nationalgrid

UK Future Energy Scenarios

UK gas and electricity transmission

JULY 2013

Welcome to our 2013 edition of the UK Future Energy Scenarios (UK FES) document. This annual publication provides a detailed analysis of credible future energy scenarios out to 2035 and 2050. The document describes, in some detail, the assumptions used in our analysis and development of future energy scenarios: for example, developments in generation and demand backgrounds, upcoming technologies, the economy and progress against environmental targets.

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Our scenarios are used as a reference point for a range of modelling activities including detailed network analysis which enables National Grid to identify strategic gas and electricity network investment requirements for the future.

The development of our Future Energy Scenarios is supported by an ongoing consultation process. Following the publication of our 2012 scenarios we gathered views at stakeholder engagement events and in a series of meetings with interested parties. We have developed our analysis in response to the views you expressed. We have retired the Accelerated Growth scenario, amended our axioms and revised some of our methodologies. Given its importance, we have put an emphasis on updating our demand models; we have made significant improvements this year and expect to continue to do so in the coming year.

Your input is of great importance to the development of our scenarios and is much valued. I would like to thank you for your continued support of the UK FES process and resulting publication. The release of this document marks the start of the next annual cycle of consultation in which we will continue to engage with you to develop our 2014 scenarios. We look forward to listening to your views and acting on what you tell us.

I hope that you find this an informative and useful document and look forward to receiving your feedback.

Executive Summary

Over the last year our Future Energy Scenarios (FES) process has continued to develop and evolve. We have undertaken broad stakeholder engagement, including bilateral meetings, dedicated stakeholder workshops, targeted questionnaires and our annual UK FES conference.

In total we have engaged with over 150 organisations and more than 350 individuals. This has enabled us to take on board the views of our stakeholders when developing our scenarios. These views have been used to inform our axioms (see Appendix 2) which underpin the modelling and analysis that drive our scenarios. The release of this document marks the start of the next annual cycle in our consultation process in which we will continue to improve our engagement with our stakeholders to develop our 2014 scenarios.

This robust process of engagement has resulted in continual improvement in the quality of our analysis and a more rigorous challenge and review process. Combined these developments enable the development of our holistic, self-consistent, data rich scenarios.

This year we have developed two scenarios:
Slow Progression, where developments in renewable and low carbon energy are comparatively slow, and the renewable energy target for 2020 is not met. The carbon reduction target for 2020 is achieved but not the indicative target for 2030.

Gone Green has been designed to meet the environmental targets; 15% of all energy from renewable sources by 2020, greenhouse gas emissions meeting the carbon budgets out to 2027, and an 80% reduction in greenhouse gas emissions by 2050.

Following consistent feedback on the range of our scenarios over the last few years we have made the decision to retire the Accelerated Growth scenario. We acknowledge that retiring Accelerated Growth could have implications for our network development analysis. We therefore consider specific sensitivity analysis/case studies alongside the core scenarios to ensure we capture potential outcomes versus key uncertainties that push the boundaries of the credible scenario envelope.

Key statistics

	Slow Progression			Gone Green		
Electricity	2012	2020	2030	2012	2020	2030
Peak Demand/GW	61.1	57.5	56.7	61.1	59.7	62.7
Annual Demand/TWh	328	303	297	328	317	323
Total Capacity/GW	92.3	96.2	115.8	92.3	111.6	153.6
Low carbon capacity/GW	24.9	37.0	56.6	24.9	50.9	95.2
Residential Heat Pump (HP)/Millions	0.1	0.3	0.6	0.1	1.2	5.7
EVs Number/Millions	0.005	0.2	0.9	0.005	0.6	3.2
Residential gas demand/TWh	337	317	324	337	298	254
Annual Gas demand/TWh	866	875	838	866	795	647
Renewable Energy %	4	13	23	4	15	34
Greenhouse Gas (GHG) reduction %	26	>34	<60	26	>34	~60

Demand

- Electricity demand projections begin lower in both scenarios than in our 2012 scenarios as a result of a number of improvements to our analysis methodology and a lower outturn demand in 2012
- Energy savings from boiler replacements are considerable. From 2005 to 2012 replacement of older, less efficient boilers has saved over 30TWh and is expected to deliver further savings of around 40TWh by 2030
- Heat pumps remain important to hitting emission targets: air to water systems dominate and are initially deployed in houses not connected to the gas grid
- Both scenarios assume that the insulation market is beginning to saturate and there is considerable uncertainty around how the Green Deal and Energy Company Obligation (ECO) will influence the uptake of solid wall insulation
- Electricity demand for lighting could halve by 2020, however, LED bulbs need to come down in cost and become a default option for this to happen
- Time-of-use tariffs (TOUTs) are an important driver for behaviour change, smart meters are a key enabler to this. Our scenarios assume between a 25% to 50% take up of households engaging with TOUTs
- Market saturation of Electric Vehicles (EVs) is not reached in either scenario. Range extended and plug in hybrids are expected to dominate the market
- In the medium term to 2020 electricity demand falls, only rising in our **Gone Green** scenario due to the impact of heat pumps, EV charging, population growth and favourable economic conditions
- Gas demand initially falls in both scenarios. In **Slow Progression** gas demand plateaus towards the end of this decade, but continues to fall in **Gone Green**.

Supply

- Future plant build (both renewables and thermal generation) is subject to considerable uncertainty and Electricity Market Reform (EMR) will play an important role in delivering new build for renewables, nuclear and gas, through anticipated mechanisms such as Contracts for Difference (CfDs) and capacity payments
- Lower electricity demand projections offset the impact of plant closures. Margins can be maintained in the medium term at around 5% (on a de-rated basis) but this is dependent on new generation build and in both scenarios they dip below this level in the next few years
- Gas generation capacity increases and the role of gas generation becomes increasingly used as a back-up for intermittent generation
- Overall, UK Continental Shelf (UKCS) continues to decline after a renaissance due to new developments, including West of Shetland, and Norway continues to be a major supplier of gas to the UK
- Supplies from the Continent and LNG are subject to the global market dynamics
- Shale gas in particular provides considerable supply uncertainty and potential upside beyond scenario assumptions
- Storage will continue to play a key role in meeting peak demand and providing supply flexibility.

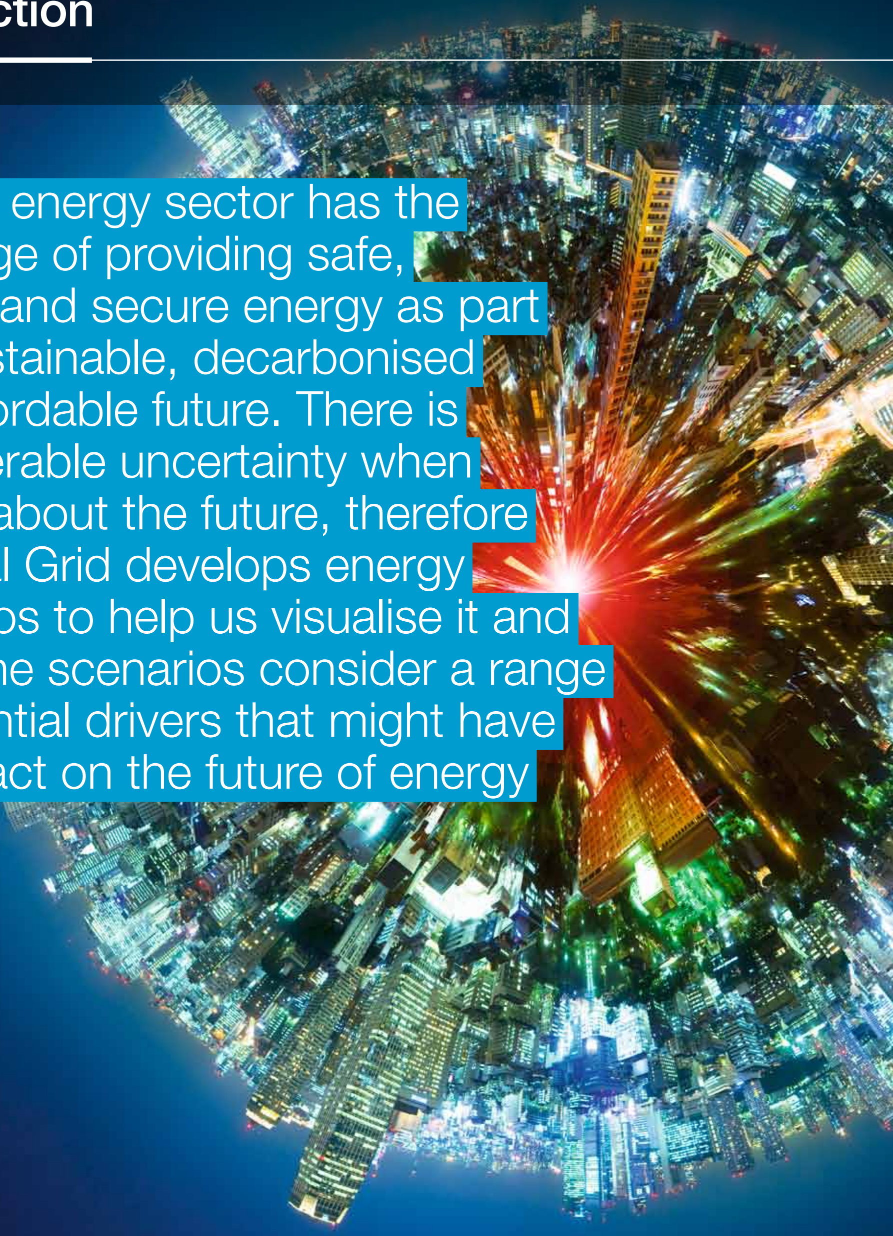
Principle factors that lead to uncertainty in our scenarios are:

- Political uncertainty, including the effectiveness of policy interventions, particularly those that seek to influence consumer behaviour
- Economic uncertainty and the timing and strength of recovery and the nature of that recovery e.g. the balance of services vs. manufacturing industry
- Social uncertainty and how our choices as consumers will affect the timing and scale of changes in energy demand
- Technology uncertainty in both the supply and demand side and what ‘disruptors’ may emerge over the next 20 years and beyond.

Through our axioms and the development of our scenarios we seek to better understand these uncertainties and identify credible, plausible outcomes for the future of energy in the UK.

Contents

Chapter one
Introduction



The UK energy sector has the challenge of providing safe, reliable and secure energy as part of a sustainable, decarbonised and affordable future. There is considerable uncertainty when talking about the future, therefore National Grid develops energy scenarios to help us visualise it and plan. The scenarios consider a range of potential drivers that might have an impact on the future of energy

In this document we describe the assumptions behind our scenarios, look at the resulting energy demand, and examine the CO$_2$ emissions and contribution from renewable energy. Where appropriate, we describe how our approach has developed since last year.

This year our detailed scenario analysis has been extended to 2035, five years beyond our previous time frame, to keep them in line with National Grid's Network Development Policy[1], which enables decisions to be made on the future development of the network. Beyond 2035 it becomes more difficult to model the scenarios in the same level of detail and so our analysis to 2050 is less granular.

Detailed tables of gas and electricity demand for our scenarios are available on the National Grid website[2] and key data is given in Appendix 3 of this document.

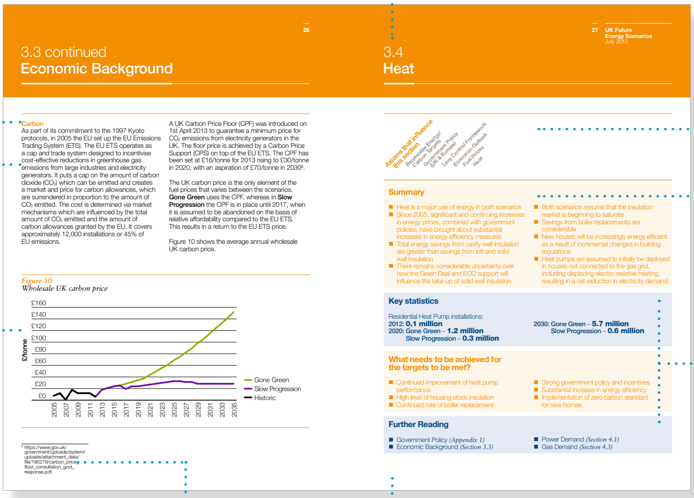
How to use this document

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

You will find 'day in the life' narratives to illustrate the technologies consumers are using today and the effect of these on their lives. Further information on the basis of these narratives is given in Appendix 4.

Subheadings
The main text is divided into sections by easily identifiable headings so that you can locate a particular piece of information.

Main heading
Clearly defined headings introduce the main topic dealt with on a particular page.



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3.3 continued
Economic Background

Carbon
As part of its commitment to the 1997 Kyoto protocols, in 2005 the EU set up the EU Emissions Trading System (ETS). The EU ETS operates as a cap and trade system designed to incentivise cost-effective reductions in greenhouse gas emissions from large industries and electricity generators. It puts a cap on the amount of carbon dioxide (CO$_2$) which can be emitted and creates a market and price for carbon allowances, which are surrendered in proportion to the amount of CO$_2$ emitted. The cost is determined via market mechanisms which are influenced by the total amount of CO$_2$ emitted and the amount of carbon allowances granted by the EU. It covers approximately 12,000 installations or 45% of EU emissions.

A UK Carbon Price Floor (CPF) was introduced on 1st April 2013 to guarantee a minimum price for CO$_2$ emissions from electricity generators in the UK. The floor price is achieved by a Carbon Price Support (CPS) on top of the EU ETS. The CPF has been set at £16/tonne for 2013 rising to £30/tonne in 2020, with an aspiration of £70/tonne in 2030[8].

The UK carbon price is the only element of the fuel prices that varies between the scenarios. **Gone Green** uses the CPF, whereas in **Slow Progression** the CPF is in place until 2017, when it is assumed to be abandoned on the basis of relative affordability compared to the EU ETS. This results in a return to the EU ETS price.

Figure 10 shows the average annual wholesale UK carbon price.

Figure 10
Wholesale UK carbon price

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190279/carbon_price_floor_consultation_govt_response.pdf

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3.4
Heat

Summary
- Heat is a major use of energy in both scenarios
- Since 2005, significant and continuing increases in energy prices, combined with government policies, have brought about substantial increases in energy efficiency measures
- Total energy savings from cavity wall insulation are greater than savings from loft and solid wall insulation
- There remains considerable uncertainty over how the Green Deal and ECO support will influence the take-up of solid wall insulation
- Both scenarios assume that the insulation market is beginning to saturate
- Savings from boiler replacements are considerable
- New houses will be increasingly energy efficient as a result of incremental changes in building regulations
- Heat pumps are assumed to initially be deployed in houses not connected to the gas grid, including displacing electric resistive heating, resulting in a net reduction in electricity demand.

Key statistics
Residential Heat Pump installations:
2012: **0.1 million**
2020: Gone Green – **1.2 million**
Slow Progression – **0.3 million**
2030: Gone Green – **5.7 million**
Slow Progression – **0.6 million**

What needs to be achieved for the targets to be met?
- Continued improvement of heat pump performance
- High level of housing stock insulation
- Continued rate of boiler replacement
- Strong government policy and incentives
- Substantial increase in energy efficiency
- Implementation of zero carbon standard for new homes.

Further Reading
- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Power Demand *(Section 4.1)*
- Gas Demand *(Section 4.3)*

Axioms
Diagram to demonstrate which axioms have input to the section.

Narrative
Including scenario descriptions, case studies, consumer experiences and 'day in the life of…' narratives.

Summary
High level section summary outlining key points and statistics.

Figure
Provides charts to support the data and scenario analysis, enabling trends to be quickly identified.

Break-out boxes
Highlight key pieces of information.

Footnotes
Used for citations and further commentary.

Further reading
Signpost to further reading within the document. This will help you locate the relevant sections in the document that relate to the section you are reading.

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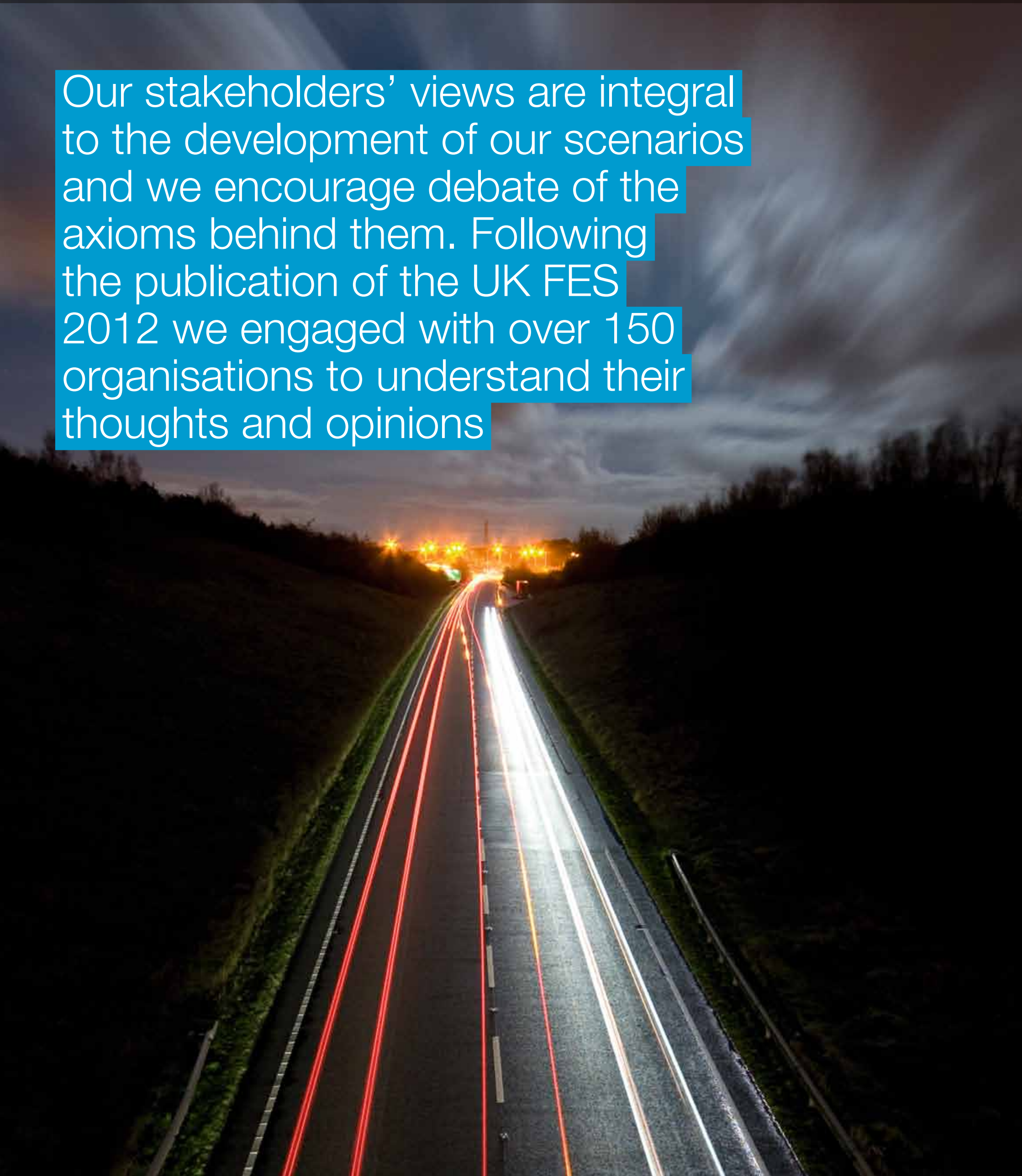
[1] http://www.nationalgrid.com/ NR/rdonlyres/DF56DC3B-13D7-4B19-9DFB-6E1B971C43F6/57770/10761_NG_ElectricityTenYearStatement_LR.pdf (see section 3.8)

[2] http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/Future+Energy+Scenarios/

Chapter two

Creation of Scenarios



Our stakeholders’ views are integral to the development of our scenarios and we encourage debate of the axioms behind them. Following the publication of the UK FES 2012 we engaged with over 150 organisations to understand their thoughts and opinions

2.1

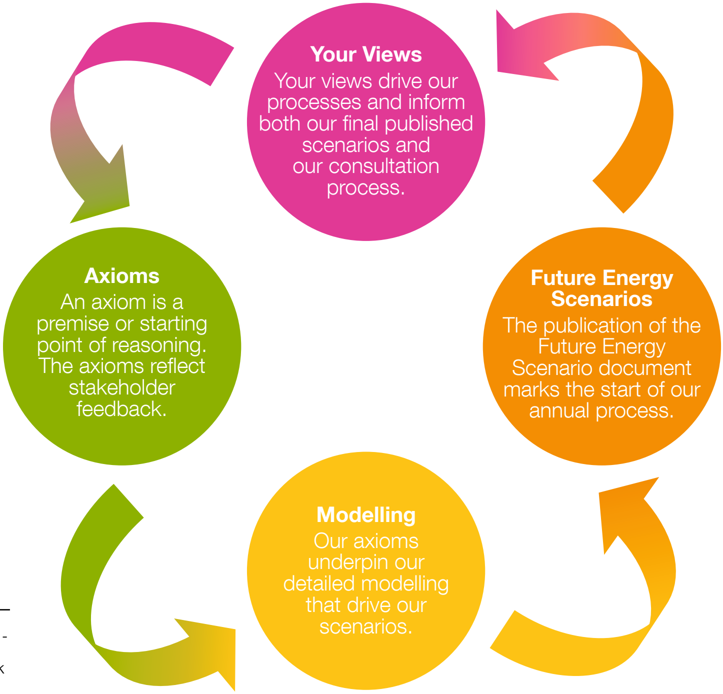
Stakeholder Engagement

Our stakeholder engagement, detailed in the UK FES Stakeholder Feedback Document[3], included bilateral meetings with 31 different companies, 4 dedicated stakeholder workshops attended by 110 individuals from 80 organisations, 54 responses to targeted questionnaires sent to importers, shippers, operators and producers and presentations followed by 'question and answer' sessions at our dedicated UK FES annual conference, which was attended by over 300 people from 150 different organisations.

We received positive feedback on our decision to publish the axioms that underpin our scenarios as an aid to understanding our scenarios and how they are constructed. In response we encouraged debate of these axioms through our consultation process, enabling us to further develop and refine the axioms for our 2013 scenarios. The full set of axioms that underpin our 2013 scenarios can be found in Appendix 2 of this document.

Figure 1 shows the pivotal role that our stakeholders play in the development of the Future Energy Scenarios. The publication of the 2013 UK FES document represents the beginning of our next cycle of engagement. We will continue to focus on improving our engagement so that our stakeholders have the opportunity to understand and debate our scenarios in detail. We will listen, discuss and act on what they tell us to improve not only our scenarios but also how we engage. We look forward to consulting on our new scenarios and hearing your views.

Figure 1
The role of stakeholders in our scenarios



Your Views
Your views drive our processes and inform both our final published scenarios and our consultation process.

Axioms
An axiom is a premise or starting point of reasoning. The axioms reflect stakeholder feedback.

Modelling
Our axioms underpin our detailed modelling that drive our scenarios.

Future Energy Scenarios
The publication of the Future Energy Scenario document marks the start of our annual process.

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[3] http://www.nationalgrid.com/NR/rdonlyres/2450AADD-FBA3-49C1-8D63-7160A081C1F2/59382/UKFES2012StakeholderFeedbackDocument2.pdf

2.2
The **Scenarios**

Our scenarios are not forecasts. Forecasting consists of predicting the future at a single point in time and modelling a solution to address such a future. Scenario planning does not predict the future; rather it considers a scope of potential drivers that might have an impact. Each scenario is purposefully different; we do not assign probabilities to our scenarios and we do not assume that one scenario is any more likely than the other.

Our scenarios are used as a reference point for a range of modelling activities including detailed network analysis which enables National Grid to identify potential gas and electricity network investment requirements in the future.

This year we have further developed our **Slow Progression** and **Gone Green** scenarios. As in previous years, **Gone Green** has been designed to meet the environmental targets; 15% of all energy from renewable sources by 2020, greenhouse gas emissions meeting the carbon budgets out to 2027, and an 80% reduction in greenhouse gas emissions by 2050.

Slow Progression represents slower progress towards environmental goals. For example, the UK 2020 renewables target is missed and greenhouse gas reductions fall short of the 2050 carbon targets and the 4th carbon budget.

After consistent feedback on the range of our scenarios over the last few years we have made the decision to retire the Accelerated Growth scenario. We have focused instead on further enhancing **Slow Progression** and **Gone Green**, which many of our stakeholders felt represented a more credible range to our scenario envelope.

We acknowledge that retiring Accelerated Growth could reduce the range of network development analysis. We therefore consider specific case studies alongside the core scenarios to ensure we capture potential outcomes versus key uncertainties that push the boundaries of the credible scenario envelope. These case studies are identified within the relevant sections.

Beyond 2035 there are increasing uncertainties regarding technology developments and likely economic outlook. We have taken our **Gone Green** analysis out to 2050 as it is important to see the level of effort that will be required to meet the 2050 greenhouse gas reduction target. Our approach to modelling the period beyond 2035 has changed since 2012. For this year's analysis we have used the Redpoint Energy System Optimisation Model (RESOM)[4]. RESOM creates solutions that satisfy all the underlying energy requirements and environmental constraints at the lowest possible cost. The level of detail and aggregation in RESOM differs from the models that we have developed for our analysis up to 2035; more factors are included but there is less detail in the electricity and gas demand results. We have constrained RESOM to match our detailed scenarios to 2035 as far as possible and then left the model free to develop least cost options to 2050.

The full detail of our gas and electricity projections are for Great Britain rather than the United Kingdom, as we only operate networks within GB. Environmental targets are set for the UK so it was necessary to scale up our initial projections, from GB to UK level and then use RESOM to confirm that the scaled-up projections met the targets.

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[4] http://www.baringa.com/files/documents/NG-003_-_Redpoint-Baringa_-_Heat_Economics_Study-_Final_-_v20120924-1_1.pdf

2.3
Axioms

An axiom is a premise or starting point of reasoning. It is a logical statement assumed to be true. To create our 2013 scenarios we have made extensive use of axioms, these have been developed and refined through a series of specifically designed stakeholder workshops and our wider stakeholder engagement.

