle, and thus the miles and energy consumed per vehicle.

As an example, if person A uses the autonomous vehicle to travel to work, rather than leave the vehicle parked all day it is then sent to be used by person B. When person A needs the vehicle later in the day they would then call it to them.

Q: Utilising large scale electrical heat storage becomes significant for distributed heating at the times of very low power price. Gas demand then reduces. What is your view on this?

A: Large-scale electrical heat storage is a potential solution when considering mass decarbonisation. We agree that storage could offset a number of elements, including gas demand, electrical demand for heating or even excess renewable generation within the day (e.g. wind and solar). In Two Degrees and Slow Progression we assume 25% of residential heat pump installations have some form of thermal storage, which allows peak electricity demand to be offset.

Q: Have you considered hybrid heating - like Wales & West Utilities / Western Power project Freedom in your scenarios?

A: Hybrid heating and its effects are considered within the scenarios. Hybrid gas + heat pump and oil + heat pump are among the heating technologies modelled as part of our low-carbon heating process. These feature in our greener scenarios and are a prominent feature of Slow Progression as they offer green heating throughout most of the year, running primarily on a heat pump, and then switch to gas for the cold peak times.

Q: What role could growth in peer-to-peer platforms play in better managing supply / demand?

A: Recent years have seen a proliferation of nimble technologies that have the potential to transform the interaction between customers, demand and where energy comes from. We monitor technological developments like these on an ongoing basis: for example, Two Degrees assumes 85% of consumers use their energy conscientiously (e.g. allow time of use tariffs to optimise home energy use) and technology is crucial to this future. However, Steady State assumes consumer engagement with energy and technological development is low.

Supply

Q: Where can I find information on your projections for generation capacity?

A: In the Charts Workbook downloadable with the main document:

- Tabs ES4, ES6, ES8, ES10 contain capacity figures (MW) for transmission connected, distribution connected and <1MW generation (contains micro-generation), as well as totals.
- Tabs ES5, ES7, ES9, ES11 contain annual output figures (GWh) by the categories described above, as well as totals.

Q: Are network constraints (such as thermal constraints, or fault current constraints) taken into consideration when calculating the amount of generation that is going to connect to either the transmission or distribution network?

A: Our modelling is built up from the capacities on the network, but we don't take into account current operational unavailability. The impact on the network is assessed in the ETSY and SOF. Both documents are published in the Autumn and are available at http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

Q: How does hydrogen feature in your scenarios?

A: Hydrogen features in the latter period of our Two Degrees scenario. It is used to fuel HGVs via fuel cells. Hydrogen for heating is not yet commercially proven, so we have not included it in our core scenarios. However, it is an interesting area and we have described a possible hydrogen future in our Decarbonised Gas Sensitivity in FES 2017.

Q: Do you consider hydrogen to be an indigenous or non-indigenous gas source? Hydrogen could potentially be produced in the UK from renewable sources.

A: Within our Decarbonised Gas Sensitivity, a large part of the hydrogen comes from gas through Stream Methane Reforming processes, and a small percentage of the hydrogen is produced from electrolysis. In essence all the hydrogen is produced within GB. However, the primary fuel, in this case mostly gas, comes from a number of sources, including imports.

Q: Why is hydrogen blending in the gas networks not included in your scenarios for heat in the shorter term? And the potential for conversion to 100% hydrogen?

A: We note that hydrogen is a topic of high interest at present, and there are numerous trials taking place or planned to take place. This year we have chosen to represent the potential of hydrogen through our sensitivities, blending into the gas network (then going to heat) is covered in the Consumer Renewables Sensitivity. The gas conversion to 100% hydrogen is covered in Decarbonised Gas Sensitivity. We will review our approach for FES 2018.

Q: Could technologies that can convert carbon dioxide (CO2) into solid carbonate for building bricks be the launch pad for hydrogen based on reforming methane?

A: As part of our emerging technologies stand at the FES 2017 conference, we collected information about a number of technologies, including the potential to capture carbon into solid materials. We will be looking into all of the technologies suggested by stakeholders to see if any would be appropriate to include in future editions of FES, or to explore in our thought piece series.

Q: Why do you use generic imports for gas supplies?

A: The background and our thinking on the UK's gas supply sources are described on pages 79 onwards in the main FES document. In summary, we build our gas supply scenarios by assessing the likelihood that various supply types come to GB. For example, UK Continental Shelf, shale or green gas (biogas or bio synthetic natural gas) are added to our supply sources first as they are indigenous. This is followed by Norwegian gas, as some fields are directly connected to import terminals in GB, and minimum levels of LNG are added as some LNG must flow due to boil-off requirements.

For some years our scenarios have included specific volumes of imported LNG and continental gas, as well as a volume of 'Generic Import', which could be LNG or continental gas, or a mixture. This approach effectively provides ranges for LNG and continental gas imports in each scenario. Predicting LNG flows in the world market is challenging, and you have told us that our approach is a sensible way of dealing with the uncertainty.

Q: What are our gas dependencies and the impact of this? A few years ago we were predicting a reduced dependency on gas and a shift to electricity.