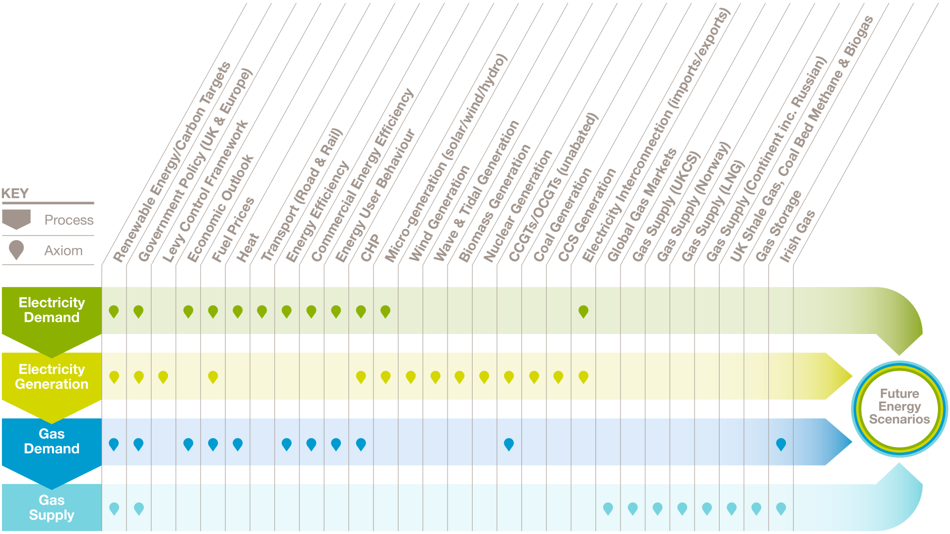
Table 1 shows the Carbon Capture & Storage (CCS) Generation axiom as an example. The full list of axioms used can be found in Appendix 2.

Table 1
Extract from the scenario axioms

	Slow Progression	Gone Green
Carbon Capture & Storage (CCS) Generation	CCS is not commercially viable for coal or gas.	Commercial deployment of coal / gas CCS occurs during the 2020s as part of a mixed low carbon and renewable generation fleet, with some deployment of biomass with CCS in the later years.

Figure 2 demonstrates how these axioms flow through our processes to produce the scenarios. An interactive version of this map is available on our website[5].

Figure 2
Axiom process map



	Electricity Demand	Electricity Generation	Gas Demand	Gas Supply
Renewable Energy/Carbon Targets	●	●	●	●
Government Policy (UK & Europe)	●	●	●	●
Levy Control Framework		●		
Economic Outlook	●		●	
Fuel Prices	●	●	●	
Heat	●		●	
Transport (Road & Rail)	●			
Energy Efficiency	●		●	
Commercial Energy Efficiency	●		●	
Energy User Behaviour	●		●	
CHP	●	●	●	
Micro-generation (solar/wind/hydro)	●	●		
Wind Generation		●		
Wave & Tidal Generation		●		
Biomass Generation		●		
Nuclear Generation		●		
CCGTs/OCGTs (unabated)		●	●	
Coal Generation		●		
CCS Generation		●		
Electricity Interconnection (imports/exports)	●	●		
Global Gas Markets				●
Gas Supply (UKCS)				●
Gas Supply (Norway)				●
Gas Supply (LNG)				●
Gas Supply (Continent inc. Russian)				●
UK Shale Gas, Coal Bed Methane & Biogas				●
Gas Storage				●
Irish Gas			●	●

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[5] http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/ (Please note that the interactive functionality may not work when accessed on a tablet device)

Chapter three
Political & Economic Background

In this chapter we discuss the main drivers behind our scenarios out to 2035

3.1

Government Targets

UK and EU legislation sets targets for renewable energy and emissions of greenhouse gases. Renewables are governed by the 2009 Renewable Energy Directive[6] which sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020.

The Climate Change Act[7] 2008 introduced a legally binding target to reduce greenhouse gas emissions by at least 80% below the 1990 baseline by 2050.

The Act also introduced carbon budgets, which set the trajectory to ensure the targets in the Act are met. The carbon budgets place restrictions on the total amount of greenhouse gases the UK can emit over a five-year period, and should result in a halving of UK emissions, relative to 1990, during the fourth carbon budget period (2023 to 2027).

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[6] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies

[7] https://www.gov.uk/government/policies/reducing-the-uk-s-greenhouse-gas-emissions-by-80-by-2050

3.2

Government Policy

There are a number of policies in place to aid the development of renewable energy and the reduction of carbon emissions. Those policies that have developed since our 2012 scenarios, or which have a significant effect on this year's projection are as follows:

- Levy Control Framework (LCF)
- Electricity Market Reform (EMR)
- Large Combustion Plant Directive (LCPD)
- Industrial Emissions Directive (IED)
- CRC Energy Efficiency Scheme (CRC)
- Renewable Heat Incentive (RHI)
- Feed-in Tariffs Scheme (FITS)
- Green Deal and Energy Company Obligation (ECO).

Further information on these policies can be found in Appendix 1.

3.3
Economic Background

Key statistics

- **3.5 million** new houses are expected to be required over the next 20 years
- GDP has historically grown at **2.5% per annum** (prior to 2008)
- GDP is strongly influenced by Services that account for **73% of GDP**. Manufacturing accounted for **11% of GDP** in 2012
- Wholesale oil prices have more than doubled since 2005; wholesale gas has increased by a third and wholesale electricity, while volatile in 2008, remains modestly above the 2005 level excluding policy intervention costs.

What's changed since 2012?

- Demographics are broadly unchanged; however, we have pushed back housing development improvements in our models from 2014 to 2016
- While **Gone Green** has similar assumptions on GDP, to our 2012 analysis, our **Slow Progression** scenario shows stagnation in economic growth followed by annual growth slightly higher than our 2012 scenario
- This year we have used a central price scenario for both **Gone Green** and **Slow Progression**. In 2012 we applied a low gas and power price scenario for **Slow Progression** and a mid to high level for **Gone Green**. Our 2013 gas prices sit within the middle of the 2012 scenario range and our electricity prices remain broadly similar to **Gone Green** 2012.

Energy demand is sensitive to growth in the economy and, especially for the residential sector, growth in the housing market. Our scenarios make use of 2013 economic and demographic forecasts by Experian Business Strategies which forms the basis for our own econometric modelling.

In **Slow Progression** economic growth remains weak due to economic conditions in Europe and depressed consumer demand. Growth over the short term remains similar to that experienced in the last 5 years, gradually recovering by 2023; this is consistent with a “lost decade” scenario similar to Japan’s experience throughout the 1990s.

In **Gone Green** the economy quickly recovers to traditional levels with further expansion in the services and the construction sectors.

3.3 continued
Economic Background

3.3.1
Demographic Background

Pre-recession construction of new housing in Great Britain averaged just over 180,000 houses per year between 2000 and 2007 with a peak in 2007 of 211,300. Post-recession, the number of completions have averaged 137,700 between 2009 and 2012, a 24% reduction.

The GB population is expected to continue to increase reaching 70 million by 2032 (from 61.4 million in 2011). There are currently approximately 2.4 residents for every household across Great Britain meaning an additional 3.5 million households would be required to maintain this present 'occupancy' rate. Housing completions would need to average over 200,000 per annum in order to satisfy such a housing demand.

We expect no real improvement in completion numbers until 2016 when a modest economic recovery is underway in the construction sector. The number of completions is expected to rise steadily, exceeding 200,000 annually by 2022. Construction continues to grow over the 2020s to balance housing demand.

3.3.2
Economic Background: GDP

The UK economy grew by over a third in the decade prior to the 2008 recession. However, UK 2012 GDP remained slightly lower than 2008 with contraction and expansion largely offset over the period (2008–2012).

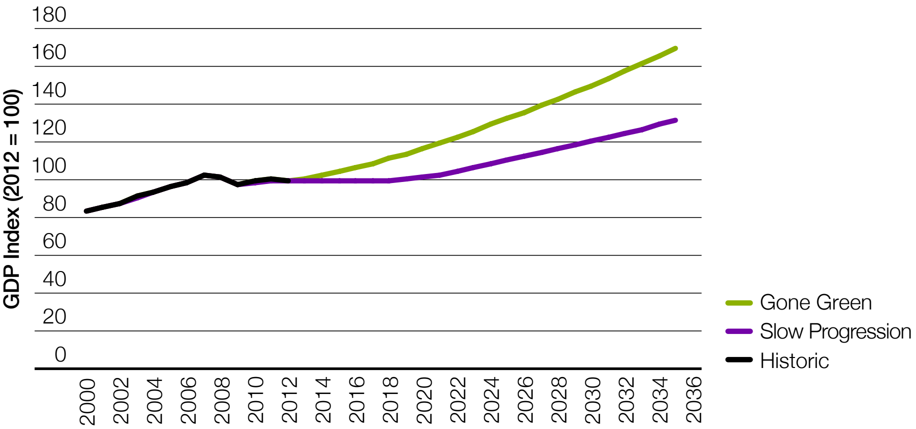
The UK economy remains strongly influenced by professional, financial and information services coupled with recreation, wholesale and retail services (around 53% of GDP in 2012). These services have grown by over 60% since 1997 and have accounted for the majority of the pre-recession growth in GDP. Public services, including health and education, have also grown and contributed nearly 20% of UK GDP in 2012, while manufacturing (around11% GDP) and other activities (utilities, transport, agriculture, fishing, construction etc.) have remained largely static in real terms. Mining and quarrying steadily declined over the period.

The recovery in the UK economic position remains tougher and more protracted than in previous recessions. A weakened financial service sector and efforts by the government and households to manage respective debts has stifled growth in recent years. With a depreciated Pound (£) exports may improve if conditions in Europe pick up. In the years ahead economic conditions in Europe (exports and investment), coupled with pay growth, increased disposable income and consumer confidence continue to significantly influence GDP growth.

In **Slow Progression** recovery remains stagnant in the short term, a continuation of the 2008–2012 experience. There remains economic uncertainty in Europe dampening growth in exports and leading to a weaker contribution from consumers at home who remain cautious and focused on debt reduction. In the longer term, as debts become less of a burden across Europe, the economy recovers but to a lower growth rate compared with the past. GDP remains sluggish until 2016 then rises annually to an average annual growth rate of 1% in 2020. Growth plateaus at 1.8% from 2023.

In **Gone Green**, GDP recovers from a difficult year in 2012 and growth improves annually reaching 1% on average by 2014. A return of growth in the service sector, coupled with improvements in manufacturing and construction, help to drive the economy forward. The economy grows annually returning to the historic rate of 2.5% by 2020. Figure 3 shows indexed GDP growth for both scenarios, with the 2012 value set to 100.

Figure 3
Indexed GDP growth



3.3 continued
Economic Background

3.3.3
Economic Background: Manufacturing Output

Manufacturing output grew steadily until the year 2000, however it then remained relatively flat until 2008 when the sector was hit hard by the recession and declined by over 10% in 2009.

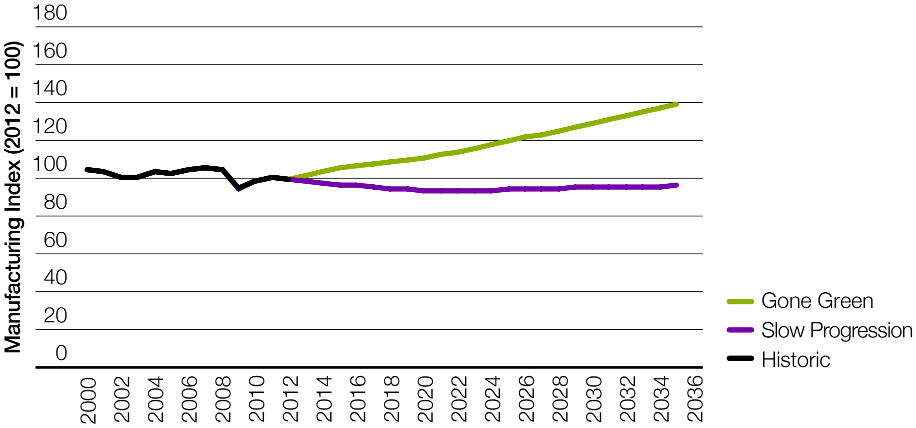
The sector has made some recovery but remains 5% below the levels in 2000. The sector shows resilience but has challenging growth prospects.

In **Slow Progression** there is a general malaise with economic activity in the manufacturing sector slowly declining with an annual reduction of 0.4% to 2023 before a modest recovery through to 2036. The scenario continues the recent historic trend in the sector with demand falling in the near term associated with broader economic conditions.

In **Gone Green** conditions improve with manufacturing rebounding to 2.0% growth in 2013 and 2014 due to continuing spare capacity in the market, growing demand across Europe and confidence from UK consumers. Over the medium term growth rates slow to an average of 1.5% per annum.

Figure 4 shows the indexed manufacturing output for the scenarios.

Figure 4
Indexed manufacturing output



3.3.4

Economic Background: Non-manufacturing Output

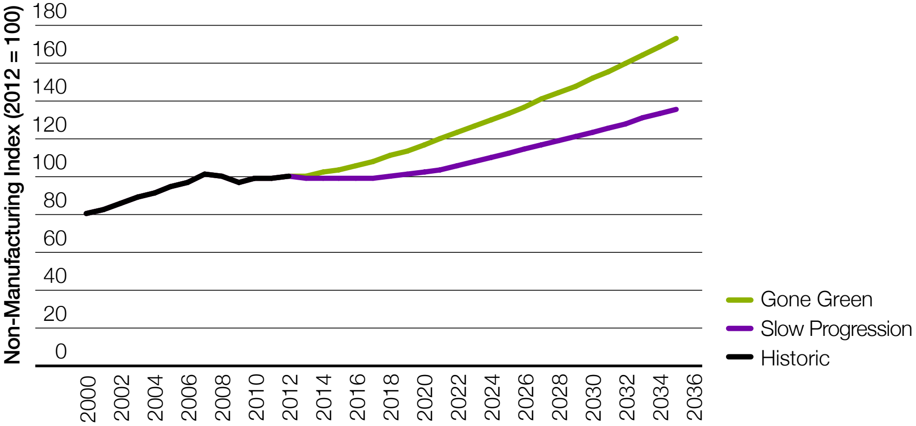
Non-manufacturing output growth has remained relatively flat since 2008 as the sector continues to recover from the recession.

Slow Progression sees a continuation of the relatively flat conditions until 2018 when growth increases annually, reaching a steady average annual rate of 1.9% from 2023 onwards.

In **Gone Green** growth rebounds quickly and reaches an average rate over 2% by 2016. Average annual growth rates for the period 2012–2036 are 2.6%.

Figure 5 shows the indexed non-manufacturing output for the scenarios.

Figure 5
Indexed non-manufacturing output



3.3.5
Economic Background: Fuel Prices

Fuel prices have a significant effect on total energy demand and form an important part of our analysis. For instance, in modelling electricity generation the relative prices of gas, coal and carbon are important in determining whether gas- or coal-fired generation is favoured. We develop our projections based on a number of sources, including government agencies, market analysts and trading houses.

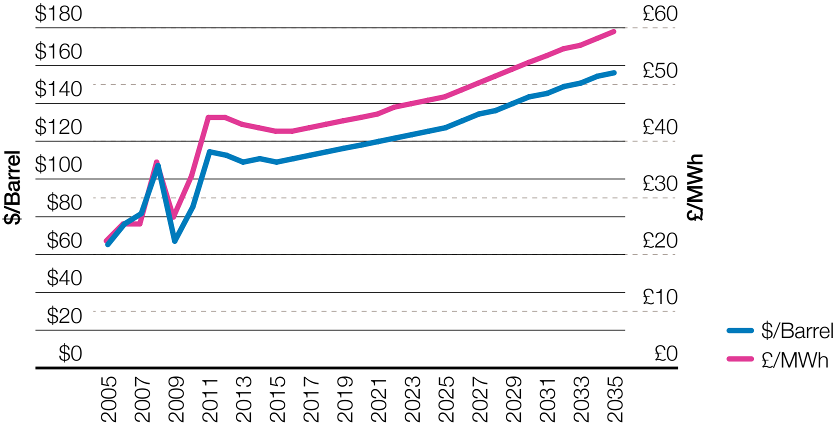
This year the fuel price assumptions used are the same for both **Slow Progression** and **Gone Green**. However, there is a difference in the carbon price projections, which will impact the fuel prices. These assumptions are comparative to the mid-point of the forecasts we benchmark against.

Oil

In both scenarios we have assumed relatively low underlying demand leading to oil prices reducing in the short term and remaining broadly flat until after 2015. After 2015, oil prices increase as a result of global demand increase, resulting from improvements in world economies. Beyond 2025 greater oil price rises reflect the increasing expense of retrieving oil from new and more costly supply sources.

Figure 6 shows the average annual wholesale oil price.

Figure 6
Wholesale oil price (Brent)

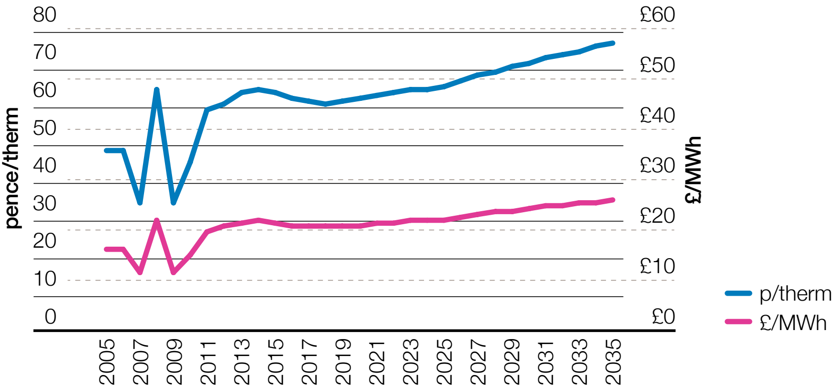


Gas

Gas prices remain fairly flat until 2020 when prices start to increase as a result of the oil linkage in prices. However, the degree of oil linkage continues to reduce throughout the scenario period and thus prices do not increase as much as oil post-2020. Any impact of US shale gas exports on price is assumed to be limited.

Figure 7 shows the average annual wholesale gas price.

Figure 7
Wholesale gas price



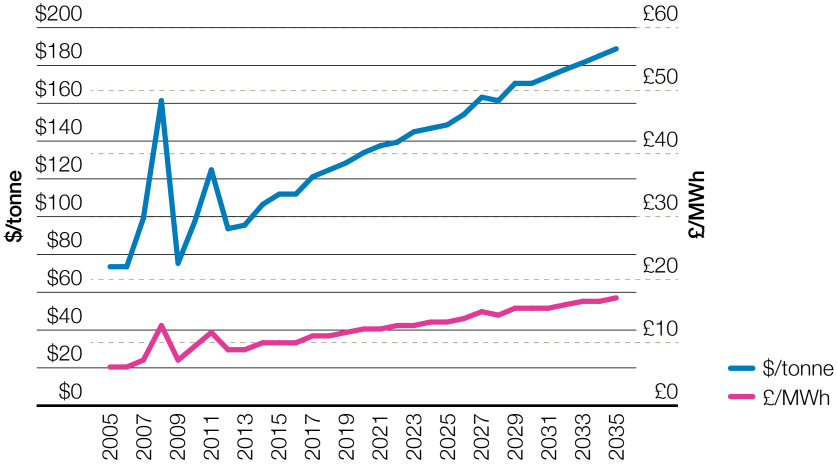
3.3 continued
Economic Background

Coal

Coal prices rise throughout the scenario period predominantly due to extra demand in developing countries, most notably from China and India.

Figure 8 shows the average annual wholesale coal price.

Figure 8
Wholesale coal price

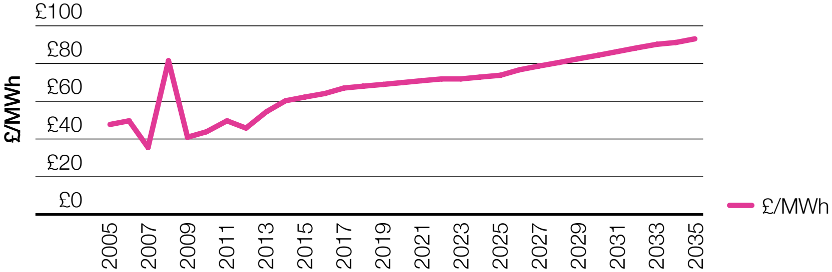


Electricity

Electricity prices are assumed to increase in the next few years due to decreasing margins as coal-fired plants retire due to the LCPD legislation. The reduction in coal prices also causes a higher relative level of linkage to gas prices in the mid-term, before costs of low carbon generation increasingly factor into the power price in the longer term. Figure 9 shows the average annual wholesale UK power price.

Note: the pronounced increase in the 2008 electricity price was due to a combination of high oil and gas prices, with low plant margins throughout the year. Both of these issues eased in 2009.

Figure 9
Wholesale UK power price (baseload)



3.3 continued
Economic Background

Carbon

As part of its commitment to the 1997 Kyoto protocols, in 2005 the EU set up the EU Emissions Trading System (ETS). The EU ETS operates as a cap and trade system designed to incentivise cost-effective reductions in greenhouse gas emissions from large industries and electricity generators. It puts a cap on the amount of carbon dioxide (CO_2) which can be emitted and creates a market and price for carbon allowances, which are surrendered in proportion to the amount of CO_2 emitted. The cost is determined via market mechanisms which are influenced by the total amount of CO_2 emitted and the amount of carbon allowances granted by the EU. It covers approximately 12,000 installations or 45% of EU emissions.

A UK Carbon Price Floor (CPF) was introduced on 1st April 2013 to guarantee a minimum price for CO_2 emissions from electricity generators in the UK. The floor price is achieved by a Carbon Price Support (CPS) on top of the EU ETS. The CPF has been set at £16/tonne for 2013 rising to £30/tonne in 2020, with an aspiration of £70/tonne in 2030[8].

The UK carbon price is the only element of the fuel prices that varies between the scenarios. **Gone Green** uses the CPF, whereas in **Slow Progression** the CPF is in place until 2017, when it is assumed to be abandoned on the basis of relative affordability compared to the EU ETS. This results in a return to the EU ETS price.

Figure 10 shows the average annual wholesale UK carbon price.

Figure 10
Wholesale UK carbon price

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[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190279/carbon_price_floor_consultation_govt_response.pdf

3.4
Heat

Axioms that influence this section

Renewable Energy/ Carbon Targets
Government Policy (UK & Europe)
Levy Control Framework
Economic Outlook
Fuel Prices
Heat

Summary

- Heat is a major use of energy in both scenarios
- Since 2005, significant and continuing increases in energy prices, combined with government policies, have brought about substantial increases in energy efficiency measures
- Total energy savings from cavity wall insulation are greater than savings from loft and solid wall insulation
- There remains considerable uncertainty over how the Green Deal and ECO support will influence the take-up of solid wall insulation
- Both scenarios assume that the insulation market is beginning to saturate
- Savings from boiler replacements are considerable
- New houses will be increasingly energy efficient as a result of incremental changes in building regulations
- Heat pumps are assumed to initially be deployed in houses not connected to the gas grid, including displacing electric resistive heating, resulting in a net reduction in electricity demand.

Key statistics

Residential Heat Pump installations:
2012: **0.1 million**
2020: Gone Green – **1.2 million**
Slow Progression – **0.3 million**
2030: Gone Green – **5.7 million**
Slow Progression – **0.6 million**

What needs to be achieved for the targets to be met?

- Continued improvement of heat pump performance
- High level of housing stock insulation
- Continued rate of boiler replacement
- Strong government policy and incentives
- Substantial increase in energy efficiency
- Implementation of zero carbon standard for new homes.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Power Demand *(Section 4.1)*
- Gas Demand *(Section 4.3)*

3.4 continued
Heat

3.4.1
Efficiency Improvements: Heat

Since 2005, significant and continuing increases in energy prices, combined with government policies, have brought about substantial increases in residential energy efficiency.

We have carried out analysis of recent demand reductions and have developed specific energy efficiency scenarios to account for potential future demand. These mainly focus on the residential sector as this remains the largest natural gas demand sector and there is relatively robust data published on the uptake of energy efficiency measures.

Our energy efficiency scenarios are concerned with the energy demand reductions from existing houses. Here we outline energy efficiency in relation to insulation and boilers. Energy demands from new houses are analysed separately, this is described in further detail later in this section.

Insulation

Our insulation analysis covers cavity wall, solid wall insulation and loft insulation take-up as these areas are where the greatest potential energy demand improvements can be or have been realised. It does not cover areas such as double glazing and draught-proofing as improvements from these areas are seen to be marginal and incremental, and as such are captured by econometric modelling (see section 3.3).

Significant savings have occurred in the last 5–10 years through improved insulation. This has been primarily due to government energy efficiency schemes for example, CERT (and formerly EEC1&2[9]), with a notable but lesser impact of Warm Front[10]. The Community Energy Saving Programme (CESP)[11] has recently contributed to an increase in solid wall insulation, mostly instigated by Local Authorities in social housing, treating whole streets at once rather than individual houses. At the start of 2013 the Green Deal and ECO were introduced and replaced CERT and CESP.

My Green Deal experience…

I had a funded Green Deal assessment arranged by my local authority. The whole process was surprisingly simple; I received a leaflet in the post and arranged the visit over the phone for the following week. For the assessment itself, which was carried out by an accredited Green Deal assessor, I had to provide my energy bills for the last 12 months and though the assessment took about 90 minutes, I was only needed for 15 minutes of that.

Given I have oil central heating (we spend about £1,800 a year on oil and electricity) I was anticipating recommendations of heat pumps, solar water heating, the works. I was surprised that the main recommendations were solar PV and a new condenser oil boiler. This may be because our energy consumption is so low as a result of the fact that oil prices are high. We are now considering this feedback.

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[9] Energy Efficiency Commitments 1 & 2

[10] https://www.gov.uk/warm-front-scheme

[11] http://webarchive.nationalarchives.gov.uk/20121217150421/http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx

Energy savings from cavity wall insulation are greater than those from loft and solid wall insulation, due to the combination of uptake numbers and the amount each installation can save. The cavity wall insulation savings account for more than the other two measures added together by 2020. Solid wall insulation has the greatest variability between scenarios as there remains considerable uncertainty over how the Green Deal and ECO incentives will influence the take-up of solid wall insulation.

Our scenarios assume the insulation market is beginning to saturate, particularly for loft and cavity wall insulation. We also assume that remaining houses that have potential insulation savings will be reluctant to adopt measures, particularly those requiring solid wall insulation that is more challenging to install and significantly more expensive.

The difference in insulation rates in our scenarios is driven by the effectiveness or otherwise of the Green Deal.

In **Slow Progression** there is a very significant reduction in the rate of energy efficiency take up as remaining households are very resistant to take up insulation and the Green Deal and ECO fail to encourage further consumer uptake.

In **Gone Green** the Green Deal is fairly successful at encouraging insulation, though not as successful as CERT and CESP. There is quite a significant reduction in the rate of take-up of energy efficiency measures due to greater prevalence of harder to treat and reluctant households. Solid wall insulation rates increase slightly over time due to the ECO but not as much as the government Impact Assessment[12] anticipates.

Installation rates of insulation measures are shown for both scenarios in Figure 11 to Figure 13. We have assumed rates consistent with the government Impact Assessment discounted to 50% for **Gone Green** and 25% for **Slow Progression** for loft and cavity insulation. **Slow Progression** adopts historic rates for solid wall insulation and **Gone Green** assumes a 50% discount to the Impact Assessment.

Around 23 million of the 27 million houses in Great Britain are gas heated with around 2 million using electricity. The energy savings from insulation are split in this ratio between gas and electricity demand.

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[12] http://www.decc.gov.uk/assets/decc/11/consultation/green-deal/3603-green-deal-eco-ia.pdf

3.4 continued
Heat

Figure 11
Take up of loft insulation

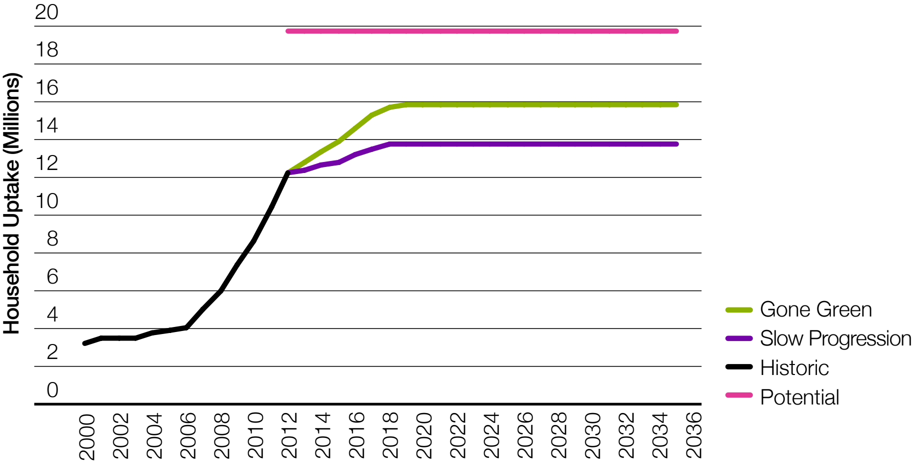


Figure 12
Take up of cavity wall insulation

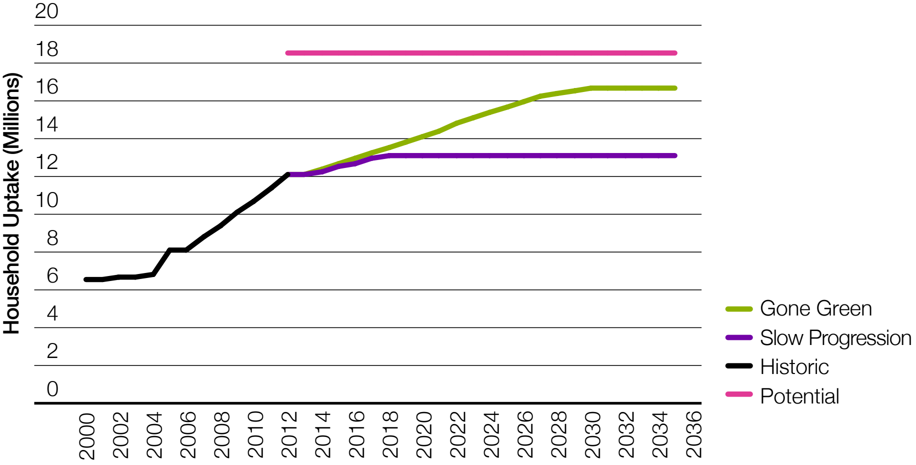
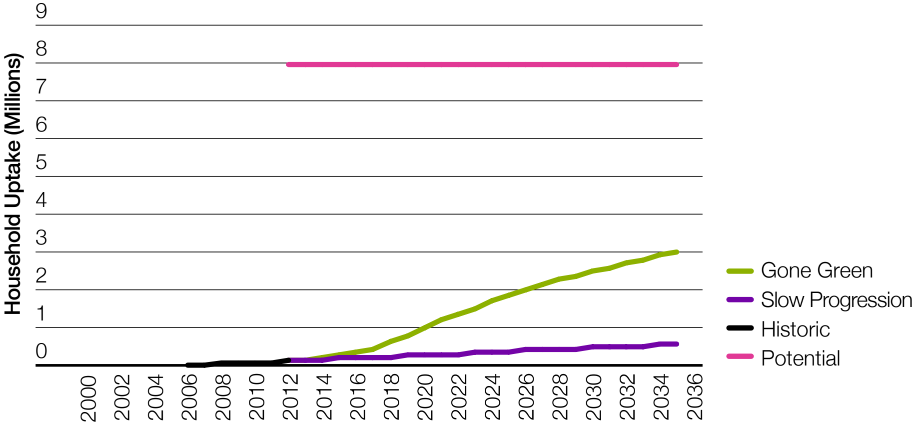


Figure 13
Take up of solid wall insulation

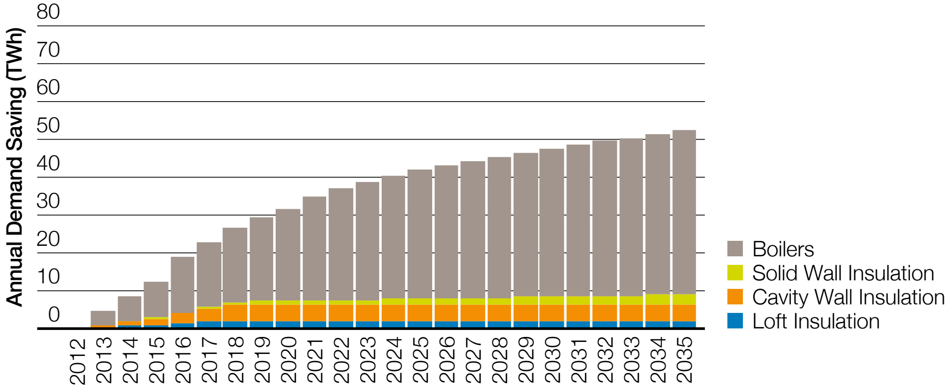


Boilers

Savings from boiler replacements are considerable in both scenarios. Differences between scenarios are marginal as gas boilers tend to be replaced due to the failure of an existing unit. The efficiencies of new boilers are legislated and well documented.

Savings in gas demand for residential heating are shown in Figure 14 and Figure 15 and total insulation savings in residential electricity demand are shown in Figure 16.

Figure 14
Gas demand savings from residential energy efficiency measures: ***Slow Progression***



3.4 continued
Heat

Figure 15
Gas demand savings from residential energy efficiency measures: ***Gone Green***

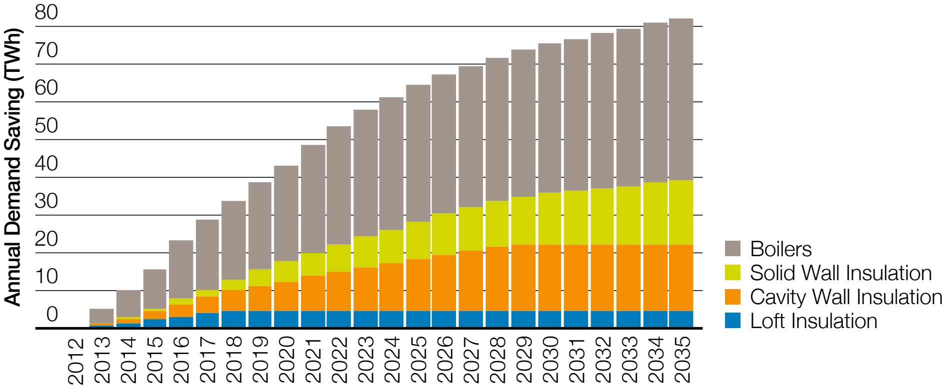
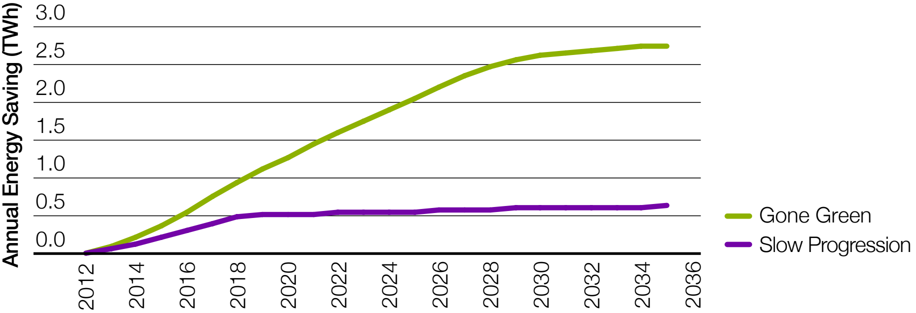


Figure 16
Residential electricity demand savings from insulation



New houses

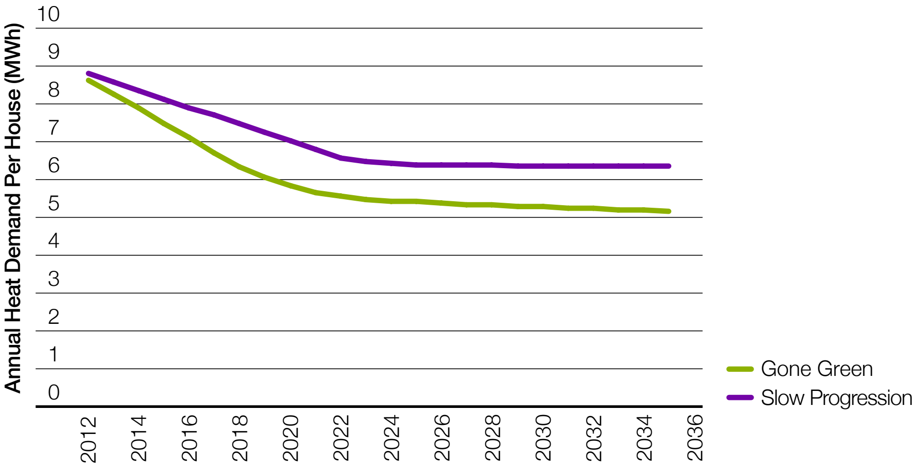
Changes in building regulations, leading to the zero carbon homes, or "code 6" standard[13] by 2016, mean that new houses will be increasingly efficient. Gas is still assumed to be part of the mix as zero carbon is an off-settable measure (i.e. gas can be used for heating a new housing estate if extra renewable generation is installed away from the estate). Differences between the scenarios are due to different views of when the zero carbon standard is achieved, boiler efficiencies and different hot water requirements.

Slow Progression assumes the effect of the zero carbon homes standard materialises in 2022, from a combination of relaxing of building regulations by four years to 2020 and an average two-year delay between achieving planning permission (at code 6) and household completion. It also assumes no reduction in hot water energy requirements.

Gone Green assumes the effect of the zero carbon homes standard materialises in 2018, two years after its implementation in 2016, due to an average two year timeframe between achieving planning permission (at code 6) and household completion. It also assumes that the energy requirement for hot water reduces by around 0.5% per year, in line with trajectory 3 in the DECC 2050 calculator[14].

Figure 17 shows how the heat requirement for a new house decreases with time in the two scenarios.

Figure 17
Decreasing heat demand from new houses



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[13] http://www.communities.gov.uk/documents/housing/pdf/2033676.pdf
[14] http://2050-calculator-tool.decc.gov.uk/

3.4.2
Heat Pumps

The development of heat pumps will be of great importance in meeting environmental targets. Our assumptions on the type of heat pump fitted in houses remains unchanged from last year in that the majority will be air-water heat pump systems, i.e. air source heat pumps supplying radiators.

The extra work involved in laying piping for ground-source heat pumps suggests that costs will be significantly higher. In all cases a high level of insulation is required to make best use of the lower temperature heat delivered by heat pumps. Upwards of 12 million properties currently meet this criterion, this figure is expected to grow under the Green Deal scheme. The timescales for installing heat pumps will be a crucial factor in determining the level of uptake of this technology as many boiler/ heating replacements are distressed purchases when the existing heating fails.

In our projections heat pumps are initially concentrated in houses not connected to the gas grid, encouraged by government policy to electrify heat[15] through the RHI, the Renewable Heat Premium Payment (RHPP) incentive scheme, the high price of non-gas fuels and the Green Deal / ECO. The next tranche of heat pumps are installed in new houses with their better insulation and lower heat demand fuelled by changes in building regulations i.e. path to zero carbon homes by 2016. Finally heat pumps enter the mainstream heating market for houses on the gas network (assuming cost benefit) as economies of scale reduce heat pump installation and unit costs to levels similar to gas boilers today.

Market saturation is not reached in either of our scenarios due to high inertia to technological change.

In **Gone Green** the 2014 RHI spurs short to medium term growth in heat pump installations while **Slow Progression** assumes growth rates continue as they are today.

Figure 18 shows the total number of residential heat pumps in both scenarios along with their associated load.

Effect on annual electricity demand

As the first heat pumps are installed they are assumed to displace electric resistive heating, resulting in a net reduction in demand.

By 2030 the electricity demand from heat pumps in new houses together with the added demand from installations, which are displacing oil and gas rather than electric resistive heating, outweighs the losses, leading to a net increase in demand.

Figure 19 shows the net change in demand for both scenarios.

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[15] DECC Heat Strategy (2013) ‘Future of Heating: Meeting the Challenge’

Figure 18
Cumulative heat pump numbers and associated load (TWh)

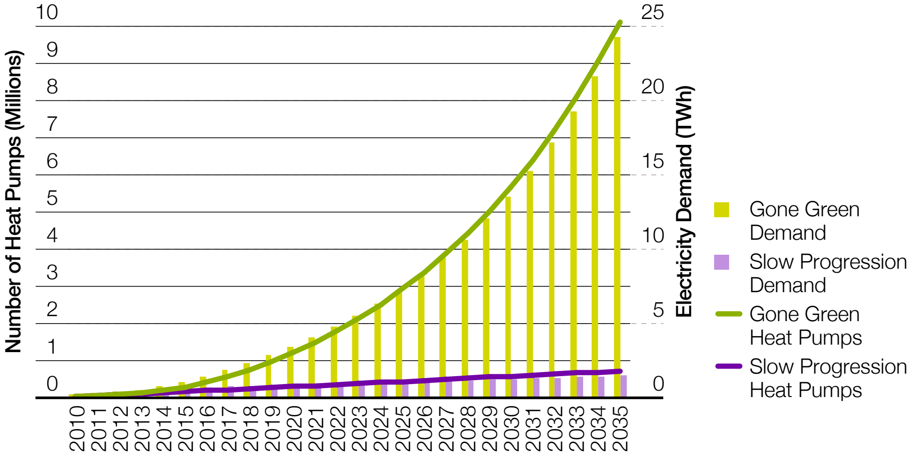
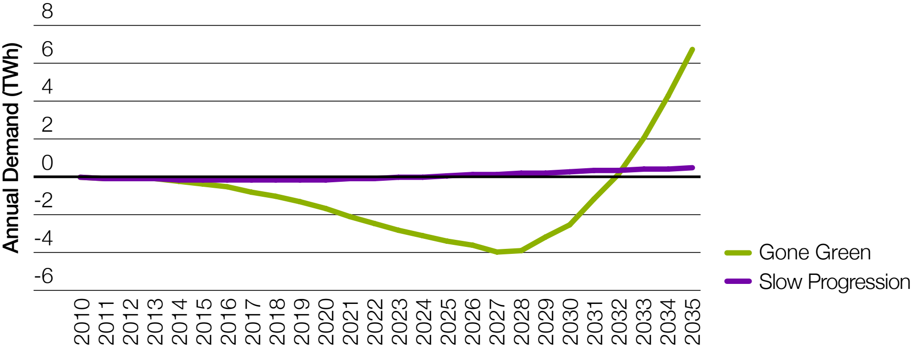


Figure 19
Changes in electricity demand due to residential heat pumps



Heat

A day in the life of my air-source heat pump…

We did a lot of research prior to purchasing our air-source heat pump as we'd been told that it could be cheaper to run than our oil-fired boiler but we knew little else about them.

We refurbished the house two years ago; the children were self-sufficient and we were a few years away from retirement, so if we were going to invest money in the house, it seemed like the right time. Our house wasn't connected to mains gas so we were reliant on heating oil – we wanted to remove this reliance, manage our fuel costs and move to a 'greener' alternative, so when we decided to refurbish, it seemed like the perfect opportunity to explore our heating options. I'd also heard about the Renewable Heat Incentive that could provide financial incentives and this was the final nudge we needed.

Our research suggested that ground-source heat pumps were more efficient, but we were limited to air-source due to the size of our garden. Although this was actually the cheaper option, we were slightly hesitant due to the noise it might produce, and our neighbours expressed similar concerns. It was a relief to find that the unit is inaudible from inside the house and even from outside the noise is minimal. There is a gentle hum, as the system kicks in for a few minutes every hour to reach the correct temperature, but this isn't constant. The unit was installed in a discreet location at the side of the house, so the aesthetics aren't an issue either.

During the refurbishment, we also had a 300-litre hot water tank and a wood burner installed, improved the insulation and opted for under-floor heating, with the intention that these improvements would complement each other.

We did have initial teething problems with setting the temperature; at first we couldn't understand the heating controls and the house seemed far too hot. Now we keep the house at a constant 20°C around the clock and it requires very little interaction day to day. The under-floor heating works well to keep the ambient temperature as you don't get heat pockets like you would with radiators and we use the wood burner to back up the heat pump when it's particularly cold.

The house does take longer to warm up since we had the heat pump installed and it takes a while to adjust to the fact that you can't just flick on the heating, but I wouldn't even describe this as an inconvenience. We've adjusted to it and I think our behaviours have changed more than we've acknowledged – from energy usage to the temperature inside and outside the house, we monitor everything now!

In the two years since having the heat pump installed, the savings on our fuel bill have been significant. As electricity is needed to drive the pump, we're not entirely self-sufficient and our carbon footprint isn't zero but this feels like an important step in the right direction.

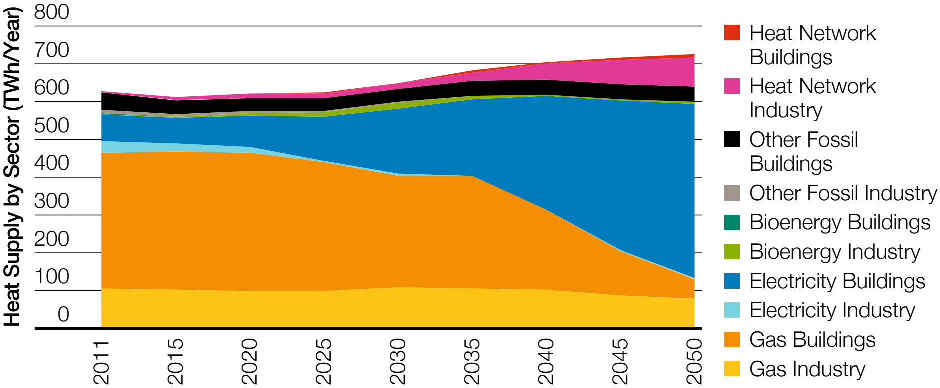
3.4.3
2035–2050

From 2035 to 2050 the heating market is increasingly dominated by electric heat pumps. These are mostly air-source but by 2050 there are some ground-source heat pumps in the mix as the higher efficiency of this technology makes a valuable contribution to meeting the carbon reduction target, despite their relatively high cost.

Gas continues to make a useful contribution and makes up between 10% and 15% of the residential heat requirement. Gas use in industry decreases slightly to 2050; gas is retained in the high temperature heat sector where there are few other suitable sources, but its use in conventional boilers is largely displaced by lower carbon sources.

Figure 20 shows the supply of heat aggregated across all market sectors to 2050.

Figure 20
Heat supply to 2050



3.4 continued
Heat

Sensitivity

Gone Green requires more low carbon options in 2050, and as a result makes more use of bio-resources for a variety of uses including bio jet-fuel and creation of bio-methane for injection into the gas network. It is possible that this level of bio-resource use may be difficult to sustain, especially if a strong global market develops and less material is available to the UK.

To address this possibility we have considered a scenario in which the availability of bio-resources falls after 2035, consistent with the Redpoint Baringa report "Pathways for decarbonising heat"[16]. Removing this low carbon resource from 2050 altogether would make it more difficult to hit the 2050 decarbonisation target, leading to some extreme strategies.

One alternative to more use of bio-resources may be hydrogen as a low carbon fuel generated by steam methane reforming in plant equipped with CCS; this has the potential to be used in industry clusters providing low carbon high temperature heat.

Seasonality of Heat[16]:

Demand for heat has a large seasonal and within day variation, much more so than electricity. By 2050 electric heat pumps are used to supply the majority of the heat load, but to electrify the entire load would require significant investment in generating and electricity network capacity. Figure 21 illustrates how heat is supplied throughout the year and on a 1 in 20 peak day. The right-hand side of the annual chart shows baseload heat, where gas makes little contribution. Moving towards the seasonal heat demand on the left-hand side of the chart, gas plays an increasingly important role. On the far left the chart shows the 1 in 20 peak day and gas supplies well over half the total heat demand. This demonstrates how gas and hybrid boilers, continue to play an important role in managing the variability of heat demand. In a new development since last year's **Gone Green** we now assume there is a reasonable amount of in-building heat storage which also helps to smooth out the swings in daily heat demand.

What has changed since 2012?

- We have updated the scenarios with the latest view of actual installations – this leads to little change in the starting position of the scenarios but beyond this we have slightly reduced the number of heat pumps with a reduction in **Gone Green** of 10% by 2030
- Effect of CRC Energy Efficiency Scheme Policy has been included in the analysis due to increased certainty around its implication.

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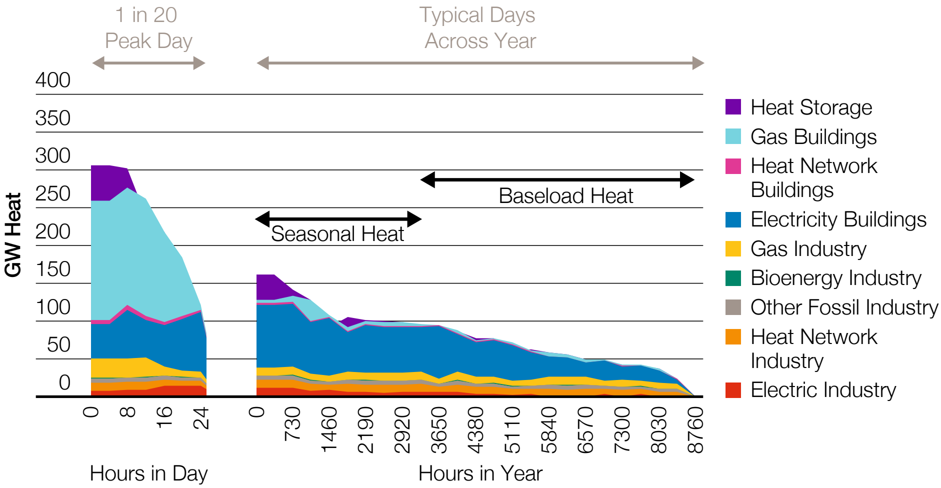
[16] http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/Future+Energy+Scenarios/Heat+Studies/

Figure 21
Heat duration supply curve for 2050



Key technologies

- There are now approximately 100,000 residential heat pumps installed in the UK
- There were approximately 25,000 heat pumps sold in 2012.

Key uncertainties and areas for development:

- Impact of the Green Deal
- The degree to which householders will install solid wall insulation
- The level of consumer acceptance to move to electrifying their heat use and consequently how many consumers will shift this load
- The impact of the residential RHI (once implemented).

3.5

Consumer

Axioms that influence this section

- Renewable Energy/ Carbon Targets
- Government Policy (UK & Europe)
- Levy Control Framework
- Economic Outlook
- Fuel Prices
- Energy Efficiency
- Commercial Energy Efficiency
- Energy User Behaviour

Summary

- Lighting and appliances are a major use of electricity consumption in the home
- European Union policy has resulted in a reduction in electricity demand for residential lighting
- Both scenarios show that electricity demand for lighting could halve by 2020
- Time-of-use tariffs (TOUTs) are an important driver for behaviour change, smart meters are a key enabler for behaviour change
- There needs to be a build up of trust, along with clarity and understanding, for consumers to engage with their energy use.

Key statistics

Lighting

Average bulb wattage in residential homes:
2012: 17W
2020: Gone Green – 7.5W
Slow Progression – 7.6W
2030: Gone Green – 6.6W
Slow Progression – 7.0W

Appliances

Average yearly demand per appliance*

KW/h year	2011	2020		2030	
		SP	GG	SP	GG
Washing Machine	211	202	193	196	184
Tumble Dryers	380	363	354	348	330
Television	140	133	128	122	98
Fridge-Freezer	437	338	310	310	254

Smart Meters

Gone Green smart meter roll-out completed by 2020.
Slow Progression smart meter roll-out completed in 2032.

Households with TOUTs:
Gone Green – 50%
Slow Progression – 25%

For households with TOUTs, peak demand is shifted by **5%****

EU standard for smart appliances agreed in 2020 for **Gone Green**

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* 'DECC: Energy Consumption in the UK 2012', available at https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-consumption-in-the-uk

** The changes to peak behaviour are in addition to the Economy 7 effect, in which a high proportion of these customers will already have taken measures to reduce electricity consumption, or shift appliance use away from peak times.