A: There are three main areas of gas dependency: residential, industrial & commercial and gas for power. In three of our scenarios gas for power generation falls significantly as non-thermal generation capacities increase substantially, reducing the requirement for gas power stations. Residential is where the highest gas dependency lies, and the de-carbonisation of heat is one of the biggest challenges with decarbonising the energy market. Gas boilers still remain the most cost-effective way of heating, and so decarbonising the space heating market requires significant advances or governmental support in alternative heating technologies, such as heat pumps, hybrids or hydrogen boilers for example. Alternatively, major developments within green gas are required.

Q: What are the assumptions in determining the proportions of sources of gas supply in the different scenarios?

A: The FES Framework document provides a high-level framework for different sources of gas supply. The document can be viewed at: http://fes.nationalgrid.com/fes-document/

Q: Where is CCS in the decarbonisation forecast?

A: CCS features only in our Two Degrees scenario, and this reflects the present uncertainty around the commercial scalability of such projects. In the Two Degrees scenario the first CCS plants come online in 2030. CCS is also essential in the Decarbonised Gas Sensitivity.

Q: What are your assumptions regarding growth in solar generation and grid parity?

A: The high pace of growth in solar seen a few years ago has now slowed and reflects more challenging market conditions. Despite this, we continue to see growth in unsubsidised solar. We expect to see a second period of growth in solar during the 2020s following a reduction in upfront capital costs.

Q: Have you considered the impact of roof top solar and that appliances are getting energy efficient?

A: We model the growth in solar at both the large ground-mounted level and at the small rooftop installation size. For appliances we model a number of sub groups (e.g. cold appliances, computing). Further detail is available in our Charts Workbook.

Q: Has a case been considered in which consumers buy a huge amount of domestic photovoltaic (PV)and batteries as a lifestyle choice without a positive return?

A: Our scenarios are based around a 2x2 matrix of green ambition and prosperity. In the highest green ambition scenario (Two Degrees) consumers will need to be very engaged in the ambition to decarbonise. For some people this may mean a willingness to decarbonise irrespective of their likely financial return.

Q: When you look at installed capacity do you use derated figures to reflect the load factor of solar PV vs combined cycle gas turbine (CCGT)?

A: All capacities are de-rated when their contribution to meeting peak demand is modelled (noting that PV is negligible at this point in time). In terms of annual contributions, load factors are generated by our dispatch modelling. However, when 'installed capacity' is quoted this is just boiler plate (i.e. the maximum capacity of the unit) and doesn't include any de-rating or load factor.

Q: How do you see sales to the grid from household solar, micro CHP, or fuel-cell generation in 2050?

A: This year we have two scenarios that are high in decentralised generation, namely Slow Progression and Consumer Power. Growth rates on a technology by technology basis are available in our Charts Workbook.

Q: You talk about shale gas as a key way of keeping indigenous supply. What is being done to support the establishment of this sector?

A: National Grid is working with its customers to try to reduce the cost and time of getting connected to a gas network. Project CloCC (Customer Low Cost of Connections) is aiming to develop a lower-cost physical connection solution that is tailored to the needs of unconventional gas customers. More information can be found on the project CLoCC webpage (http://www2.nationalgrid.com/UK/Our-company/Innovation/Projects/Gas-T-Projects-CLoCC/)

Q: What assumptions are being made for g CO2 / kWh for UK shale, compared with imported non-shale gas?

A: We recognise that there is some industry analysis stating that the carbon emissions from indigenous shale gas should be lower than imported LNG, and therefore better for global emissions. Other stakeholders remind us that the carbon emissions produced from the process of liquefying natural gas will not count towards GB emissions as they will form part of the producing countries' emissions. Currently we treat all natural gas with the same carbon release factor. Green gas on the other hand has a reduced carbon release factor.

Q: Where does tidal fit in to your assumptions?

A: Tidal generation is modelled in our generation backgrounds in the same way as other generation technologies, in that known future projects are included and that FES Framework Assumptions are applied to provide the differences between the scenarios (e.g. start dates etc). Further detail is available in our Charts Workbook.

Q: If reducing load factors and relative carbon pricing makes gas the 'new coal' by 2040, could the government find themselves in a similar position to the 1980s Tory government in shutting down industry?

A: Across our scenarios there is a range of capacities for gas in the future. Gas, as a flexible source of electricity, will be critical in maintaining security of supply as we transition to a low-carbon future. What future Government policy will be towards gas generation will, of course, be a matter for the Government of the day.

Q: Is it possible to provide battery capacity in GWh to understand how long the batteries are available for?

A: We did not include duration (GWh) within the 2017 scenario analysis for storage, as we only looked at Nominal Power (GW). This has recently been brought up by several stakeholders and we will consider including duration (GWh) in our 2018 analysis.

Q: Why do you not include an option of less than 30% for renewable generation, as existing capacity retires and subsidies are completely withdrawn?

A: The general assumption in most scenarios is that renewable generation will start to be built without the need for subsidies (e.g. solar and wind). However, in Steady State we don't assume re-powering of wind turbines for example.