What needs to be achieved for the targets to be met?

- LED bulbs need to come down in cost and become the default option
- Consumers need to be given the opportunity to save money and energy through time-of-use tariffs
- The smart meter roll-out needs to be completed to facilitate time-of-use tariffs
- EU standards for smart appliances need to be agreed and appliances must continue to become more efficient over time
- Electric vehicle (EV) charging points and heat-pumps need to be integrated with smart meter infrastructure.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Power Demand *(Section 4.1)*
- Gas Demand *(Section 4.3)*

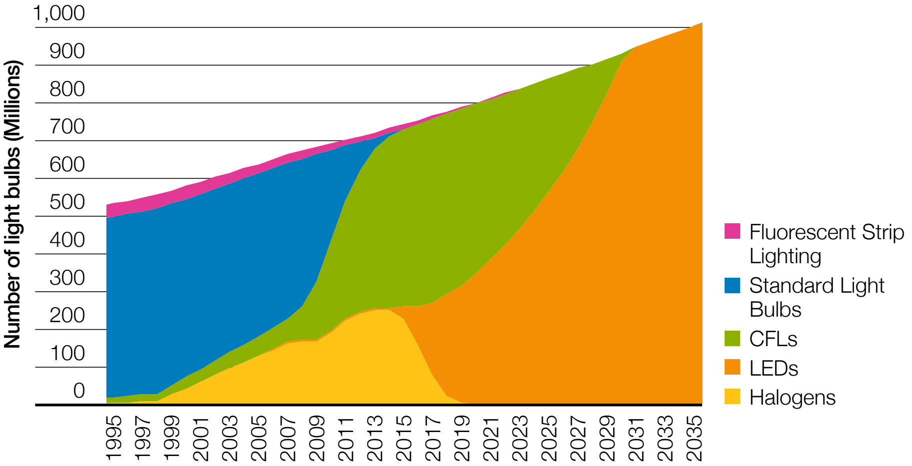
Changing consumer energy use is an important element to achieving the 2050 carbon emissions target; improvements in energy efficiency will be central to this.

3.5.1
Lighting

Electricity demand for residential lighting has fallen significantly in recent years predominantly due to the replacement of standard incandescent bulbs with compact fluorescent bulbs (CFLs) and halogens, and the emergence of light-emitting diode (LED) bulbs.

Government policy has enabled this reduction, predominately via CERT which provided for the roll-out of significant amounts of CFLs. In addition legislation has phased out the sale of standard incandescent light bulbs. Looking ahead the EU has legislation in place to remove more inefficient halogens from sale by 2016. Together, these pieces of legislation will have a significant effect on the electricity demand for lighting in the coming years. Figure 22 shows the historic and predicted changes in the make-up of light bulb types in the UK and the effects of legislative change in our **Gone Green** scenario.

Figure 22
*Number of light bulbs in **Gone Green***[17]



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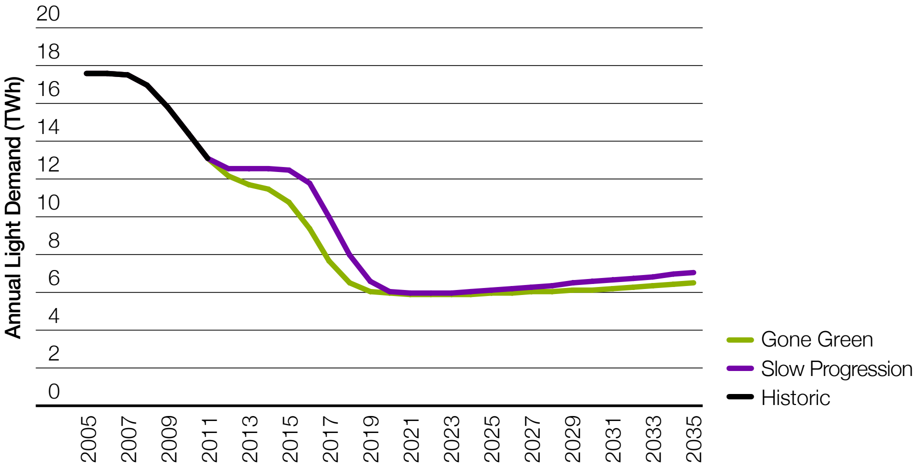
[17] Historic light-bulb data from: Energy Consumption in the UK, Domestic data table 3.11, 2012 Update. https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-consumption-in-the-uk

Both our scenarios show that electricity demand for lighting could halve by 2020 even though numbers of bulbs are increasing. Both fall to the same level due to the legislated requirement to replace any failed inefficient bulbs with more efficient ones.

The difference between the scenarios is due to the speed, timing and different views of what technology replaces incandescent and halogen bulbs. Demand increases post-2020 as increasing house numbers begin to offset earlier efficiency gains.

Figure 23 shows the 2013 demand scenarios for residential lighting.

Figure 23
2013 Light demand scenarios



Slow Progression assumes the number of halogens continues to increase at current rates until EU policy takes effect, which causes demand to increase to 2016. After which demand falls rapidly due to the replacement of halogens with CFLs and LEDs. CFLs are not replaced by LEDs.

Gone Green assumes demand falls sooner as fewer halogens are purchased and the technology is replaced by LED spot lights. Both CFLs and halogens are replaced by high quality and low cost LEDs, which start to saturate the market in the 2030s.

3.5 continued
Consumer

Case Study: Greenwatt Way

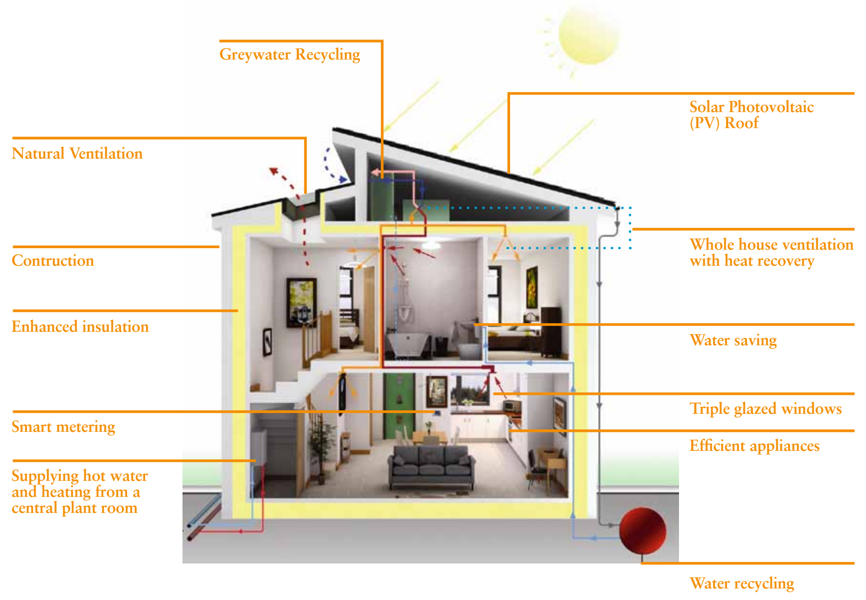
SSE plc have built 10 ‘zero carbon’ homes using the latest construction methods and technologies to deliver housing to level 6 of the Code for Sustainable Homes. The housing development opened in autumn 2010 and features smart metering, efficient appliances, solar photovoltaic roofs, water saving and recycling, and hot water and heating from a central plant room. Different technologies in the central plant room generate heat from renewable and sustainable sources. Tenants also have access to a shared electric car, and benefit from reduced energy and water bills.

This research project aims to provide the SSE group and its partners with a better understanding of the needs of customers in a low carbon world as currently very little is understood about how much heat and power is needed and how occupants will ‘use’ zero carbon homes.

SSE is studying energy consumption levels, how the occupants interact with their energy efficient zero carbon homes and the energy generation performance levels of each of the renewable technologies.

The findings from this study have the potential to provide a better understanding of consumers’ needs as the UK moves to reduce its carbon emissions; helping the energy industry to determine the changes in energy generation and consumption that are required for a low carbon society to become a reality.

For further details please visit
http://www.ssezerocarbonhomes.com/



Source: SSE Plc

3.5.2
Appliances

This section is concerned with residential electrical appliances only. To improve our methodology this year we have benchmarked predicted improvements in appliance electrical efficiency to corresponding improvements on the EU energy label scale (A+++ to D).

In the past 20 years the electrical efficiency of residential appliances has improved considerably, largely as a result of EU standards. This has led to a reduction in demand per appliance. However, these reductions in demand have been outweighed by the growth in the number of appliances in homes. Currently appliances account for around two thirds of residential electricity demand; around a fifth of total demand.

Our appliance scenarios have been developed using data from the '2012 Energy Consumption in the UK report published by DECC'[18]. The categories of appliances considered are as follows:

- Cold appliances: fridges and freezers
- Wet appliances: washing machines, dishwashers and tumble dryers
- Consumer electronics: TVs, games consoles, chargers, power supply units etc.
- Home computing including printers
- Cooking including microwaves and kettles.

Slow Progression assumes slower economic recovery resulting in less efficient technology remaining in homes for longer as consumers have less disposable income to spend on replacements. As a result more efficient technology takes longer to filter through the UK stock. The use of less efficient appliances results in a demand increase to 2035.

Gone Green assumes economic conditions are more favourable meaning consumers have more money to spend on new and replacement appliances. As a result appliances are bought more frequently, leading to a quicker take up of new, more efficient, technology. The increased energy efficiency of appliances offsets the increasing numbers of appliances enough to provide a levelling off of power demand and then a reduction to 2035.

Underlying demand increases from new houses are assumed in both scenarios.

Where possible we have used a benchmarking method to compare possible efficiency improvements against current EU Energy Label bands[19].

For **Slow Progression** it is assumed that the average appliance will improve by one band by 2035.

For **Gone Green** it is assumed that the average appliance will improve by two efficiency bands by 2035 compared to the current level.

The main differences between the scenarios are due to differing views on the take-up of more efficient technology:

Fridge Freezers – In **Slow Progression**, the increase in the number of appliances, resulting from new homes, outweighs the lower efficiency gains. In **Gone Green** more efficient fridge freezers on sale in the last few years continue to penetrate the market, leading to steady demand reductions.

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[18] https://www.gov.uk/government/publications/energy-consumption-in-the-uk

[19] http://ec.europa.eu/energy/efficiency/labelling/labelling_en.htm

3.5 continued
Consumer

Televisions – In **Gone Green** new technology such as Organic Light-Emitting Diodes (OLED) start to penetrate TV stock, replacing older Plasma and liquid-crystal display (LCD) technology. In **Slow Progression** this technology is much slower to take off, with consumers retaining plasma and LCD TVs for longer.

Set-top boxes – In **Gone Green**, set-top boxes and DVD players decline in both scenarios as they become obsolete and are replaced by internet services and smart TVs. In **Slow Progression**, consumers retain these devices for longer.

Desktops – In **Slow Progression**, the decline of desktops is slower and consumers buy more laptops instead of moving straight to mobile computing. In **Gone Green**, small electrical devices such as tablets and smart phones continue to increase in numbers leading to a significant fall in numbers of desktop computers.

Increasing numbers of other appliances such as dishwashers and microwaves lead to modest increases in overall demand in both scenarios, due to greater adoption within new and existing households.

Figure 24 shows the total appliance demand.

Figure 24
Total appliance demand

3.5.3
Smart Meters

The introduction of electricity smart meters, when coupled with time-of-use tariffs (TOUTs), is intended to facilitate demand-side management at times of peak electricity demand[20]. The government is calling for smart meters to be installed in all households by 2020. Our scenarios assume maximum installation is 95%, to reflect some consumer reluctance and geographical complexity in connecting smart meters to IT infrastructure, but by different dates, as discussed below.

The installation of a smart meter is only one in a series of long-term tasks that will realise the potential of smart technology.

Time-of-use tariffs and in home displays are an important driver for behaviour change: successful trials have tended to be simple, with predictable high demand periods and clear financial benefits for consumers. These tariffs could be valuable commercial tools within our **Gone Green** scenario, with high proportions of renewables, but to be fully effective there needs to be appropriate price signals, acceptance of automated smart appliances and wide consumer engagement.

“” My experience of in-home displays…

The visual reinforcement of the in-home display has driven the change in my behaviour; seeing how the display changes depending on which appliances are in use has helped me to understand my energy consumption. It's been a learning curve, but now I understand my consumption, I'm in a position to manage it. For instance I'm mindful not to boil the kettle several times for one cup of tea and lights are switched off when I leave a room now. When you see the display turn from green to red, it's a hard message to ignore. It's a simple but powerful form of education.

“” My experience of time-of-use tariffs…

We've been on Economy 7 for a decade now. It was a conscious decision to save money and, as a result, we've shifted about one third of our appliances to run overnight when electricity is cheaper. This includes the dishwasher, washing machine and tumble drier, but it hasn't changed our cooking patterns.

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[20] The changes to peak behaviour are in addition to the Economy 7 effect, in which a high proportion of these customers will already have taken measures to reduce electricity consumption, or shift appliance use away from peak times.

3.5 continued
Consumer

Consumer behaviour is critical to the success of smart technology. Views on the proportion of consumers who will engage vary widely.

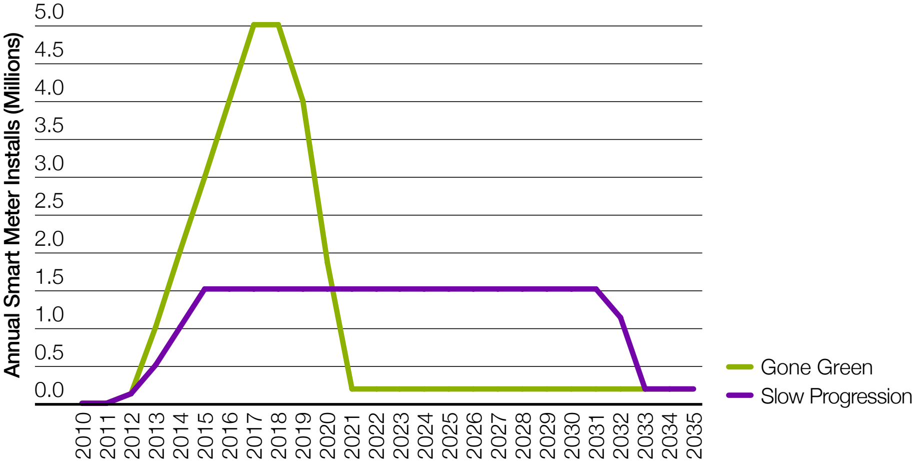
In **Slow Progression**, smart meter roll-out is assumed to build up to the current replacement rate of non-smart meters (around 1.5 million replacements per year) achieving completion in 2032. 25% of consumers are assumed to engage with smart meters and use TOUTs. These consumers reduce their annual demand by 1% and their peak demand by 5% compared to unconstrained demand. Smart appliances are not widely available in this scenario.

Gone Green assumes the smart meter roll-out is completed during 2020, requiring the recruitment of significant numbers of installation agents and a favourable appointment to installation ratio. 50% of consumers are assumed to use TOUTs. These consumers reduce their annual demand by 4% and initially reduce their peak demand by 5% compared to unconstrained demand.

Gone Green assumes an EU standard for smart appliances is agreed before 2020 and that smart appliances are readily available. The gradual purchase of these devices by engaged consumers allows them to respond to dynamic TOUTs and their peak demand falls by a further 5% compared to unconstrained demand.

Figure 25 shows the numbers of electricity smart meters assumed to be rolled out in our 2013 scenarios. In both scenarios, smart meter installation continues in the long term due to new housing growth.

Figure 25
Number of smart meters assumed to be rolled out



Consumer education

We need to dramatically change the way that we consume energy if we are to achieve the 2050 target; to reduce carbon emissions by 80% from 1990 levels. We all need to become more efficient in our use of energy, reduce our consumption levels and embrace low carbon energy.

Education will be vital in empowering consumers to change their behaviour and play their role in reducing carbon emissions. Understanding the audience is crucial, and education will need to be targeted and tailored to individuals, whether this is education in schools or educating households.

For those in full-time education, energy issues need to be embedded in the national curriculum and be supported by practical applications. Information should be relevant and continually reinforced through each year of school. Pupils should be given responsibility for energy efficiency actions and as they reach school leaving age, links should be made to finance and consideration of household bills to reinforce their learning. Enthusing children has the potential to make a huge impact.

Educating consumers will be most effective if the approach is tailored to each consumer group. Those in employment may benefit from workplace initiatives that inspire change; an average household may require practical advice and information that is tailored to fit all occupants (for example, literature for adults accompanied by education packs for children); trusted support and help with new technologies should be offered to the retired generation; and those in fuel poverty should be given guidance on what their energy use is costing by appliance and shown where savings can be made. In all cases, it is important for behavioural changes to be linked directly to the benefits.

Our aspiration is for the energy industry, educators, consumer groups and communities to work together to deliver targeted communications to raise awareness, inform and inspire consumers, and empower them to change their energy behaviours in everyday life.

3.5 continued
Consumer

What has changed since 2012?

- Our new bottom-up approach for residential demand means that we now assess and implement our analysis on appliances differently using EU energy efficiency ratings to provide a “floor” on how efficient appliances can get
- Our assumptions for smart meter roll-out in **Gone Green** have changed: **Gone Green** assumes completion in 2020 (we assumed 2022 completion in 2012), **Slow Progression** assumes completion after 2030
- In May 2013, DECC announced the start of the smart meter roll-out programme would be delayed to 2015. From a demand perspective, a one year delay has minimal impact. How many consumers actually engage with smart meters and TOUTs, and when smart appliances become available, are more significant factors
- Feedback obtained from the 2012 UKFES consultation process (peak demand might fall by up to 10% in **Gone Green**, and by up to 5% in **Slow Progression**) has been reflected in our 2013 scenarios
- We have examined UK smart meter trial reports that have been made available over the last 12 months to further back up our assumptions and analysis
- We have further considered consumer behaviour and who might engage with smart technology. As we are no longer assuming 100% consumer engagement in the 2013 scenarios, this has reduced the long-term impact of smart meters and TOUTs and therefore has the effect of increasing demand
- We have included consideration of the impact on demand of smart appliances, previous technology roll-outs (e.g. set-top boxes, mobile phones) and appliance life-spans.

Key uncertainties and areas for development:

- To what extent and at what rate will consumers engage with simple TOUTs and avoid peak consumption, between now and 2035?
- The interaction of electric vehicles and heat pumps with smart meters and TOUTs
- By what proportion will consumers reduce annual and peak demand?
- When will user controlled smart appliances become readily available? Smart appliances are critical if greater energy efficiency and system balancing benefits are to be realised
- Actual smart meter roll-out progress.

3.6
Transport

Axioms that influence this section

- Renewable Energy/Carbon Targets
- Government Policy (UK & Europe)
- Levy Control Framework
- Economic Outlook
- Fuel Prices
- Transport (Road & Rail)

Summary

- There are only a small number of electric vehicles (EV) currently on the road
- Range extended and plug-in hybrids are expected to dominate the market
- Users in London, second car and fleet buyers are likely to make up the bulk of the early adopters
- Market saturation of EVs is not reached in either scenario
- **Slow Progression** assumes rail demand continues to grow at historic rates of 1.5% annually and reaches 5TWh by 2030
- **Gone Green** assumes rail demand will grow at 2.5% annually, reaching 6TWh by 2030.

Key statistics

Approximately **5,000** electric vehicles are on the road today: **84%** PEV, **16%** PHEV/E-REV

Number of electric vehicles in:
2020: Gone Green 0.56 million, of which:
25% PEV, 75% PHEV/E-REV
Slow Progression 0.16 million, of which
20% PEV, 80% PHEV/E-REV

2030: Gone Green 3.2 million, of which:
18% PEV, 82% PHEV/E-REV
Slow Progression 0.9 million, of which
8% PEV, 92% PHEV/E-REV

What needs to be achieved for the targets to be met?

- Up front purchase costs of EVs need to fall
- Continued development of battery technology
- Strong and sustained government policy and incentives.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Power Demand *(Section 4.1)*
- Gas Demand *(Section 4.3)*

3.6 continued
Transport

3.6.1
Electric Vehicles

The successful introduction of electric vehicles will be a key part of the move towards meeting environmental targets. While there has been considerable activity and publicity from manufacturers and a range of government incentives on offer to support the electric vehicle roll-out, there are still only a small number of vehicles on the road[21].

Our analysis utilises benchmarked data from government, manufacturers and industry bodies. We have used a similar approach for both scenarios, and assumed that the same technology is available in each case but that the rates of adoption differ.

We have modelled three types of electric vehicle:
- Plug-in Electric Vehicles (PEV) / Battery Electric Vehicles (BEV) use an on-board rechargeable battery which is recharged by connecting it to an electricity supply
- Plug-in Hybrid Electric Vehicles (PHEV) have a smaller battery, with petrol or diesel as a back-up if the battery runs out of power
- Extended Range Electric Vehicles (E-REV) are similar to PHEVs, but are always driven by the electric motor, when the battery power runs out a small engine recharges the battery, which in turn drives the electric motor.

We see range-extended and plug-in hybrids dominating the market, followed to a lesser degree by BEV / PEV as battery prices and range issues begin to be addressed.

Users in London, second car and fleet buyers are likely to make up the bulk of the early adopters. London drivers benefit from congestion charge exemption, parking and charging concessions. The market for second family cars develops next as prices reduce and the range of vehicles on offer increases. EVs enter the mainstream market when they reach cost parity with internal combustion engines, though we expect this to be no earlier than the mid-2020s.

Figure 26 shows the number of electric vehicles in both scenarios together with the annual electricity demand. Note that electricity demand increases at a faster pace when pure EVs enter the mainstream market and are used for everyday motoring, including longer journeys.

PHEV / E-REV growth is not restrained by range as they can switch to fossil fuel sources when appropriate.

Market saturation is not reached in either of our scenarios due to consumer resistance to technological change.

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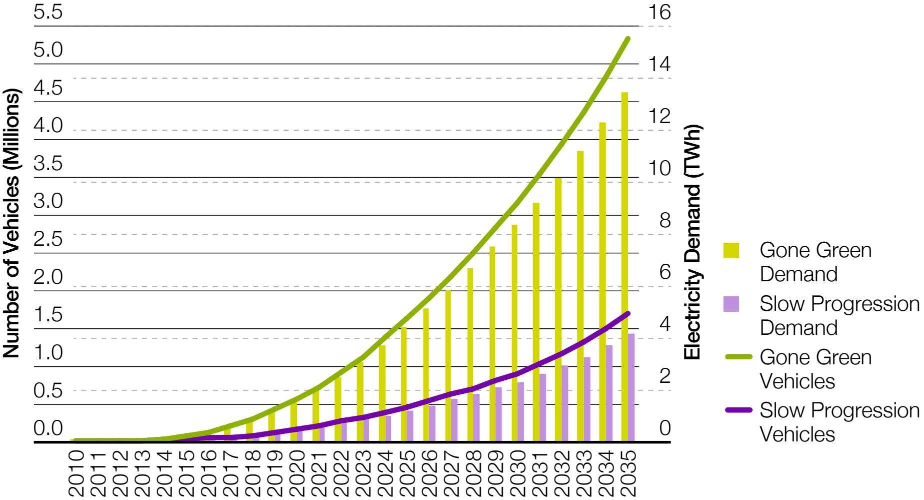
[21] There are now 5-6000 electric vehicles on UK roads.

Figure 26
Number of electric vehicles in both scenarios



3.6 continued
Transport

Electric Vehicle Charging

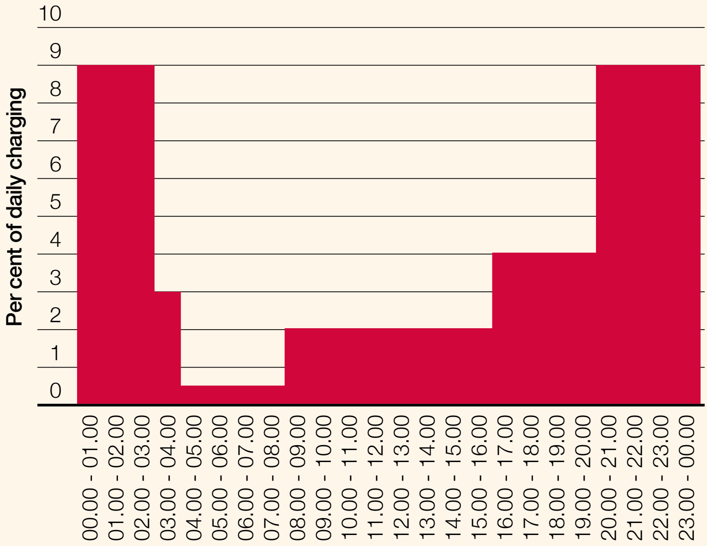
Most modern variants of electric vehicles can be slow, fast or rapid charged.

There are public rapid charging points that can deliver an 80% charge in under 30 minutes, though the most common method is overnight charging, which typically takes 2 to 4 hours.

With so few electric vehicles on the road there is little information about when vehicles will be charged with trials not necessarily representative of private owner behaviour. Figure 27 shows the assumed profile based upon:

- Engaged and informed consumers who will make logical choices as to when to charge their car
- When consumers purchase an EV they receive a SMART meter and a specific EV time-of-use tariff (e.g. economy 7). EV owners with home charging points are assumed to charge during the off-peak period when possible
- British Gas has an EV tariff which gives a 12% discount outside the peak period from 16:00 to 20:00 hours. EV owners with home charging points on a standard meter are expected to charge at off-peak times where possible. This leads to the step increase at 20:00 hours
- Overnight charging will take no longer than 3 to 4 hours for most vehicles. There is a drop at 03:00 and a further drop at 04:00 hours to reflect completion of charging
- From 04:00 to 08:00 hours there will be very little charging with most cars fully charged ready for the morning commute
- The increase at 08:00 hours represents the start of daytime charging at work, at the supermarket or via city centre on-street parking.

Figure 27
EV charging profile



“” A day in the life of my electric vehicle…

I decided to take the plunge and switch my petrol car for an electric vehicle two years ago when I realised just how much I was spending on fuel each month. I didn’t see my mileage reducing any time in the near future, nor did I see petrol getting any cheaper. Although the initial outlay was considerably more than I spent on my last car, I thought the long-term fuel savings and the fact that I am now exempt from paying road tax would counteract this. As you might expect considering the price of the EV, ‘going green’ was an additional motivation for me.

I had a traumatic experience during my first week with the car – it was winter and an unfavourable combination of minus temperatures and inefficient driving meant I very almost didn’t make it home – but since then, I have adjusted my driving style (and tucked a blanket under the passenger seat) and it has been just great!

The electric vehicle still attracts a lot of interest from friends and colleagues, mainly regarding how it fits in with my lifestyle. As I’m on a time-of-use tariff, I plug the EV in when I get home from work, with the peace of mind that the battery will charge during cheaper periods and be fully charged for when I need it in the morning. It’s great because I don’t have to think about it again until I come to drive it the next day.

A full charge from empty costs approximately £2.00; this takes 8 hours and typically gives me 55 miles in the summer and 22 miles in the winter, though the range depends greatly on the outside temperature, how I drive and whether I have the heaters on.

‘Range anxiety’ is the one serious drawback of the electric vehicle. My commute is 25 miles a day through an urban setting so in the summer I can manage this comfortably, and the car really comes into its own in stop-start traffic. It is more of a challenge in the winter as the cold temperature zaps the battery and I need to plug in at work – fortunately there are several spaces reserved specifically for electric vehicles. Due to the limited range, even in summer the car is not practical for long journeys, therefore I occasionally use my partner’s car – I would encounter some logistical problems without this!

Driving an EV requires a completely different mindset; it’s not about getting there as fast as you can, but getting there using as little charge as possible. Efficiency is key! It drives like a normal car and can reach reasonable speeds... as long as you don’t want the heaters on! The silence of the car was slightly disconcerting to start with. I’m used to it now, but I do think about the safety implications of driving a silent vehicle when I find myself crawling behind pedestrians in residential areas.

For me, the change in mindset is a relatively small price to pay to safeguard our environment for future generations, but I appreciate that it is easier said than done. In order for the cars to appeal to your average motorist and really take off, I think the price needs to come down and the right infrastructure needs to be in place. At the moment, in many areas, you need a driveway to charge your vehicle, which eliminates a certain demographic. I am intrigued to see what the future holds for electric vehicles in the mass market.

We acknowledge that developments in recent years have led to improvements in charging time, winter performance and overall range, making electric vehicles a more viable alternative. For example, the Nissan Leaf pure electric vehicle has a range of 109 miles and is capable of 0-62 mph in 11.9 seconds, with a maximum speed of 90mph. Nissan state that driving range is indicative only, based on the New European Driving Cycle urban driving test which is without heating or air conditioning; actual driving range is influenced by topography, speed, driving style, heating, ventilation and air conditioning.

3.6.2

Rail, Shipping & Aviation

In the period from now to 2035, gas and electricity demand for shipping (ports) and aviation (airports) is captured within our econometric modelling processes (see section 3.3.4 and section 4.1).

Projections for aviation are based on the 'likely' scenario[22] published by the Committee on Climate Change (CCC), while shipping is based on Trajectory 2 from the DECC 2050 calculator. In December 2012 the government deferred a decision[23] on whether to include international Aviation and Shipping (IAS) in the UK's net carbon account. The CCC has advised the government that emissions from IAS should be included, and in recognition of this our UK energy system model carbon target has been adjusted to include a proportion of these international aviation and shipping emissions.

Electrification of public transport (rail, buses and trams) has the potential to reduce CO_2 emissions. Network Rail's annual electricity demand is approximately 3TWh/year. DECC data indicates rail transport demand was 4TWh in 2011, we have assumed most of this is demand from Network Rail and the London Underground.

Network Rail has aspirations to further electrify the GB passenger routes[24]. Drivers for this include environmental and emissions legislation, cost and maintenance reduction, passenger growth, and the desire for services such as air-conditioning and Wi-Fi connectivity. In their 2009 Rail Utilisation Strategy, Network rail stated 49% of passenger train miles and 6% of freight train miles were electrified. This has the potential to increase annual electricity demand by 1%, while enabling transport emission reductions which could be reduced further by modal shifts to public transport.

In **Slow Progression** we have assumed rail demand continues to grow at historic rates of 1.5% annually and reaches 5TWh by 2030. In **Gone Green** we have assumed rail demand will grow at 2.5% annually, reaching 6TWh by 2030. **Gone Green** does not assume full electrification of passenger and freight service by 2030.

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[22] http://www.theccc.org.uk/wp-content/uploads/2013/04/Aviation-factsheet.pdf

[23] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65686/7334-int-aviation-shipping-emissions-carb-budg.pdf

[24] Network Rail 2009 Rail Utilisation Strategy: Electrification Strategy, available at: http://www.networkrail.co.uk/browseDirectory.aspx?root=&dir=%5cRUS%20Documents%5cRoute%20Utilisation%20Strategies%5cNetwork%5cWorking%20Group%204%20-%20Electrification%20Strategy

3.6.3
2035–2050

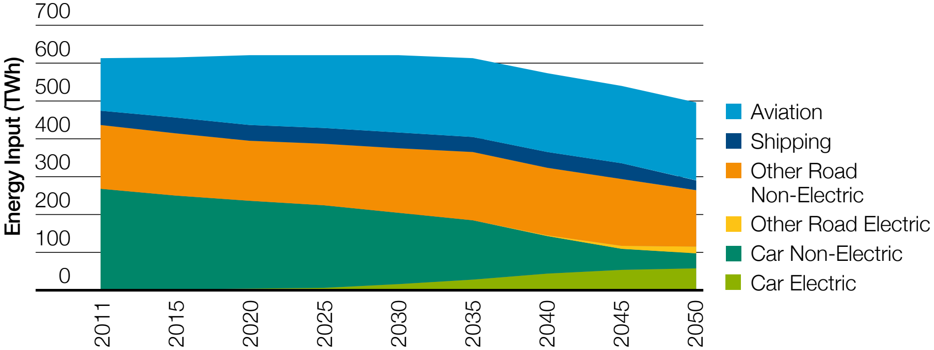
Over the period 2035 to 2050 electric vehicles, both pure EVs and hybrids, make further inroads into the private car market, and by 2050 there are no conventional fossil fuelled cars left. There is some fossil fuel left in the car market but this is all used in hybrids.

In the 2012 **Gone Green** scenario we did not include electric vans but in this year's scenario pure EV and hybrid vans appear from 2040 onwards and supply over half the van traffic by 2050. Electric power makes no inroads into the HGV sector. Figure 28 shows the energy input to the transport system out to 2050.

In the hydrogen sensitivity case (see section 3.4.3) vans powered by hydrogen fuel cells become the dominant type by 2050 and fuel cell powered vehicles completely displace fossil fuel in the HGV sector.

There is potential for future technologies normally associated with electric vehicles to offer some possible technical solutions for rail. Hybrid diesel-electric trains could be charged over-night and off-peak to take advantage of off-peak electricity, and could also take on "top-up" charge during scheduled stops or while travelling on electrified sections of track. In a similar fashion to electric vehicles, hybrid trains can also recover braking energy, or use "battery-swap" techniques to extend range. Use of these techniques may offer additional value and opportunities for energy and system balancing.

Figure 28
2050 Energy inputs to transport



3.6 continued
Transport

What has changed since 2012?

- Stakeholder feedback on our 2012 scenarios suggested that our views on EV penetration were too optimistic. As a result we have revised our projections to address this concern
- We have sought independent scrutiny of our electric vehicle analysis from external consultants at the Transport Research Laboratory (TRL)
- We have moved the focus of our assumptions from pure EVs to a combination of PHEV/E-REV which has reduced the average electricity demand per car and the charging profiles assumed
- EV vans are important by 2050.

Key uncertainties and areas for development:

- Level of consumer acceptance of EVs
- The types of charging profiles adopted
- Battery technology for EVs including the degree to which they will reduce in cost and to what level battery chemistry will improve the range of the vehicles.

Chapter four
Scenarios

In this chapter we discuss the supply/demand balance for both electricity and gas

4.1
Power Demand

Axioms that influence this section

- Renewable Energy/Carbon Targets
- Government Policy (UK & Europe)
- Economic Outlook
- Fuel Prices
- Heat
- Transport (Road & Rail)
- Energy Efficiency
- Commercial Energy Efficiency
- Energy User Behaviour
- CHP
- Micro-Generation
- Electricity Interconnection

Summary

- Residential demand plateaus until 2016 following which demand reduces due to the phasing out of inefficient halogen lighting in favour of CFLs and LEDs. Demand then falls due to improvements in heating and lighting efficiency
- In **Gone Green** demand then climbs towards 2030 due to the impact of heat pumps, EV charging, population growth and favourable economic conditions
- In **Slow Progression**, residential demand climbs post 2020 due to less development in the efficiency of appliances and population growth. Total demand falls mainly due to declines in the Industrial and Commercial sectors
- There is the same level of interconnection with Ireland in both scenarios.

Key statistics

GB annual demand:
In 2011/12 was **328TWh**
Gone Green – **317TWh** in 2020, **343TWh** in 2035
Slow Progression – **303TWh** in 2020, **295TWh** in 2035

GB Average Cold Spell (ACS) peak demand:
In 2011/12 was **61GW**
Gone Green – **60GW** in 2020, **67GW** in 2035
Slow Progression – **58GW** in 2020, **56GW** in 2035

What needs to be achieved for the targets to be met?

- Improved energy efficiency across all technologies
- Increased consumer engagement with energy and energy efficient behaviours, followed by consumers adopting new technologies such as heat pumps and electric vehicles.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Heat Pumps *(Section 3.4.2)*
- Consumer *(Section 3.5)*
- Electric Vehicles *(Section 3.6.1)*
- Power Supply *(Section 4.2)*
- Gas Demand *(Section 4.3)*
- Gas Supply *(Section 4.4)*

4.1 continued
Power Demand

4.1.1
Annual Demand

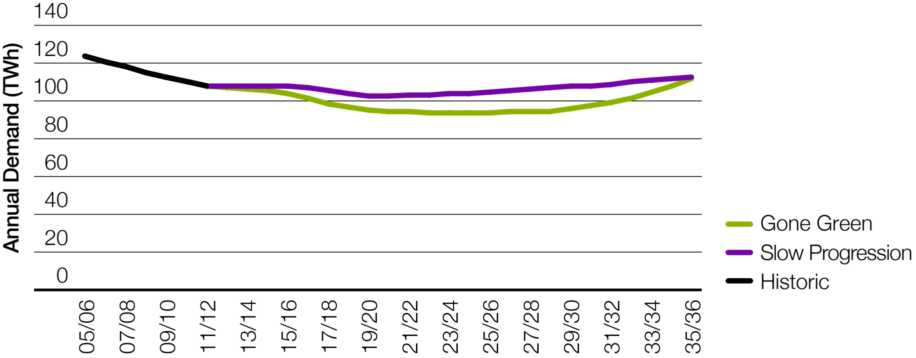
There are different definitions of demand. For annual demand we include exports to Ireland and transmission and distribution losses. We treat embedded generation and micro-generation as generation, not negative demand. We treat CHP as negative demand. We ignore Continental exports, station demand and pumping demand.

Our residential demand scenarios, shown in Figure 29, are created with our improved bottom-up approach, which is an extension of our energy efficiency modelling from last year and replaces our historic econometric approach.

Residential demand is an aggregation of lighting, heating and appliances. As detailed in previous sections.

In both **Slow Progression** and **Gone Green**, residential demand plateaus due to the short-term impact of halogen lighting (see section 3.5.1), and then falls due to improvements in heating and lighting efficiency.

Figure 29
Annual electricity demand assessment: Residential [25]



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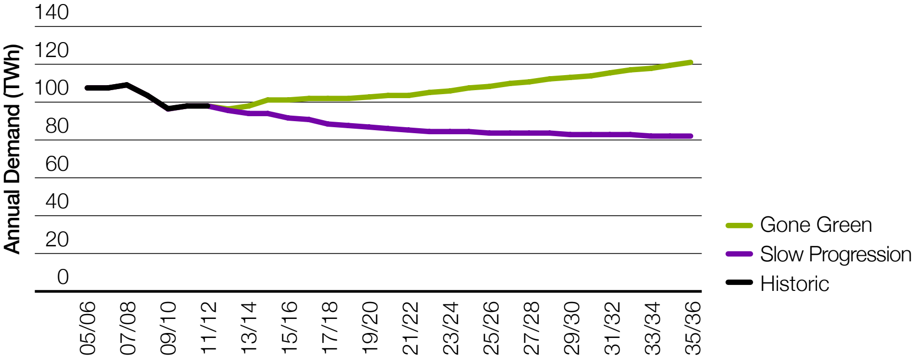
[25] Residential demand including heat pumps and EV charging

In **Gone Green** residential demand begins to climb post-2025 due to the impact of heat pumps, EV charging and population growth. Higher energy efficiency offsets increased numbers of appliances and GDP growth and as a result pushes demand below **Slow Progression** levels.

In **Slow Progression**, residential demand climbs post-2020 due to less efficient appliances and population growth.

Our industrial scenarios, shown in Figure 30, are created using an econometric model based on a ten-year historic data set, reduced from fifteen years previously to reflect medium-term historic trends. In **Gone Green** demand increases due to a favourable economic environment and **Slow Progression** falls due to a less favourable economic environment.

Figure 30
Annual electricity demand assessment: Industrial[26]



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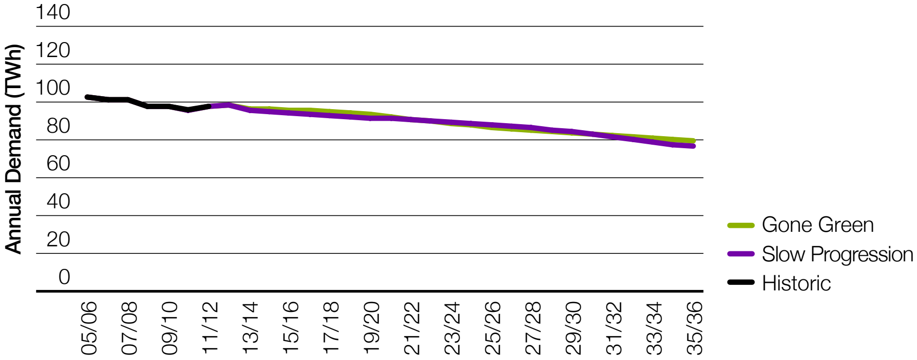
[26] Industrial demand including direct connects, CHP treated as negative demand

4.1 continued
Power Demand

Our Commercial & Other demand scenarios, shown in Figure 31, are also created using an econometric model based on a ten-year historic data set. In **Gone Green** demand falls due to increased energy efficiency offsetting higher economic growth. In **Slow Progression** demand also falls due to low economic growth, which is partially offset by lower energy efficiency. This results in the two scenarios being very similar.

Figure 31
Annual electricity demand assessment: Commercial & Other[27]



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[27] Defined by DECC as commercial premises, public administration, transport and agriculture.

Figure 32 shows total GB annual electricity demand. This is created through the individual demand scenarios for Residential, Industrial and Commercial and Other. In **Gone Green** demand initially rises due to industrial recovery and then falls due to increased energy efficiency measures. Demand increases towards 2030 due to growth in industrial demand, increased population, EVs and heat pumps. In **Slow Progression** demand falls mainly due to the economic background.

Figure 32
Total annual electricity demand: GB[28]

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[28] Includes exports to Ireland and losses, CHP treated as negative demand. Ignores Continental exports, station demand and pumping demand.

4.1 continued
Power Demand

4.1.2
GB Peak Demand

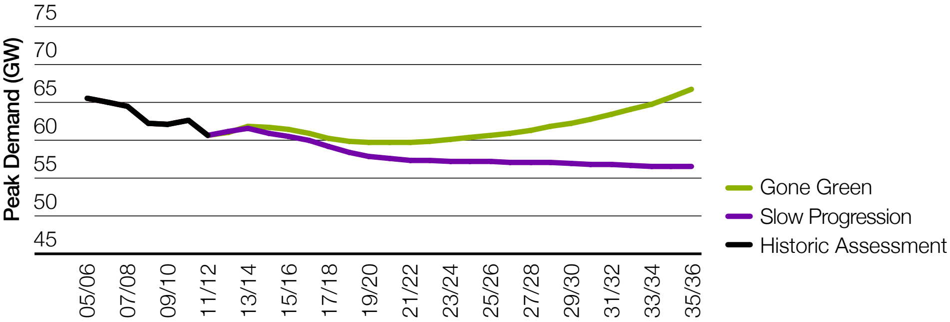
For peak demand we use GB ACS Demand with embedded generation, micro-generation and CHP treated as generation, not negative demand. We include losses and exports to Ireland. We ignore Continental exports, station demand, pumping demand and business driven peak avoidance, known as Triad avoidance.

GB peak demand, shown in Figure 33, is needed to assess how much electricity generation is required at peak, and to inform future system investment plans. It is derived from annual demands, using the historic relationship between peak and annual demands with additional analysis applied for new emerging technologies such as heat pumps and EVs. These are treated separately in the absence of sufficient historical data.

To allow direct comparison our modelled GB peak scenarios are based on the same components as the annual consumer demand scenarios with the exclusion of the following due to their relative unpredictability:

- The behaviour and impact of embedded and micro-generation at peak, particularly wind generation (discussed in section 4.2.2)
- Exports to the Continent (see section 4.1.3).

Figure 33
Unrestricted total GB ACS[29] peak demand[30]



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[29] Average Cold Spell (ACS): A level of peak demand which has a 50% chance of being exceeded as a result of weather variation.

[30] GB ACS Demand with embedded generation/micro-generation/CHP treated as generation, not negative demand. Includes losses and exports to Ireland. Ignores continental exports, station demand, pumping demand and business driven peak avoidance (Triad avoidance).

In **Gone Green** peak demand initially rises due to industrial recovery and then falls due to increased energy efficiency measures. Demand increases towards 2030 due to growth in industrial demand, increased population, EVs and heat pumps. In **Slow Progression**, peak demand falls due to the effects of our economic background assumptions on non-residential demand.

In **Gone Green**, most consumers with EVs are assumed to move some of their demand off-peak, as they will be influenced by smart meters and time-of-use tariffs. However, life-style choices (and on-street charging) will dictate that a proportion of EV owners will need to charge their vehicles when they want, creating additional peak demand.

Gone Green assumes heat pumps will be smart devices, enabling them to run optimally and ensure that consumers have warm houses when required. Current data indicates heat pumps run in a continuous manner (much like a refrigerator) and therefore will create additional demand throughout the day as well as peak demand.

Increased energy efficiency in **Gone Green** has the effect of reducing demand. In **Slow Progression** there is less demand reduction due to energy efficiency, which reduces the difference between the scenarios.

In **Slow Progression**, peak avoidance remains similar to current levels at around 1GW. In **Gone Green**, peak avoidance increases to 8% of non-residential demand in 2020. This is based on an Element Energy report[31] for OFGEM which assessed a potential mid-case level of 2.5GW. The 8% assumption produces a figure slightly lower than this of 2.2GW.

Sensitivity: For our own analysis we apply sensitivities to demand and generation. Excluding lighting management produces a much lower level of peak avoidance so a sensitivity we have around this is to reduce load management to the 1GW level observed in 2012/13.

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[31] http://www.element-energy.co.uk/wordpress/wp-content/uploads/2012/07/Demand-Side-Response-in-the-non-domestic-sector.pdf (see page 33).

4.1.3
Imports and Exports

We model all interconnector capacity and flows in order to understand the impact on generation. Flows between GB and Ireland also feed in to our demand scenarios.

Our assumptions on electricity interconnection capacity with Continental Europe vary between the two scenarios, and are broadly consistent with National Grid's submissions to the European Network of Transmission System Operators for Electricity (ENTSO-E) for the 2014 European Ten Year Network Development Plan. We have assumed the same level of interconnection with Ireland in both **Slow Progression** and **Gone Green**.

In both scenarios, electricity flows in both directions between GB and Continental Europe for every year to 2035.

In **Slow Progression**, interconnection capacity with Continental Europe gradually increases over time. The scenario shows GB as a net importer of electricity to 2035, by which point net annual imports could be approximately double the current levels. Reasons for this include greater deployment of renewable generation in Europe compared with GB.

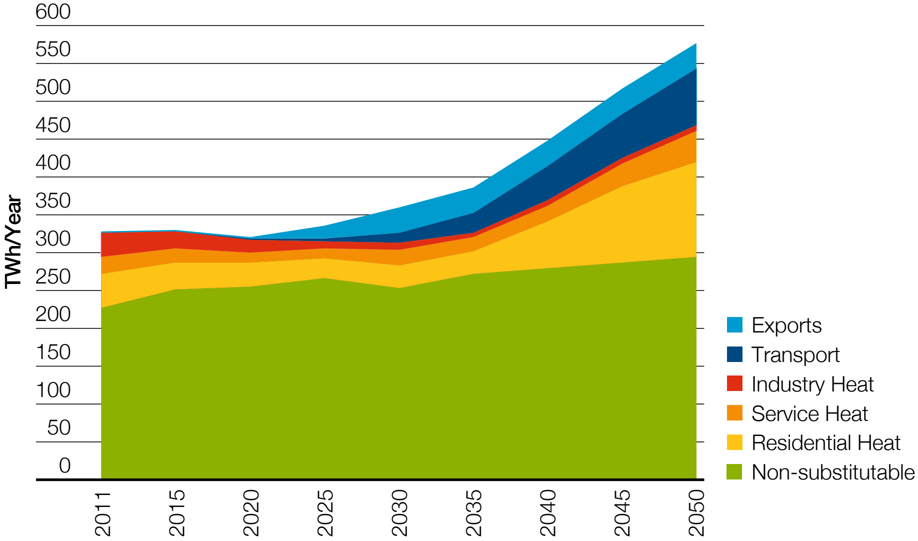
In **Gone Green** by 2035 interconnection capacity with Continental Europe is higher than **Slow Progression**. Under **Gone Green**, net imports increase in the years to 2020, but start to decline after this. GB becomes a net exporter by the mid-2020s due predominantly to large increases in GB renewable generation.

In our generation margin calculations (see section 4.2.4), we assume that at times of peak demand, electricity will always be flowing from GB to Ireland and that the interconnectors between GB and Continental Europe will be importing at a similar level to the Irish export, meaning that GB as a whole has a net import / export position around zero MW. This assumption is based on analysis of historic flows.

4.1.4
2035–2050

Electricity demand continues to grow from 2035 to 2050, with significant increases in the residential heat and transport sectors towards the end of the period, as shown in Figure 34.

Figure 34
Electricity use to 2050[32]



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[32] Note: the 'non-substitutable' category includes lighting and appliances, service sector cooling and industry non-heat uses. These categories are outside the scope of the RESOM optimisation.

4.1 continued
Power Demand

Demand for electricity within the UK in 2050 is higher than in our Gone Green 2012 analysis, due to a number of factors:

- Higher demand in residential heating. The penetration of heat pumps is similar but last year we assumed that more of the heat from hybrid electricity and gas units would be provided by gas. In this year's analysis gas use is concentrated more in the colder months. In addition, in last year's **Gone Green** we allowed a lower building internal temperature, leading to a lower heat demand
- Electric vans have been introduced into this year's scenario
- There are more electric cars by 2050
- The 2050 modelling uses values for lighting and appliances taken from Trajectory 2 in the DECC 2050 calculator. Our detailed projections for lighting in this year's **Gone Green** and our assumptions for 2050 in last year's **Gone Green** include a greater penetration of low energy lighting and consequently a lower electricity demand than Trajectory 2.

What has changed since 2012?

- Direct use of feedback obtained from the 2012 UKFES workshops has been incorporated into the modelling (for example, stakeholders indicated that Smart metering and TOUTs might result in demand falling by up to 10% in **Gone Green**, and by up to 5% in **Slow Progression**).

Residential sector

- Residential demand has been assessed using a ground up assessment of appliance efficiency, heat and light demand, instead of using an econometric approach
- Weaker economic outlook has negatively impacted the number of new house builds
- A slower take-up in heat pumps has been reflected in reduced scenario numbers
- We have reduced our 'smart' assumptions thus increasing demand slightly.

Industrial sector

- Further falls in industrial demand due to recessionary impacts have been reflected in our starting position
- Medium-term, rather than longer-term, trends have been used to assess growth, also reducing the scenario demands.

Commercial & Other sector

- Further recessionary and energy efficiency impacts reduce demand
- Weaker longer-term outlook due to the use of medium-term trends rather than longer-term historic trends
- Our economic growth and energy efficiency assumptions have pushed the commercial scenarios together reducing the range of commercial demand.

Key uncertainties and areas for development:

- GDP growth, household disposable income, industrial and commercial growth
- Future levels of political, consumer and business engagement with green technology, energy efficiency and the UK's low carbon targets
- What time EVs and heat pumps will be used and for how long
- For the 2014 scenarios we are examining the feasibility of doing ground up analysis for non-residential demand and analysing historic consumer behaviour further to create richer scenarios.

4.2
Power Supply

Axioms that influence this section

- Renewable Energy/ Carbon Targets
- Government Policy (UK & Europe)
- Levy Control Framework
- Fuel Prices
- CHP
- Micro-Generation
- Wind Generation
- Wave & Tidal Generation
- Biomass Generation
- Nuclear Generation
- CCGTs/ OCGTs (unabated)
- Coal Generation
- CCS Generation
- Electricity Interconnection (Imports & Exports)

Summary

- Our **Gone Green** generation background is designed to meet the 2020 government renewable energy target and to comply with the carbon budgets beyond that
- In **Slow Progression** there is no requirement to meet either the 2020 renewable energy target or the carbon budgets
- The capacity mix for both scenarios is similar out to 2017/18, then diverges based on the underlying axioms
- Each scenario maintains a de-rated margin of around 5% for security of supply
- The key driver for the resulting generation supply technology mix is the relative cost of generation.

Key statistics

- Current total GB installed capacity is approximately **92GW**, this increases to **111GW** by 2020 in **Gone Green** and **96GW** in **Slow Progression**
- Of the total installed capacity in 2020 **42GW** of this is renewable in **Gone Green** and **28GW** in **Slow Progression**
- Plant margin drops to a low in 2015/16 of **2.2%** in **Gone Green** and **1.4%** in **Slow Progression** before increasing out towards 2020 due to an increase in installed capacity (spot de-rated margin calculation with wind at 7%).