Q: How do you believe distributed generation will affect suppliers?

A: Our scenarios have a range of distributed generation. How suppliers choose to respond to distributed generation will be a decision for each individual supplier as there are numerous business models which could be adopted here.

Q: Is distributed energy primarily a grid / B2B (business-to-business) level activity in 2030, or is there also a significant B2C (business-to-consumer) element by then?

A: When we talk about 'Distributed Energy' in FES we are referring to both generation (or DSR, storage etc) that is connected to a Distribution Network, as well as micro generation that is connected directly to homes and businesses. We do not explicitly consider the contractual arrangements of future generation, but acknowledge that there is potential for change (e.g. peer-to-peer local transactions).

Network and System Impacts

Q: What are the grid development implications of each of these scenarios? And by when will action be needed to ensure Two Degrees scenario is not held back?

A: Our GYTS and ETYS documents illustrate the potential development of the gas and electricity transmission systems. Further information is available at http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

Q: Will it be more difficult for the System Operator (SO) to have visibility of what's happening in distribution networks if Distribution Network Operators (DNOs) become Distribution System Operators (DSOs)? / How do you see the Transmission System Operator (TSO)-DSO interaction, especially with regard to visibility of power flows?

A: As DNOs become DSOs they will manage their networks more actively. The actions the SO and DSOs take will affect each other's networks, and each will have flexibility that could provide benefits for the other. To allow efficient cooperation and sharing of resources between the SO and DSOs much greater visibility will be needed on the state of networks and assets, the actions that are being taken, and the actions that could be taken.

There are many complex operational and commercial issues to be resolved to ensure that TSO-DSO interaction is effectively facilitating network and market access for all parties. The National Grid SO and the DNOs are working together to address these challenges through the Energy Networks Association (ENA) Open Networks Project. More information can be found here: http://www.energynetworks.org/electricity/futures/open-networks-project/

Q: What level of collaboration / joined-up thinking can consumers expect between the new National Grid Electricity System Operator (ESO) and DNOs, particularly regarding infrastructure investment?

A: Through our Future Role of the SO (FRSO) programme we are building new ways of working with the DNOs to start thinking across networks and deliver a more joined-up perspective between transmission and distribution. Investment is one of the areas that we will be addressing, and activities like the ongoing development of our 'Network Options Assessment' (NOA) tool will see us working together with the DNOs, TOs and other interested parties to be able to evaluate a wider range of solutions to meet network needs and optimise investment decision making. We are also working as a part of the ENAs Open Networks Project, where we will be sharing our lessons learned and outputs from the FRSO programme.

Q: If Network Operators demonstrate that solutions such as synchronous compensators are cost effective for customers, should they be able to directly provide services?

A: There are many complex operational and commercial issues to be resolved to ensure that TSO-DSO interaction is effectively facilitating network and market access for all parties. The National Grid SO and the DNOs are working together to address these challenges through the ENA Open Networks Project.

Q: How capable are the existing transmission and distribution systems of accommodating a large-scale transition to heat pumps in densely populated urban areas?

A: Our SOF publication takes a holistic view of the changing energy landscape to assess the future operation of GB electricity networks. The Gas Future Operability Planning (GFOP) publication describes how changing requirements may affect the future capability of the National Transmission System. Further information on both publications is available at http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

Q: Will parts of the gas grid need to be decommissioned? How does this affect current investment?

A: We acknowledge that some gas-receiving terminals will have no gas when the UK Continental Shelf (UKCS) is exhausted. We do not explicitly state that they will close as this is commercial information that we do not have. We make no comment on other parts of the network being decommissioned. The future development of the gas transmission network is dealt with in GTYS. Future developments in the distribution networks are covered by equivalent publications from the DNOs.

Q: How should the FES work inform the work of the System Needs and Product Strategy (SNAPs) team in reforming ancillary services? (The current SNAPs proposals only have a five-year outlook)

A: The information flow between FES and SNAPs is via our SOF report. FES data is fed into the SOF process, and then our SNAPs document considers how issues raised in SOF relate to the development of balancing services and future markets in this area.

Questions relating to the FES launch on 13 July 2017

Q: Will all presentation slides from the FES launch be available after the event?

A: The conference presentations, as well as the live-stream recording of the morning session, are available at http://fes.nationalgrid.com/conference/

Q: Can you share the flexibility 'game' presented on the afternoon of the FES launch more widely?

A: The slides used for the flexibility game are available on our website at http://fes.nationalgrid.com/conference/. We would be happy to present the game more widely and encourage interested parties to contact us.

Q: Please can you explain what the audience data that was collected at the FES launch is to be used for? In the future, can we get some demographics associated with these survey responses?

A: We asked conference attendees for their feedback on a number of current energy topics. This engagement will feed into our work for FES 2018. For ease and speed we used Slido software, which does not capture demographic data.

Version control

Version number	Date of update	Description of update
1.0	13/07/2017	First upload for FES 2017 launch on 13th July 2017
2.0	27/09/2017	Document updated to include answers to a number of questions received on the day of the FES conference In July 2017 and subsequent frequently asked questions from stakeholders

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