What needs to be achieved for the targets to be met?

- Sustainable sources of biomass need to be available
- Sufficient consents, support and finance are required for offshore and onshore wind in order to meet the target level in 2020 and beyond
- An effective supply chain needs to be in place to reduce barriers to delivery in the offshore industry
- Existing nuclear power stations need to have appropriate life extensions and new plant needs to obtain relevant consents (and the negotiations on nuclear Contracts for Difference (CfD) strike prices needs to reach a conclusion)
- Capital costs for solar PV need to continue to reduce
- Commercial deployment of technologies such as PV and CCS is needed
- Networks need to develop to allow increasing levels of variable and low inertia generation to connect
- EMR needs to be implemented to ensure support for low carbon generation and a capacity market to maintain security of supply.

4.2 continued
Power Supply

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Heat *(Section 3.4)*
- Consumer *(Section 3.5)*
- Transport *(Section 3.6)*
- Power Demand *(Section 4.1)*
- Gas Demand *(Section 4.3)*
- Gas Supply *(Section 4.4)*

Our scenarios show total GB generating capacity including embedded generation and micro-generation[33] as well as transmission connected generation. Each scenario has a generation mix capable of meeting the ACS demand projections for the relevant scenario, with an appropriate margin.

Our **Gone Green** generation background is designed to have an adequate level of installed capacity to generate enough renewable electricity by 2020 to meet the government renewable energy target and sufficient low carbon generation to comply with the carbon budgets. We have also designed **Gone Green** to stay within the Levy Control Framework (LCF) budget for supporting low carbon generation.

Due to lead times for new generation plant, the capacity mix for both scenarios is broadly similar out to 2017/18; thereafter the generation mix diverges due to assumptions driven by our axioms.

Generation capacity split by fuel type are shown in Figure 35 for **Slow Progression** and Figure 36 for **Gone Green**.

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[33] Embedded generation for example large CHP (greater than 10MW). Micro-generation, for example residential solar PV.

Figure 35
*Demand and generation background: **Slow Progression***

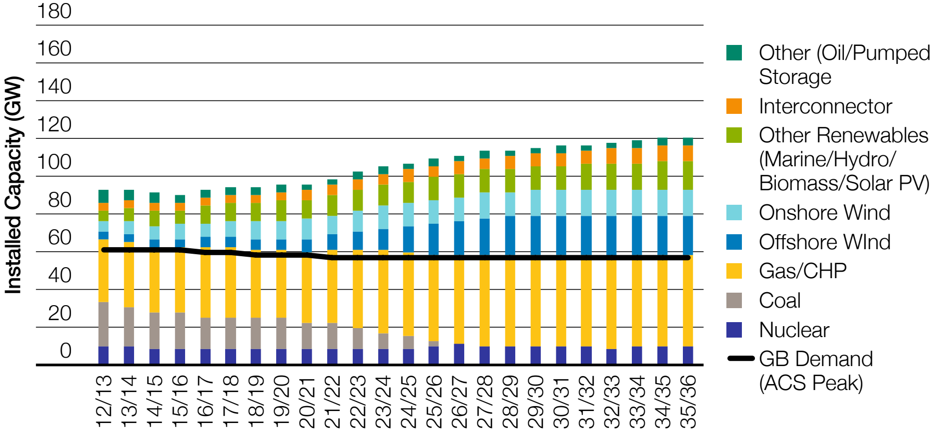
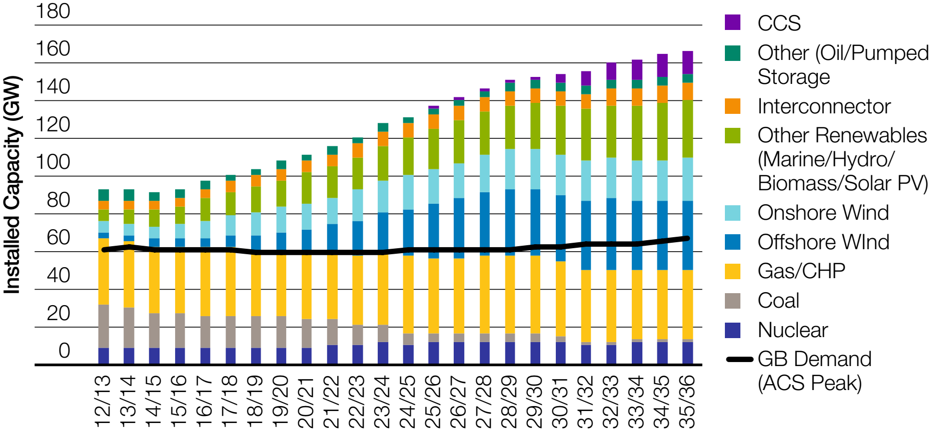


Figure 36
*Demand and generation background: **Gone Green***



4.2.1
Generation Capacity

Nuclear

In Slow Progression we have assumed an average ten-year life extension[34] of existing nuclear plant. Total nuclear installed generation capacity levels remain relatively static throughout the period to 2035. The first new nuclear plant is not assumed to connect until the mid-2020s, illustrating a slow ramp-up rate with the full period seeing a net increase in nuclear generation capacity of just 0.8GW, taking into account relevant openings and closures over time.

In **Gone Green** we have assumed an average seven-year life extension[35] of existing nuclear plant. Installed capacity levels rise steadily throughout the period to 2035. The first new nuclear plant is assumed to connect in the early 2020s contributing to an overall net increase in nuclear capacity over the full period of 2.4GW.

Coal/Coal CCS

Our assumptions for coal plant closures through the LCPD, IED[36] and development of CCS determine the levels of coal plant featured in both **Slow Progression** and **Gone Green**.

In **Slow Progression** we assume the majority of plants within the coal sector opt out under IED and run for 17,500 hours until closing before the end of 2023, with most of the remaining plant opting into the Transitional National Plan (TNP) and running for a maximum of 1,500 hours a year until closure by the mid-2020s.

This scenario sees a rapid decrease in the level of coal generation capacity with all plant closing by 2026/27 showing a 23.2GW decrease on current levels (assuming no new build for coal plant and that CCS is not a viable source of generation capacity).

In **Gone Green** our assumption covers a broader range in terms of IED outcomes coupled with some additional plants converting to biomass, resulting in a lower total level of installed coal capacity in comparison to the 2012 scenarios across the period. Most existing unabated plant is closed by the mid-2020s resulting in a total unabated coal installed capacity in 2030 of around 2GW. We assume the addition of some coal CCS plant in the late 2020s and 2030s in the **Gone Green** scenario with total CCS capacity reaching over 6GW by 2035.

Gas/Gas CCS

Across both scenarios the level of installed gas capacity is lower than in the 2012 backgrounds. This is primarily driven by a reduced need brought about by lower ACS peak demands in the 2013 scenarios and also in **Gone Green** by increased levels of biomass plant conversions.

In **Slow Progression** in order to maintain the required level of capacity we have assumed that most existing gas-fired plant will remain open in the short term and out to 2020. Closures of 2.7GW of existing plant are offset by openings in the interim, this results in total installed gas-fired capacity at 2020 of 36.7GW. This rises steadily out to the late 2020s when total installed capacity reaches 48.5GW in 2030 and remains relatively flat out to 2035.

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[34] An average of 3 years on top of the EDF announcement (http://www.edfenergy.com/media-centre/press-news/EDF_Group_2011_results.pdf (see page 11).

[35] As per EDF announcement in reference 34

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

[37] http://www.renewableuk.com/en/publications/reports.cfm/Wind-SOI-2011

In **Gone Green** the capacity profile for gas-fired plant is generally flatter than in **Slow Progression** as less gas-fired plant is required over the period as the level of renewables, especially onshore and offshore wind, are much greater in this scenario. In **Gone Green**, gas-fired capacity only increases by a total of 1.9GW out to 2035, with closures to existing plant roughly balanced by installation of new capacity.

We have assumed no gas CCS at all in **Slow Progression** and limited gas CCS build from the mid- to late-2020s in **Gone Green**. This results in a total installed capacity for gas CCS of around 2GW by 2030 and 6GW of gas CCS by 2035.

Wind

One key change from our 2012 scenarios is that the **Gone Green** level of installed capacity for offshore wind in 2020 has fallen by approximately 5GW from the 2012 **Gone Green** background. This decrease is driven by lower demand and our assumption in the 2013 scenarios, based on a number of publically announced plans, that there will be an increased number of biomass conversions that will connect to the system over the next few years therefore lowering the contribution from wind needed to meet 2020 renewable targets.

In **Slow Progression** onshore wind shows a steady increase over time from 5.5GW in 2012 to 13.8GW in 2035 (5GW of which is deemed to be embedded) including some replanting. Offshore installed wind capacity shows a modest increase to 7.5GW in 2020 followed by increased deployment post-2020 to 15.9GW in 2025, thereafter there is a slow rise to 21.3GW out to 2035. This results in a total installed wind capacity figure for **Slow Progression** of 35.2GW in 2035.

In **Gone Green** onshore wind shows a steady albeit a higher increase from 5.5GW in 2012 to 21GW in 2035. Offshore wind also shows a higher increase post-2015 to a level of 12.1GW in 2020. Post-2020 there is a further increase in the deployment of offshore wind reaching 28.6GW in 2025 and an installed capacity of 37.5GW in 2035, resulting in a total wind capacity figure of 59.2GW by 2035.

Biomass

Biomass conversions are one of the key changes between our 2012 and 2013 scenarios encouraged by the support for this technology announced in the 2012 Renewables Obligation (RO) banding review. In both scenarios we have assumed a certain amount of biomass conversion albeit to a lesser extent within the **Slow Progression** scenario (just under 3GW in **Slow Progression** in 2020 compared to nearly 4GW in **Gone Green**).

In meeting renewable targets, the higher load factor attributed to biomass over wind generation further reduces the required capacity of wind generation. In addition to biomass conversions, the scenarios include some new dedicated biomass plants, mainly small embedded plants. Furthermore, in **Gone Green** a limited amount of biomass capacity is fitted with CCS by 2035.

In **Slow Progression** installed capacity for biomass (including conversions) remains relatively flat over the period starting at 3.3GW in 2012 increasing to a peak of around 5.4GW before falling back slightly to 5.1GW by 2035 following the closure of some biomass conversion. **Gone Green** shows a greater uptake of biomass reaching around 7.3GW at its peak in the mid to late 2020s before falling to just over 7GW by 2035.

Marine

Marine is a technology which is still in its infancy and has not yet reached commercialisation so predictions on progress within this sector are solely reached by using our axioms and examining forecasts by parties operating within the sector. However, there are significant developer aspirations, with the Renewable UK State of the Industry report 2011[37] highlighting 2.17GW of potential by 2020; the Renewable Energy Action Plan stated 1.3GW by 2020 and the Pentland Firth and Orkney Waters could have 1.6GW developed.

4.2 continued
Power Supply

For our scenarios, considering the pace of technological development implied by the axioms it is likely that for **Slow Progression** marine technology does not progress beyond the research and development stage until beyond 2030.

In **Slow Progression** marine generation is assumed to develop very slowly, due to high costs, with minimal deployment by 2035, less than 0.5GW. For **Gone Green** the technology starts to become commercially deployed in the 2020s. There is limited build up of marine generation, mainly post-2020. There is total marine capacity of 1.3GW by 2035.

Hydro

Installed hydro capacity remains fairly flat in both scenarios. However we assume some additional pumped storage capacity of approximately 0.6GW in the mid-2020s in **Gone Green** as the level of connected variable renewable generation increases.

Sensitivity Case Studies

In addition to the generation backgrounds for our main two scenarios, we have produced generation backgrounds for four case studies, designed to give alternative, plausible generation mix outcomes for both **Gone Green** and **Slow Progression**. These case studies will be discussed in more detail in the Electricity Ten Year Statement (ETYS) published later this year.

There are two case studies produced on each scenario. Please note that these case studies relate only to the transmission connected electricity power generation backgrounds, all other aspects of the base scenario are held static.

Gone Green Case Study 1: (High Offshore Wind)

Description – high levels of offshore wind compensate for a more pessimistic outlook for onshore wind across the whole period, with lower levels of nuclear and CCS towards the end of the period to 2035.

Key Points:

- Nuclear and CCS plant are generally delayed in this case study and have a slower build rate
- 2.6GW decrease in onshore wind levels by 2020 from the **Gone Green** scenario and a 4.5GW decrease by 2030
- Offshore wind levels are increased in this case study resulting in a 1.4GW increase on the **Gone Green** levels in 2020 and 7.1GW by 2030.

Gone Green Case Study 2: (High Onshore Wind)

Description – as a contrast to the first case study this iteration will contain high onshore wind levels with lower levels of offshore wind, nuclear and CCS.

Key Points:

- Nuclear and CCS plant are generally delayed in this case study and have a slower build rate
- Onshore wind increases by 4.8GW on the levels shown in the **Gone Green** background by 2020 and by 9GW in 2030
- Offshore wind has decreased by 4.7GW in 2020 on **Gone Green** levels and by 4.9GW in 2030.

Please note that for the **Gone Green** case studies the axioms regarding level of renewables and meeting the 2020 targets still apply as well as the 2030 carbon target. The case studies must also be within the budget of the LCF framework.

Slow Progression Case Study 1: (High Combined Cycle Gas Turbine (CCGT), Low Coal)

Description – this case study shows higher levels of CCGT capacity (compensating for less growth in renewable generation) and also sees lower levels of coal capacity assuming that IED plant closes more quickly.

Key Points:

- No change to renewable generation from the 2013 **Slow Progression** scenario
- 3GW less coal plant in 2020 than **Slow Progression** and all existing coal plant is closed by 2025/26)
- 4.8GW increase in gas capacity compared to **Slow Progression** in 2020 and a 2.6GW increase by 2030.

Slow Progression Case Study 2: (High Coal, Low CCGT/Biomass)

Description – this study sees the opposite effect to **Slow Progression** case study 1 showing less CCGT capacity and a higher coal capacity for longer which assumes that coal plant would either retrofit Selective Catalytic Reduction (SCR) systems in order to stay connected following the closure of LCPD and IED plant or select the limited hours option choosing to generate a maximum of 1,500 hours per year and stay open longer.

Key Points:

- No change to renewable generation from the 2013 **Slow Progression** scenario
- 1.4GW increase in coal plant in 2020 over the **Slow Progression** figures and 5.9GW of coal still open in 2030, whereas all coal plant is shut in **Slow Progression** by 2026/27
- No change in gas capacity by 2020 but a 1.9GW increase on **Slow Progression** levels in 2030.

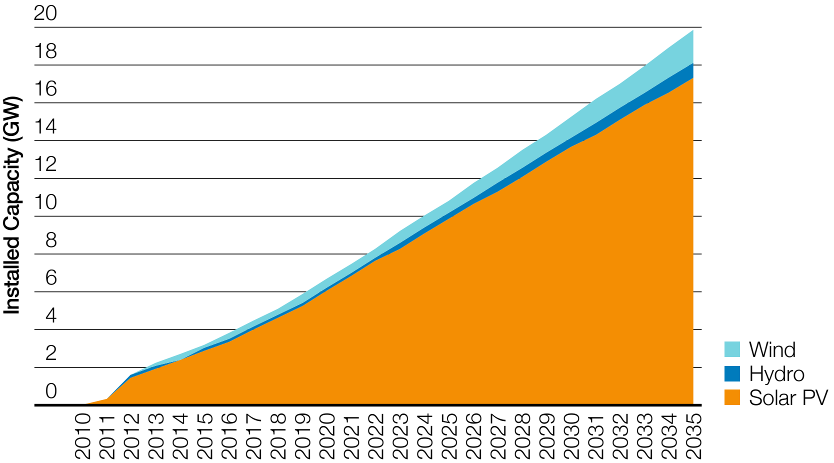
4.2.2
Micro-generation

To date most installations registered under the Feed-In Tariff (FIT) scheme are solar PV (1.5GW or 99%). The growth in solar PV in both scenarios is higher than our 2012 scenarios driven by the FIT and lower unit and installation costs, but PV is still a relatively high cost generation (un-incentivised) relative to power generation prices. Continued reduction in the FIT is expected to scale back growth, but there are currently no government signals to remove the PV incentive completely.

In **Slow Progression** Solar PV generation increases but at a much lower rate than in **Gone Green**.

In **Gone Green** Solar PV generation continues to increase post-2015 due to a reduced unit cost, improvements in technology, reduction in installation costs and economic recovery. Figure 37 shows the split of technologies in **Gone Green**.

Figure 37
*Microgeneration installed capacity in **Gone Green***



A day in the life of my Solar PV…

When I first told my friends and family I was considering solar photovoltaics, they seemed somewhat unconvinced; even my wife was sceptical when I first suggested it. However, 18 months since the 4kW system was installed, they are certainly a lot more enthusiastic and open minded.

For me, the financial incentive of the feed-in tariff was a powerful driver. I receive the higher tariff and as our roof is south facing, my rough calculations indicated that I would make back my initial investment within 6 to 8 years; this makes it a much better investment than having my savings sat in the bank. As a family, we are fairly conscious of our energy consumption and keen to "do our bit" for the environment, however, I don't think we could have justified the initial outlay without the feed-in tariff.

I have been pleasantly surprised by the output of the panels and the return so far, despite a poor summer last year. As you might expect there is a noticeable difference in output between summer and winter, and bright and overcast days, however, you start to get a feel for what you're generating by just looking out of the window, it becomes second nature after a while. In terms of the financial benefits, we have seen a considerable (40%) reduction on our monthly electricity bills; however this is a small bonus in comparison to the income generated from the tariff.

We've seen no downsides to having the panels installed so far. The installation was very straightforward – we used a local supplier, who was recommended by several neighbours – and the panels are low maintenance and self-cleaning. My only concern is the inverter, which would be very costly to replace. However, I've been told it has a lifespan of approximately 10 years.

Have the panels changed me? A little. I'm not often home when the sun is shining, but if I am, I make sure I run my energy-thirsty appliances at this time as it's effectively free, and we now run appliances in sequence rather than simultaneously so our energy usage doesn't exceed generation when possible. We take energy efficiency relatively seriously; it influences our behaviour but doesn't dictate it. With a young family, convenience is still an important factor.

My next project… I am considering solar water heating. We had the PVs installed to one half of the roof to keep our options open, however I think the next step for us will be to focus on energy efficiency and energy savings, before investing in other technologies.

4.2.3
Cost of New Generation

During our stakeholder consultation we received a number of requests for information on costs associated with our scenarios and new generation in particular. In response to that feedback we have derived a breakdown of the estimated capital costs associated with new generation connecting between now and 2020 (see Table 2), for the Slow Progression and Gone Green generation backgrounds.

Please note that these costs do not include infrastructure, maintenance or any other operating costs and are derived using the publically available Parsons Brinckerhoff[38] and Arup[39] reviews for the Department of Energy and Climate Change. For assumptions, definitions and detailed descriptions of the unit costs used please refer to those reports.

Table 2
Estimated capital cost of new generation, now to 2020

Fuel Type	Unit Cost (£m/GW)[38,39]	Slow Progression Openings (GW)	Slow Progression Capital Cost (£m)	Gone Green Openings (GW)	Gone Green Capital Cost (£m)
CCGT	575	3.2	1,852	3.2	1,852
CHP	705	0.5	345	0.5	345
Biomass	2,350	0.2	357	0.3	639
Biomass Conversion	441	2.2	977	3.0	1,304
Embedded Biomass	3,250	-	-	0.2	588
Offshore Wind Round 2 (includes R2 ext. & STW)	2,214	4.0	8,849	5.5	12,157
Offshore Wind Round 3	2,699	-	-	3.1	6,843
Onshore Wind	1,456	3.0	4,397	5.8	8,502
Solar PV	2,148	1.9	4,176	5.5	11,722
Embedded Wind <5MW	1,479	1.7	2,491	3.0	4,366
Other (Hydro / Marine)	2,315	0.2	484	0.1	299
Total		**16.9**	**23,925**	**30.1**	**48,610**

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[38] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65712/6884-electricity-gen-cost-model-2012-update.pdf

[39] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147863/3237-cons-ro-banding-arup-report.pdf

4.2.4
Plant Margin

Plant margin is a key area for focus as we diversify our generation mix. For the illustration and calculation of plant margin within this section we have used two slightly different measures; spot de-rated plant margins and Equivalent Firm Capacity (EFC) plant margins.

Both of these calculation methodologies are different from the traditional gross plant margin calculation historically used. This is due to the requirement for a calculation methodology for plant margin which takes into account the likely availability of each generation type given the increasing diversity of the generation mix going forwards.

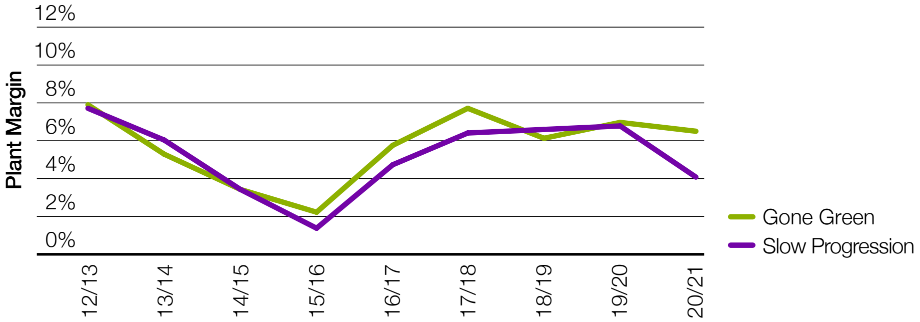
Spot De-Rated Plant Margin – this methodology uses de-rating factors for each generation type to reflect likely availability. A key feature of this margin calculation is that it assumes a static de-rating factor for wind capacity over the full scenario period of 7%. This is a prudent approach that represents a 1 in 10 value for wind generation at the spot half-hour demand peak.

Equivalent Firm Capacity (EFC) Plant Margin – this methodology uses de-rating factors for each generation type in the same way as the spot de-rated plant margin; with the exception of wind these are identical. EFC treats wind differently and does not assume a static de-rating factor, the factor changes over time in relation to how much wind capacity is installed and the availability of the generation mix in total. Rather than looking at the historic peak half hour to derive a de-rating factor for wind this methodology adopts a statistical risk-based view over the full winter period.

For further information on plant margin methodologies see Appendix 5.

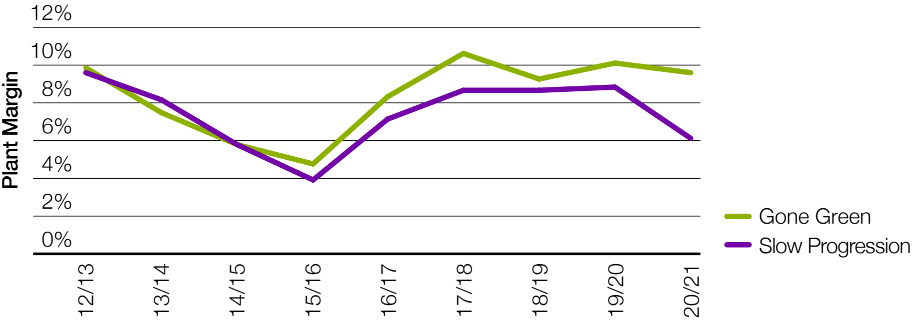
Figure 38 and Figure 39 show the plant margin percentages for **Slow Progression** and **Gone Green** on both the standard de-rated methodology and the EFC basis.

Figure 38
Spot de-rated plant margins (transmission)



4.2 continued
Power Supply

Figure 39
EFC plant margins (transmission)



The margins in the two scenarios are quite similar out to 2015/16 with the spot de-rated margin falling to around 1.4% in **Slow Progression** and 2.2% in **Gone Green** (with the EFC margins showing at approximately 3.9% in **Slow Progression** and 4.8% in **Gone Green**). The drop off in margin during this initial period is due to a number of gas plants being mothballed as well as recent announcements regarding plant closures, Transmission Entry Capacity (TEC) reductions and the closure of LCPD plant coupled with limited new capacity connecting to the system before 2015/16.

Between 2016/17 and 2020/21 margins start to increase with assumed returns of mothballed plant and the connection of additional installed capacity in both scenarios. A difference in margins starts to emerge between the scenarios over the period to 2020/21 largely owing to a greater build of capacity, especially renewables. In the **Gone Green** scenario resulting in spot de-rated margins reaching about 6.5% in 2020/21 and 4.1% in **Slow Progression** (with EFC margins showing 9.6% in **Gone Green** and 6.1% in **Slow Progression**).

In delivering our medium- to long-term generation background we target a spot de-rated margin of 5% in both scenarios. For the **Gone Green** scenario further analysis has shown that if only plant that is currently under construction or has a final investment decision is considered when calculating plant margins then plant margin drops below 0% in 2020/21 on the spot de-rated calculation method and in 2021/22 on the EFC basis, underlying the need for Electricity Market Reform (EMR) to deliver according to timetable.

4.2.5
Generation Supply

The generation supply for each source of power is determined from the respective capacities and the relative cost of generation. We determine this by the Short Run Margin Cost (SRMC) for each technology. For each half hour the plants that are available with the lowest SRMC run until the projected demand in that half hour is met, the generation supply is then aggregated to annual levels and the result can be seen in Figure 40 and Figure 41.

Technologies can broadly be spilt into three tranches: zero short run margin costs, low short run marginal costs and fossil fuel plant.

Zero Short Run Marginal Costs

The first tranche of technologies have zero SRMC; these are typically renewable, variable technologies, such as wind and hydro. These are assumed to run whenever they are able to i.e. when the wind is blowing. Each technology has an assumed load factor, based on observed history and taking into account improvements in future technologies. See Table 3.

It should be noted that for peak supply analyses a different range of load factors (LF) are considered rather than annual averages.

Table 3
Renewable technology average load factors

Technology	Annual Average Load Factor
Onshore Wind	27%
Offshore Wind Round 1	33%
Offshore Wind Round 2	35%
Offshore Wind Round 3	38%
Solar PV	8%
Hydro	40%

Low Short Run Marginal Costs

The next tranche of technologies have either very low SRMC or receive support from other sources. These include nuclear, biomass, CHP and CCS technologies. Each technology has an assumed availability that is a percentage of the time the plant could run if required, see Table 4. Again these availabilities are based on observed history and take into account possible changes due to, for example, improving generating efficiencies.

4.2 continued
Power Supply

Table 4
Technology average availabilities (Transmission Connected)

Technology	Average Availability
Nuclear	77%
Biomass	61%
CHP	60%
CCS	85%

It should be noted that during the winter period availabilities are higher than those shown above.

Fossil Fuel Plant
The final tranche of technologies are fossil fuel plant. These include coal, gas and oil fuelled plants. The SRMC of these plants is determined by the cost of fuel and cost of CO_2 (carbon) emissions (see section 3.3.5 for further detail). As fossil fuel price assumptions are the same across the two scenarios, the cost of carbon emissions is the only difference between the scenarios.

Coal
Generation from coal is broadly similar in each scenario until 2016/17, when the carbon price diverges with higher carbon costs in **Gone Green**. This results in declines from recent highs of around 130TWh / 65% load factor to around 85TWh / 60% load factor as plants close or convert to biomass. In **Slow Progression** after 2016/17 generation remains around 75 – 90TWh/ 60% LF until 2020/21, when the IED either closes or restricts the running hours of plants to an average load factor of around 35%. All coal generation ends in **Slow Progression** in 2026/27. In **Gone Green** after 2016/17 generation decreases at a greater rate due to the carbon price assumptions. By 2025/26 we assume limited unabated coal generation is required only for reserve. In **Gone Green** in the early 2030s coal CCS commercialises, after a demo plant in the mid-2020s, and generates around 20TWh over the remainder of the period.

Gas
Generation from gas is broadly similar in each scenario until 2016/17 and increases from recent lows of around 95TWh / 30% LF to around 105TWh/35% LF in 2014/15 as a result of LCPD coal closures. After 2014/15 gas generation again reduces to around 80TWh/26% LF due to a combination of lower demands, increased renewable generation and higher interconnector imports. This trend continues in **Slow Progression** post-2016/17 until 2020/21 when coal generation is restricted and gas generation increases to around 120TWh / 32% LF. Thereafter gas generation gradually declines as renewable and nuclear generation increases. In **Gone Green** after 2016/17 gas generation is flat at around 90TWh/ 30% LF, until 2020/21, this is higher than in **Slow Progression** due to the assumption of a higher carbon price reducing coal generation. Post-2020/21 gas generation further declines in **Gone Green** due to an increase in renewable and new nuclear generation. By the late 2020s gas CCS commercialises and replaces unabated gas. Total gas (CCS and unabated) generation is then flat for the remainder of the period.

Figure 40
*GB generation by fuel type – **Slow Progression***

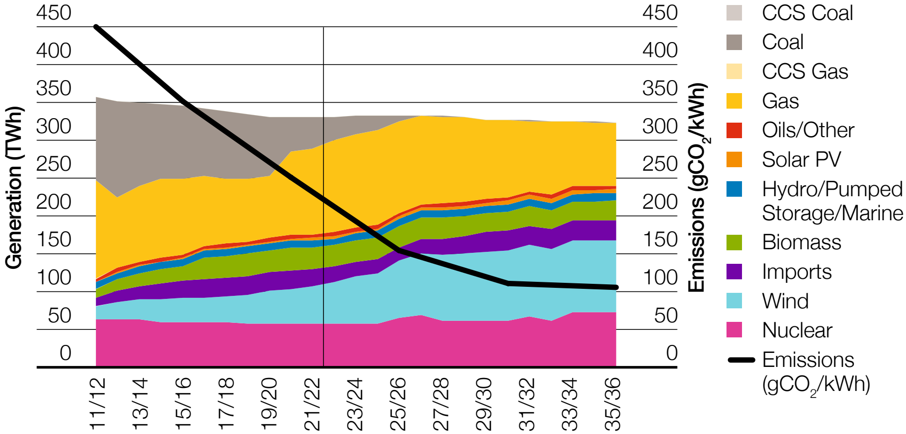
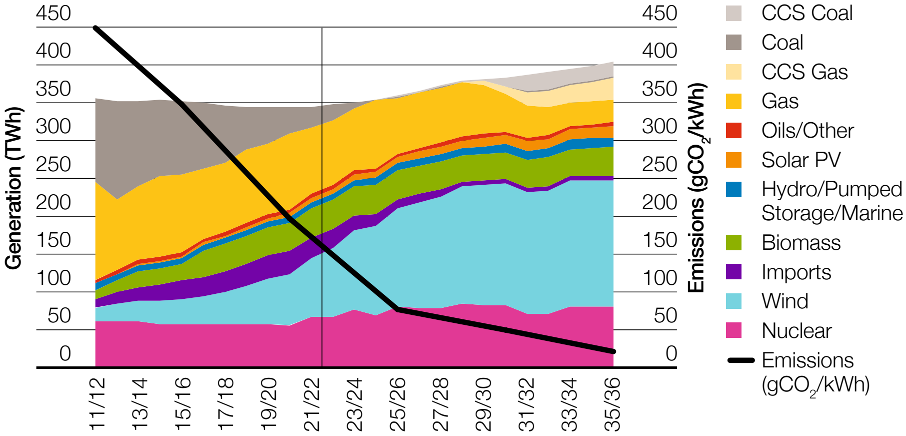


Figure 41
*GB generation by fuel type – **Gone Green***



4.2.6
Dispatch Model

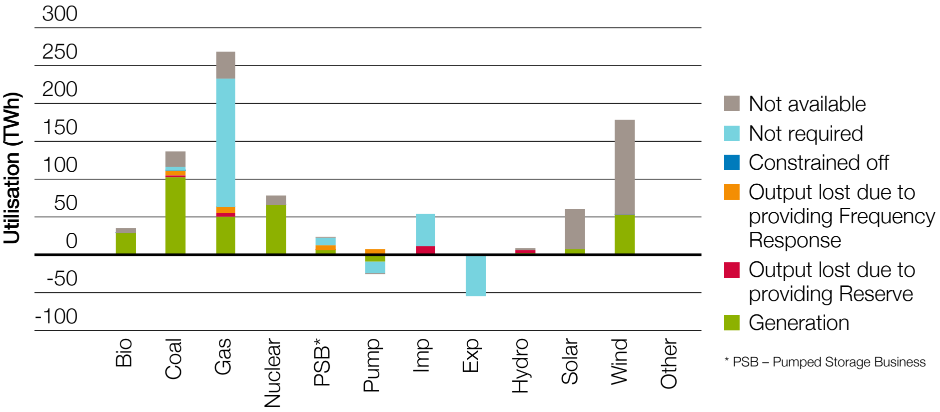
This year, in response to stakeholder feedback, we have undertaken new analysis to investigate the operational issues regarding the electricity transmission network and the generation mixes within our Gone Green and Slow Progression scenarios.

We have developed a new model that produces an electricity generation dispatch solution for every hour for any chosen year within our scenarios.

The model enables us to investigate whether the electricity system is able to maintain appropriate levels of reserve, frequency response and inertia for the modelled levels of generation capacity within our scenarios.

Figure 42 shows annual utilisation of generation by type for 2020/21 using our **Gone Green** scenario assumptions for generation capacity, with coal generation cheaper than gas generation.

Figure 42
***Gone Green** 2020/21*



* PSB – Pumped Storage Business

The output is shown by fuel type broken down by whether the plant is generating, providing frequency response or reserve, constrained off (e.g. due to a shortage of inertia), not required or not available. It is important to note that the transmission network is not modelled and hence the analysis assumes no transmission constraints.

The key findings from the analysis include:

- The impact of increasing levels of renewable generation on system inertia
- The value of flexibility as provided by pumped storage and/or interconnectors
- The criticality of relative prices of coal and gas generation
- The need to retain plant with low load factor on the system for security of supply.

A copy of the analysis is available on the National Grid website[40].

4.2.7
2035 – 2050

Beyond 2035 there is further development of low carbon generation, as shown in Figure 43 (see overleaf). The largest growth is in nuclear power but there is continued growth in onshore and offshore wind and other renewables.

There is continued increase in biomass use, both in dedicated plant and in co-firing with coal. Some gas-fired CHP is developed in conjunction with heat networks principally supplying the industrial market. There is very little fossil fuel combustion without CCS. Using bio fuels with CCS leads to negative emissions as carbon is taken out of the ecosystem.

What has changed since 2012?

- The 2013 scenarios have seen a decrease in the levels of wind expected to be connected in 2020 (particularly Round 3 offshore), this is due to an increase in the level of biomass conversions and new biomass plant
- More CCGT openings have been delayed in the 2013 scenarios, reflecting the current hiatus in new CCGT projects
- Estimated support of renewable generation build now falls within the indicative Levy Control Framework budget for 2020/21
- Solar PV has seen a sizeable increase from an installed capacity of 0.3GW in 2011 to 1.5GW of currently installed capacity in 2012
- The level of incentives available for renewables has decreased but in turn so have some of the costs associated with renewable generation hence the continuation of growth in the renewables sector.

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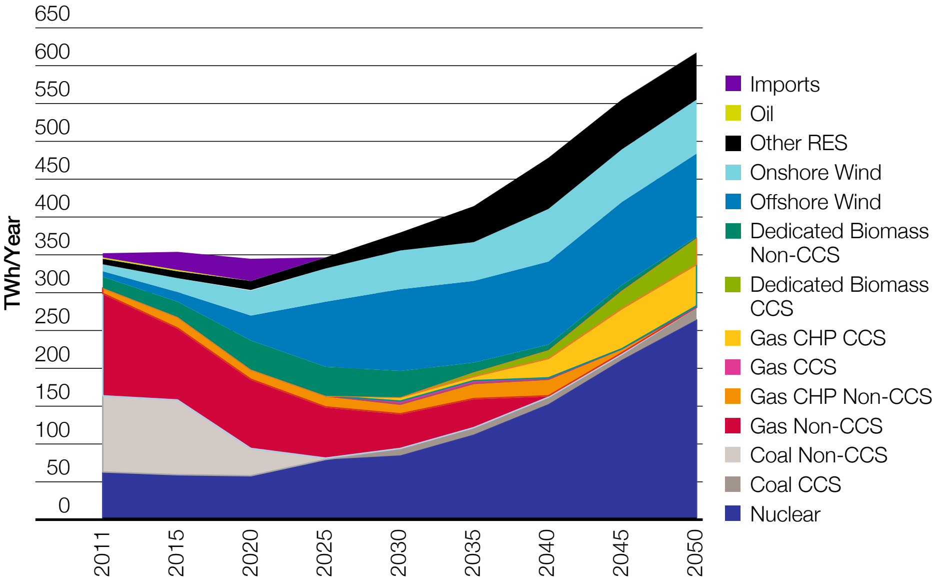
[40] http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/Future+Energy+Scenarios/

4.2 continued
Power Supply

Figure 43
Electricity Generation to 2050



Key uncertainties and areas for development:

- At time of analysis, details of EMR were unknown
- The choices to be made by existing generators under the Industrial Emissions Directive
- The potential for OCGT development and the role of storage
- The potential for further mothballing or early closure of plants
- The impact of cash out reform.

4.3
Gas Demand

Axioms that influence this section

- Renewable Energy/ Carbon Targets
- Government Policy (UK & Europe)
- Economic Outlook
- Fuel Prices
- Heat
- Energy Efficiency
- Commercial Energy Efficiency
- Energy User Behaviour
- CHP
- CCGTs/ OCGTs (unabated)
- Irish Gas

Summary

- Gas demand consists of four key sectors including residential demand for home heating, Industrial and Commercial consumption related to public buildings and businesses, exports to Ireland and through IUK, and gas used in power generation
- Residential demand is driven by developments in energy efficiency, extra demand from new houses, behaviour changes and change of heating fuel
- **Gone Green** has limited additional demand from new housing post 2018 and demand reduces from fuel switching beyond 2020
- **Slow Progression** assumes a high proportion of new homes will continue to be heated by gas boilers offsetting efficiency savings. Overall demand remains flat
- The Industrial and Commercial demands in both scenarios reduce as economic trends encourage further investment in efficiency and fuel switching while process load demand remains largely unaltered
- We assume similar energy trends in Ireland to that in the UK; hence Irish demand is essentially flat until the early 2020s when demand increases from power generation
- Consistent with our generation scenarios, gas demand for power generation recovers in 2013 following LCPD plant closures. However, gas demand continues to reduce with lower electrical demand, favourable coal prices, and increasing renewable generation. In **Slow Progression** gas demand increases in 2020/21 following additional coal plant restrictions but then continues to decline annually.

Key statistics

- Total demand in 2012/13 was **866TWh**, this decreases to **795TWh** in **Gone Green** and increases to **875TWh** in **Slow Progression** by 2020
- Residential demand accounts for **39%** of total gas demand in 2012/13. This falls by **11%** in **Gone Green** and by **6%** in **Slow Progression** by 2020
- Industrial and Commercial demand accounts for **29%** of total gas demand in 2012/13. This falls by **6%** in **Gone Green** and by **11%** in **Slow Progression** by 2020
- Exports account for **13%** of total gas demand in 2012/13. This decreases by **5%** in **Gone Green** and increases by **47%** in **Slow Progression** by 2020
- Power Generation accounts for **19%** of total gas demand in 2012/13. This decreases by **7%** in **Gone Green** and increases by **1%** in **Slow Progression** by 2020 .

4.3 continued
Gas Demand

What needs to be achieved for the targets to be met?

- Continued displacement of older gas boilers with A Rated condensing boilers
- Successful uptake of Green Deal and ECO that further improve building insulation and efficiency levels
- Increased productivity per unit of energy consumed from both Commercial and Industrial sectors
- EMR needs to be implemented to ensure support for low carbon generation that influences the role and demand levels for gas driven generation
- Adoption of new heating technologies, such as heat pumps, in off-gas regions to establish supply chains and enhance product economics to widen their appeal in time.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Heat *(Section 3.4)*
- Consumer *(Section 3.5)*
- Transport *(Section 3.6)*
- Power Demand *(Section 4.1)*
- Power Supply *(Section 4.2)*
- Gas Supply *(Section 4.4)*

Our gas demand projections are defined in terms of customer annual consumption bands rather than customer type as this is the information that we have available to us. These bands do not map directly to traditional descriptions such as residential, commercial or industrial. Residential demand maps reasonably well to the non daily metered 0–73 MWh per year category but above that level it is often safer to consider industrial and commercial demand in aggregate as customers with demand greater than 73 MWh per year. Gas Demand for Power Generation and Exports are generally metered separately and hence can be considered individually.

UK Gas Demand is made up of four main categories:

- Residential Demand
- Industrial and Commercial Demand
- Power Generation Demand
- Exports.

4.3.1
Residential Gas Demand

There are four main drivers for changes in demand in the residential sector:

- **Behaviour change**
- **Energy efficiency**
- **Extra demand from new houses**
- **Change of heating fuel.**

These drivers have been modelled using stakeholder feedback, econometric analysis and application of our axioms.

Behaviour change

There are a number of behavioural changes that consumers can make to change their energy consumption, for example adjusting the thermostat setting or turning heating off at a different time in the evening or the year. These can mostly be captured by considering their effect on the average internal temperature of the house. Since 2005, average household temperatures have reduced by 1–2°C as a result of changing consumer behaviour as increasing gas prices and reduced household income have made higher internal temperatures less affordable to households.

Stakeholder feedback suggests that future increases in internal temperatures will be limited and that they would be highly unlikely to increase above the highest historical temperatures.

Slow Progression shows very limited temperature change for the next five years, after which temperatures increase steadily until they reach the highest historical levels in 2025, where they remain capped until the end of the scenario period. The total increase in demand, resulting from temperature change, in 2025 is around 5% of current residential demand.

Gone Green shows no consumer behaviour change however the impact on gas demand is also driven by energy efficiency, insulation and the shift to heat pumps.

Energy efficiency

This has been covered in detail in section 3.5.

Extra demand from new houses

The extra heat demand for new houses is covered in detail in section 3.4.1.

In **Gone Green** the majority of heating in new houses is delivered by heat pumps, with only a small increase in gas demand.

In **Slow Progression** at least 80% of new houses are heated by gas boilers leading to more demand growth from new houses.

Change of heating fuel

Heat pumps have been discussed in section 3.4.2. We assume that early deployment of heat pumps will be in houses not connected to the gas grid, and in new houses, due to better economics and legislation respectively. Only once these markets are mature and they become cost effective do we expect existing gas heated houses to begin adopting heat pumps.

In **Slow Progression** the heat pump market is not large enough for this to happen, however in **Gone Green** this occurs and becomes significant from the mid-2020s.

A breakdown of the change in residential gas demand is shown in Figure 44 and Figure 45. Residential gas demand in both scenarios is shown in Figure 46.

4.3 continued
Gas Demand

Figure 44
Changes in residential gas demand: ***Gone Green***

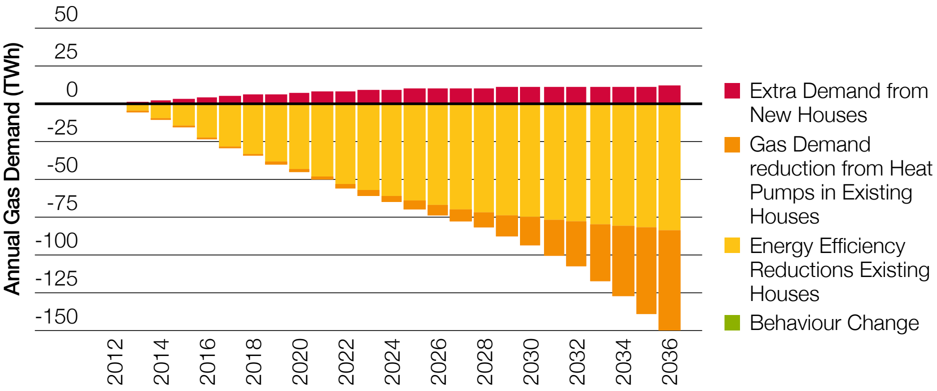


Figure 45
Changes in residential gas demand: ***Slow Progression***

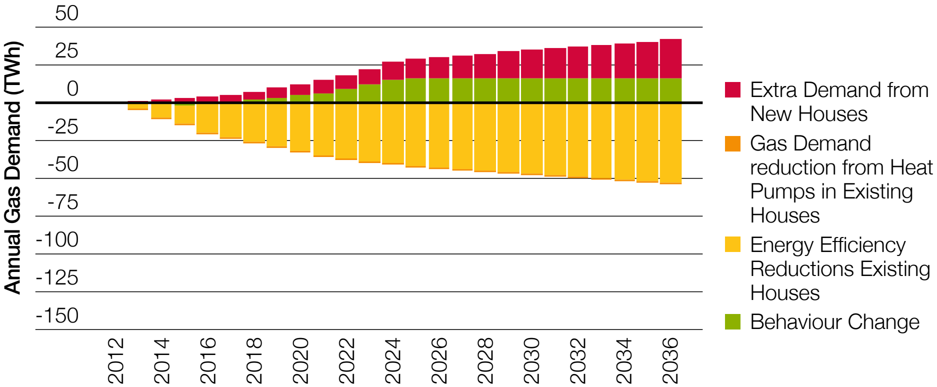
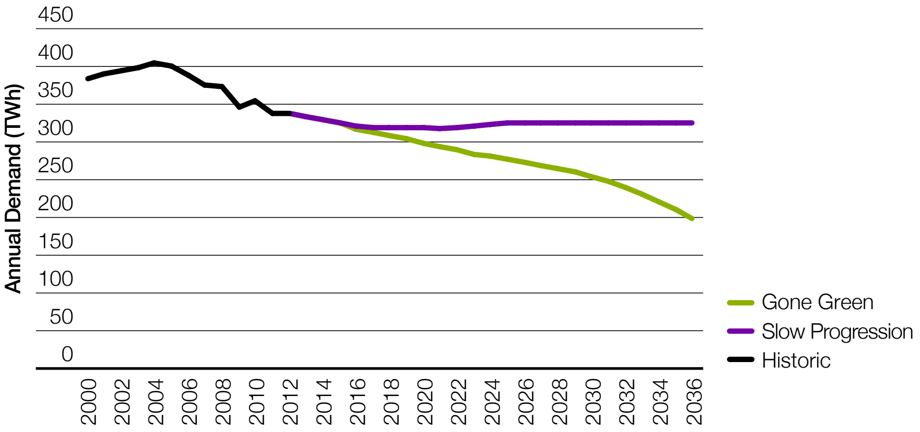


Figure 46
Residential gas demand in both scenarios



4.3.2
Industrial & Commercial Demand

Due to less detailed information relating to energy use within Industrial and Commercial (I&C) sectors we rely far more on econometric methods to model than for residential demand.

The I&C scenario modelling is conducted for three bands; 73–732 MWh, >732 MWh LDZ connected demands and NTS directly connected industrial demands.

The projections for the 73–732 MWh load band are all taken from our econometric modelling. This load band has good scope for further electrification, which is reflected in the **Gone Green** Scenario from the mid-2020s.

The projections for the >732 MWh load band are largely based on our econometric modelling, but in addition we identify sites that do not follow the econometric trends and project these via a separate site by site process after consultation with the gas distribution networks in which they reside. These are mainly high temperature process loads and heavy manufacturing (e.g. steel, glass, paper, chemical and oil refining), which account for just over a third of the demand for this sector.

All of the National Transmission System (NTS) directly connected industrial demands are modelled via a site by site process, as there are relatively few of them and they tend to have fairly consistent demands.

4.3.3
Exports: Ireland and Europe

Understanding the gas exported to the Republic of Ireland and Continental Europe is important for network operation purposes, although it does not contribute to UK renewable energy or carbon emissions targets.

The predicted level of gas exports to Ireland is heavily influenced by the development of indigenous Irish gas supplies via the Corrib gas field and the prospects regarding Irish gas demand. For each scenario we assume Irish supplies from Corrib post-2016/17, no developments of LNG projects and new Irish storage projects in the mid-2020s to meet peak gas demand. On the demand side we assume similar energy trends in Ireland to that in the UK for each scenario; hence Irish demand is essentially flat in each scenario until the early 2020s when demand increases from power generation.

Flows to and from Europe via Interconnector UK (IUK) are highly sensitive to both the overall UK supply/demand balance and Continental gas markets, for this reason both the levels of imports and exports flowing through IUK are subject to a great deal of uncertainty. As described in section 4.4.4 the level of imports from the Continent and LNG are interrelated and subject to uncertainty in both scenarios.

In **Gone Green** the overall utilisation of IUK (combined imports and exports) is assumed to remain close to the historical average of around 7 bcm (20 mcm/d). In **Slow Progression** the UK is very well supplied from UKCS and other imports in the years to 2020, with some decline in demand during this period, exports through IUK rise towards historical maximum levels before gradually falling thereafter. Given this the mid-case assessment of IUK flows and therefore exports to the Continent shows an increase in the years to 2020 as the UK is well supplied from other sources, before falling to lower levels thereafter.

4.3.4
Power Generation Gas Demand

Power generation gas demand is derived directly from our generation supply modelling (see section 4.2.5).

Gas demand for generation increases by over 10% in 2013 relative to 2012 as a result of LCPD coal and oil plant closures. Both scenarios are broadly the same with annual reductions following electricity demand reductions, coal prices favouring coal generation to gas and increasing renewables. In the short term **Gone Green** has a higher demand for gas generation due to higher carbon prices adding costs to coal generation.

By 2020/21 further restrictions reduce coal plant capacity leading to a step increase in **Slow Progression** gas demand. However, longer term both scenarios continue to have declining demand.

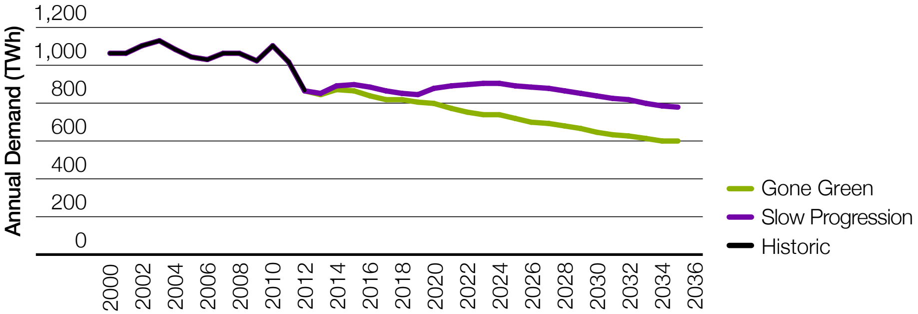
4.3.5

Total Gas Demand

Total gas demand for both scenarios is shown in Figure 47. For a breakdown by sector for each scenario please see Figure 48 and Figure 49. Both scenarios are broadly similar for the first few years, due to differences between scenarios largely offsetting each other.

In **Gone Green** gas demand declines in residential, I&C and power generation post-2020 leading to a steadily reducing total gas demand. Unchanging residential demand and increasing gas demand for power generation in **Slow Progression**, lead to gas demands that are not much lower than current levels, and account for the main differences between the scenarios.

Figure 47
Total gas demand for both scenarios



4.3 continued
Gas Demand

Figure 48
Total gas demand: ***Gone Green***

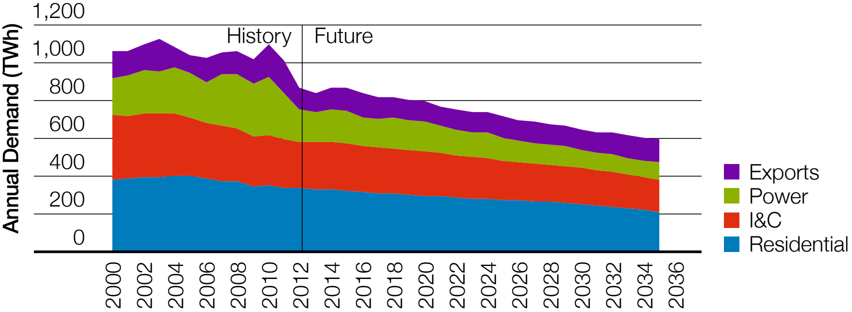
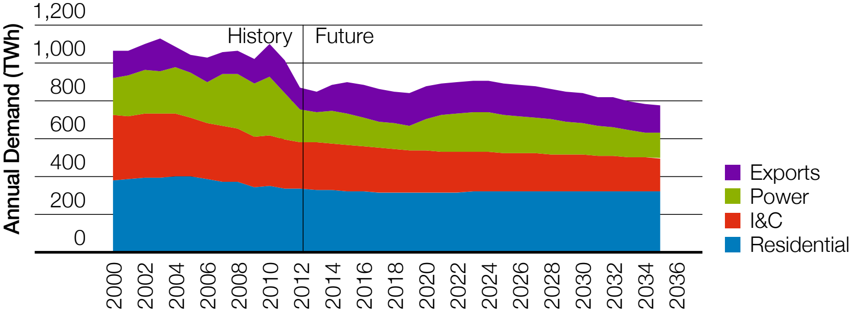


Figure 49
Total gas demand: ***Slow Progression***



4.3.6
Peak Gas Demand

Peak gas demand is based on a historical relationship between daily demand and weather combined with the amount of gas-fired electricity generation expected on a peak day. The relationship between peak and annual demand has remained unchanged for each load band.

The relationship between total annual demand and peak will change as the market mix changes. Peak gas-fired electricity generation is less related to weather and more dependent on assumptions about generation availability and the position of gas power stations in the generation order. Unlike annual gas demand for the sector, peak gas-fired electricity generation will either increase or remain broadly as it is today, due to the increasing requirement for gas-fired power generation to act as a back-up for renewable generation. This requirement will increase over time as more renewable generation comes online. The degree and timings of this vary between scenarios.

Figure 50 shows the peak demand for both scenarios. The similar peaks for both scenarios up to 2018/19 reflect the similarity between annual demands over the same period. From 2020 the differences in peaks reflect the differences in residential demand and gas demand for power generation.

Figure 50
Peak gas demand

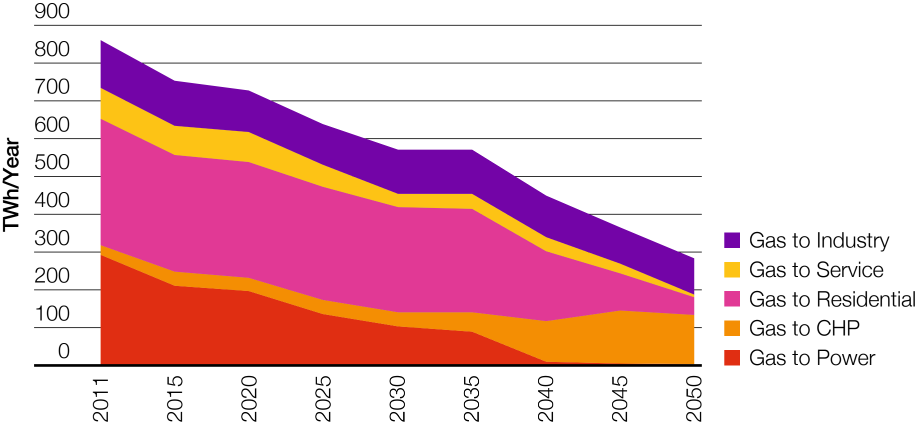
4.3 continued
Gas Demand

4.3.7
2035–2050

Gas demand continues to decline from 2035 to 2050 as shown in Figure 51. Gas use in conventional power generation, even with CCS, falls to zero by 2050, but is replaced by gas in CHP units fitted with CCS, which provide heat principally for industry, as well as electricity.

Some gas is retained for heating in the residential and service sectors and demand declines slowly in the industrial sector where there are few other options for providing high temperature heat.

Figure 51
Gas use to 2050



What has changed since 2012?

- We have made improvements to our econometric models and revised assumptions in our power generation scenarios
- **Slow Progression** 2013 remains similar to our 2012 scenario with the exception of lower demands for power generation
- In contrast, **Gone Green** 2013 has a higher demand overall with higher demands from residential buildings. Revised heat pump assumptions have resulted in a greater retention of gas appliances by 2030.

Key uncertainties and areas for development:

- The UK has a small demand for Liquified Natural Gas (LNG) and Compressed Natural Gas (CNG) for transport with scope for considerable growth. We have not included any demands for transport within our scenarios and will review the position for subsequent scenarios as further information comes to light
- Uncertainties remain to the levels of demand reduction from new policy mechanism such as Green Deal, ECO, EMR and the implications of economic growth on UK commercial and industrial investments. However, the range between our scenarios is designed to accommodate the variation in demand levels.

4.4
Gas Supply

Axioms that influence this section

Renewable Energy/ Carbon Targets
Government Policy (UK & Europe)
Global Gas Markets
Gas Supply (UKCS)
Gas Supply (Norway)
Gas Supply (LNG)
Gas Supply (Continent incl. Russian)
UK Shale Gas
Coal Bed Methane & Biogas
Gas Storgae
Irish Gas

Summary

- Subdued gas demands (particularly for power generation) lead to lower gas supply requirements
- There is a continued trend of declining production of UK Continental Shelf (UKCS)
- There is considerable uncertainty over the development of onshore gas sources, notably shale gas
- Norwegian imports are expected to continue to play a pivotal role in meeting UK demand
- Due to global market dynamics, supplies from LNG and Continent are subject to significant uncertainty
- Gas storage continues to play a key role in meeting high demands and providing flexibility.

Key statistics

- UKCS contributions increase slightly from **40%** today to **43%** in 2020 before reducing to **22%** in 2035 for **Slow Progression**. For **Gone Green** it slightly increases to **45%** in 2020 before reducing to **13%** in 2035
- Onshore contributions increase from essentially **zero** today to about **2%** in 2020. The contribution increases to **8–10%** in 2035 with the highest proportion being associated with **Slow Progression**
- Norwegian imports in the scenarios change little from about **35%** today to about **30%–36%** in 2020 before declining to **14%–18%** in 2035
- In **Slow Progression** by 2020 the UK is **55%** gas import dependent, increasing to **68%** by 2035. In **Gone Green** by 2020 the UK is **53%** dependent on gas imports increasing to **79%** by 2035.

Further Reading

- Government Policy *(Appendix 1)*
- Economic Background *(Section 3.3)*
- Heat *(Section 3.4)*
- Consumer *(Section 3.5)*
- Power Supply *(Section 4.2)*
- Gas Demand *(Section 4.3)*

For each gas demand scenario there is a dedicated supply scenario based on assumptions derived from our axioms. In determining the gas supply scenarios, each of the main supply components are individually assessed before being considered collectively such that the aggregate level of annual gas supply matches the annual gas demand in each scenario.

Peak supply is calculated separately. The peak supply assessment, with the exception of the UK Continental Shelf (UKCS) component, is based on the utilisation of available imports and storage capacity. For security assessments lower levels of capacity utilisation are used. These are not detailed in this document.

The main gas supply components consist of:
- UKCS
- Onshore Gas Sources
- Norwegian Imports
- Liquified Natural Gas (LNG) Imports
- Continental Imports
- Storage.

The UK import requirement is dependent on UK gas demand and indigenous sources of gas. The ‘mix’ of imports is subject to numerous global considerations, these can have a material impact on gas imports. For 2013, a new axiom ‘Gas Global Markets’ has been developed to reflect the impact that global factors can have on the UK gas supply mix.

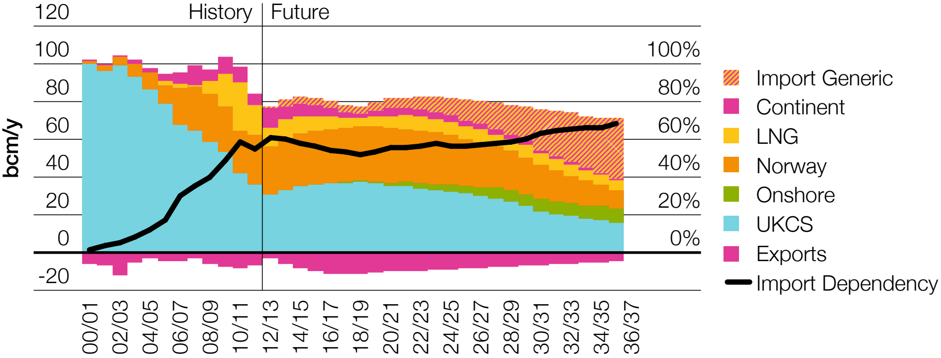
4.4 continued
Gas Supply

4.4.1
Annual Gas Supply

The annual gas supply projections for Slow Progression and Gone Green are shown in Figure 52 and Figure 53.

For both scenarios the charts show an area of import uncertainty to reflect the possibility that the imports could be either LNG or from the Continent or a combination of both. This approach has been deemed necessary to reflect global supply issues that could shift the UK towards either of these supply sources.

Figure 52
*Annual gas supply – **Slow Progression***[41]



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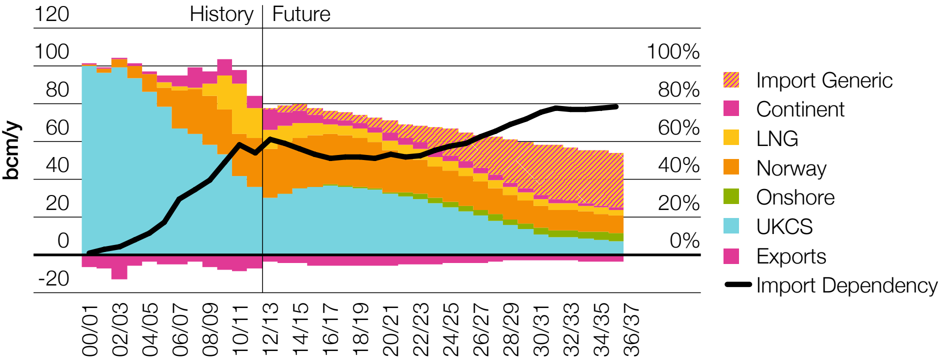
[41] Exports represent a mid-point assessment of Continental imports which is incorporated into the annual gas demand scenarios.

Figure 53
*Annual gas supply – **Gone Green***[42]



Slow Progression assumes a higher level of gas supply from UKCS and onshore sources compared to **Gone Green**, due to increased certainty in the UK gas market and assumed government initiatives to promote further UKCS and shale developments. Norwegian imports are also higher in **Slow Progression**, again due to increased certainty in the UK market for gas. LNG and Continental supplies are shown at relatively modest levels in both scenarios with an increasing range connecting these two sources to reflect the possibility of further imports from either source. On an annual basis, flows between the Continent and the UK are weighted more to exports than imports in **Slow Progression** due to relatively high UK supply availability. In both scenarios, the gas importation requirement becomes more marked from the mid-2020s due to the decline in gas from the UKCS and Norway.

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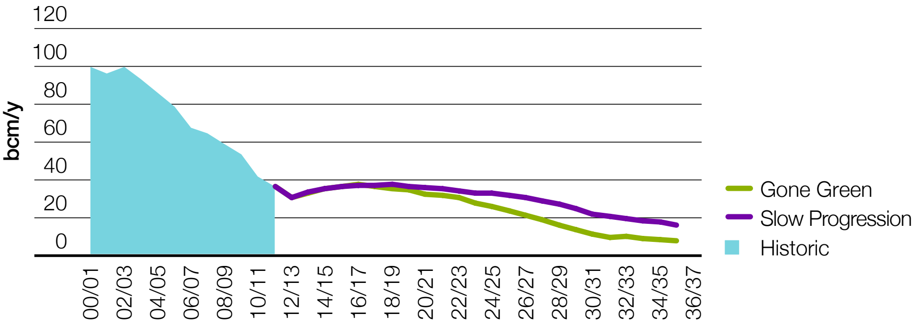
[42] See footnote 41

4.4 continued
Gas Supply

4.4.2
UK Continental Shelf (UKCS)

The UKCS supply scenarios are shown in Figure 54. As in previous years there is a trend of declining production, though this is affected in the near term by new developments including West of Shetland.

Figure 54
UKCS



The UKCS profiles are based primarily on data from Oil and Gas UK which reflect the aggregate view of UKCS upstream parties.

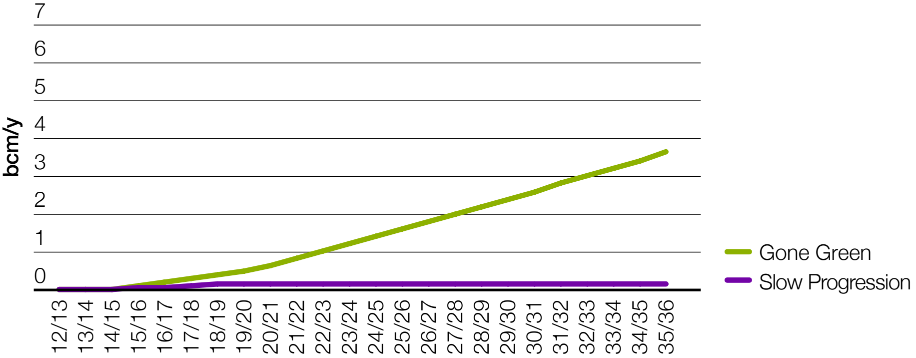
Despite the diversity of assumptions there is relatively little difference in the UKCS projections for the two scenarios, particularly in the short term as these levels are based on fields that are currently in production and under development. Over time there is some divergence in the UKCS supply profiles with higher longer term UKCS production in **Slow Progression** due to the assumption of more new field developments than in **Gone Green**.

As a proportion of UK demand, the contribution of UKCS increases slightly from 40% today to 43% in 2020 before reducing to 22% in 2035 for **Slow Progression**. For **Gone Green** it slightly increases to 45% in 2020 before reducing to 13% in 2035.

4.4.3
Onshore Gas Supplies

The supply scenarios include a contribution from onshore gas sources, specifically shale, coal bed methane (CBM) and biogas, as shown in Figure 55 and Figure 56. Each of these sources is considered independently for each scenario.

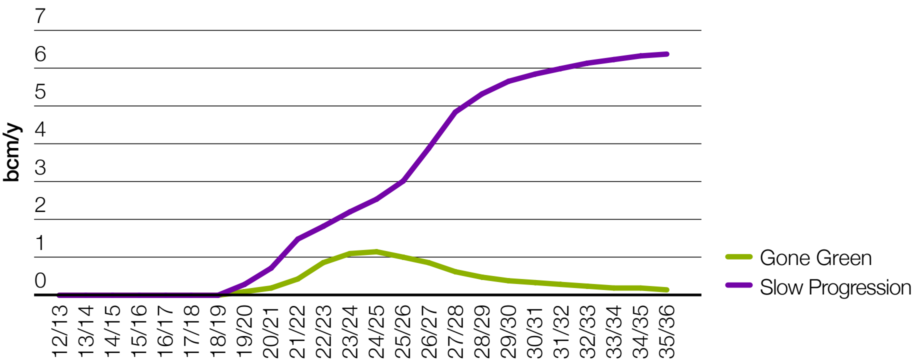
Figure 55
Biogas



4.4 continued

Gas Supply

Figure 56
Shale



As a proportion of UK demand, the contribution of onshore gas sources in the scenarios increases from near zero today to about 2% in 2020 and 8–10% in 2035, with the highest proportions being associated with shale gas in **Slow Progression** and biogas in **Gone Green**.

CBM is assumed to make a small contribution in both **Slow Progression** and **Gone Green**. For all three onshore gas sources there is considerable uncertainty over development timescales and potential volumes, hence the assumed contributions could be significantly understated.

4.4.4
Imports

The difference between the demand in each scenario and the assumed levels of UKCS and onshore gas sources determines the import requirement.

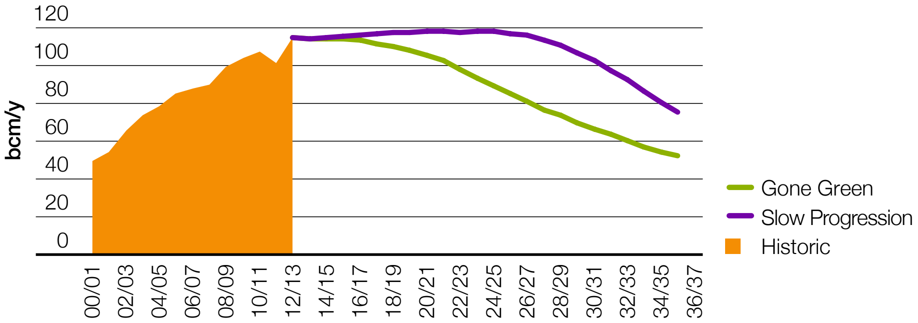
For both scenarios future imports are assumed to be a combination of Norway, LNG and Continent. Due to proximity and less export options, imports from Norway are considered ahead of LNG and Continental supplies.

Norway

To assess levels of Norwegian flows to the UK, we firstly determine the total level of Norwegian production. This is followed by determining the proportion of Norwegian gas used in Norway and exported to the Continent and the UK. For each scenario we create a different Norwegian production projection and a different projection of supply to the UK. Our assessment of Norwegian production and UK supplies is discussed with gas producers (including the Norwegian energy companies).

The total Norwegian production projection shown in Figure 57 is based on the reported total reserves for the Norwegian Continental Shelf (NCS), external forecasts for key fields such as Troll and Ormen Lange and an assessment of the development of remaining Norwegian gas reserves. While Norway is a mature province, there still remain considerable areas for exploration with the potential for significant reserves in new discoveries. It is the assessment and production from these potential new discoveries that provides most of the variation in future Norwegian production and as such supplies to the UK.

Figure 57
Norway gas production (history and scenario projections)



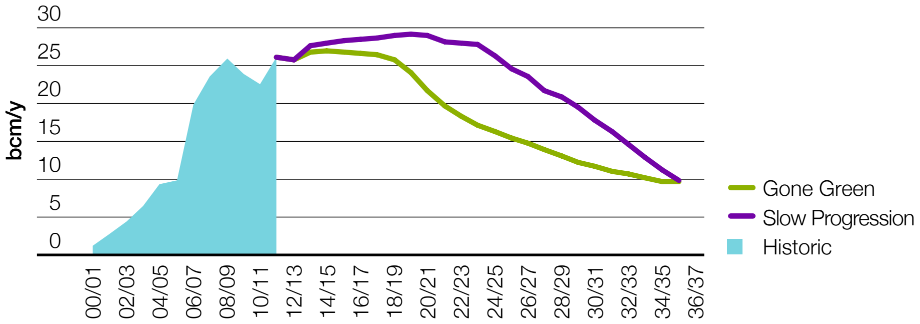
4.4 continued
Gas Supply

For **Gone Green** we assume modest discoveries over the next few years, which alleviate the rate of decline until the middle of this decade. **Slow Progression** has higher discoveries and production at or above current levels until the middle of the next decade. Both scenarios have a gradual decline in the level of Norwegian production, even with the discoveries and subsequent developments of new fields in the Norwegian Sea and Barents Sea.

In terms of the split of Norwegian production we assume relatively modest levels of gas consumed in Norway. **Slow Progression** has higher Norwegian flows to the UK compared to **Gone Green**. In both scenarios, the levels of Norwegian gas imported to the Continent are higher than that to the UK.

As a proportion of UK gas demand, the contribution of Norwegian imports in the scenarios changes from about 35% today to about 30%–36% in 2020 and 14%–18% in 2035. Figure 58 shows Norwegian imports to the UK for both scenarios.

Figure 58
Norway gas supply to the UK (history and scenario projections)



LNG & Continent

The remaining UK gas import requirements are provided though a combination of LNG and Continental supplies. The impact of the global gas market on the UK gas supply is material and has a noticeable effect on the levels of gas that may be expected from both the Continent and LNG.

In previous years, the gas supply scenarios provided a view of the levels of LNG and Continent that could be required to meet gas demand. However, experience has illustrated that both LNG and Continental imports are difficult to predict and are dependent on a variety of external factors influencing global gas markets.

Given this, a new approach has been introduced to articulate more clearly this uncertainty. For LNG and Continent, the axioms for both **Slow Progression** and **Gone Green** consider the possibility of high or low levels of LNG and/or Continent to the UK. This reflects recently observed trends and captures future uncertainty. Therefore, in each scenario, a minimum level of gas from LNG and Continent imports has been included that reflects levels that could be expected from that particular gas source. The difference between the minimum amount and the level of imports that is required, for a particular year, has not been allocated to a particular source (referred to as 'import generic') as both LNG and Continent have the capability of providing some, if not all of this gas to the UK.

LNG

Both **Slow Progression** and **Gone Green** show a range of potential LNG supplies, the exact levels are dependent on a number of factors, these include:

- Existing and future UK LNG contracts or upstream partnerships
- Global availability of spot LNG
- Global supply/demand fundamentals (as considered by the Global Gas Market axiom).

Global Supply

Both scenarios assume an increase in global liquefaction capacity through to 2020. This is primarily from Australia although the USA also has the potential to provide significant LNG. Beyond 2020, there is more uncertainty over future liquefaction with potential for new projects in East Africa and the Eastern Mediterranean. Further Australian expansion is also possible though rising project costs may limit this.

There is also some downside to global LNG supply including:

- Declines in indigenous production, for example in Indonesia
- Use of gas for local consumption rather than for LNG export, for example in Egypt
- Availability of gas due to supply disruption and geopolitics
- Delays and cost overruns to new projects.

Global Demand

In addition to the uncertainty over liquefaction, there is considerable uncertainty over LNG demand. Global drivers for demand include:

- Economic growth in Asia, notably China and possibly in the longer term India
- The level of future Chinese demand:
    - Total Chinese gas demand has increased over the past 5 years at a compound annual rate of 13.5%. If these rates continue, by 2020 Chinese gas demand could be 350 bcm compared to around 147 bcm today. Pollution in China may also force a shift from coal to gas for power generation
    - The Chinese gas supply mix (currently 20 bcm LNG), will be dependent on the level of domestic production (conventional or shale), pipeline supplies (Caspian/Russia) and LNG imports. A high case for LNG could lead to China becoming the world's largest LNG importer by the mid-2020s
- Timing and extent of nuclear restarts in Japan is uncertain, as is the longer-term power generation mix in Japan and other economies
- Further uncertainty over demand in South America (especially Brazil)
- New markets for LNG notably transport and marine.

Continent

The level of Continental imports to the UK are also subject to considerable uncertainty, this is compounded by the bi-directional nature of IUK (physical) and BBL (commercial) pipelines. Other factors that influence Continental imports to the UK include:

- Existing and new supply contracts or upstream partnerships
- Availability of UKCS and other UK imports
- UK and Continental gas price differentials
- Continental market liberalisation and access to storage and transmission
- Energy supply and demand in Europe including the role of gas in meeting this need
- Levels of indigenous gas supply in Europe from conventional and unconventional sources

4.4 continued
Gas Supply

- Russian gas supply to Europe:
  - – Russian internal demand, exports to Asia and upstream investment will all impact the level of gas exports available to Europe
  - – The development of infrastructure projects along with contractual negotiations with both downstream customers and transit states will impact the destinations for gas exports
- Level of other European gas imports, such as North Africa and the Caspian Sea.

Managing the Uncertainty of LNG & Continent

Figure 59 and Figure 60 show the combined import requirement from LNG and Continent. The charts show minimum levels for both LNG and Continent and an area described as 'generic' imports that represent supply that could flow from any combination of LNG and Continent sources.

Figure 59
Slow Progression

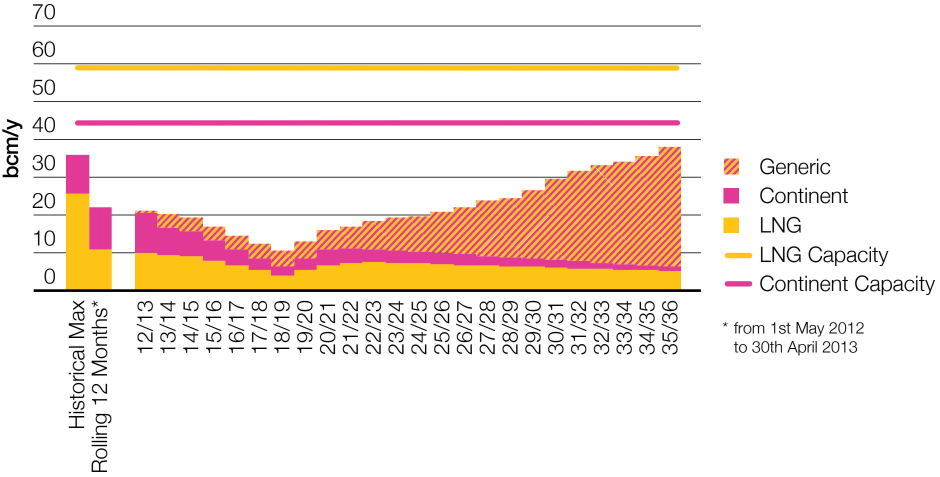
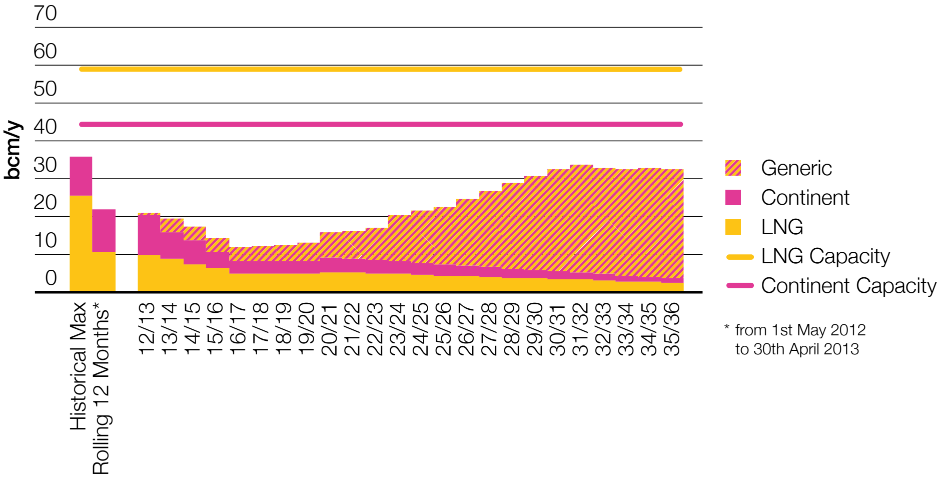


Figure 60

Gone Green



The minimum levels have been determined by a combination of historic flows and consideration of other parameters, for example LNG boil off rates and gas supply contracts.

For **Slow Progression** and **Gone Green** the combined supply from LNG and Continental gas sources can in theory meet the generic import requirement without exceeding their historic maximum import levels or the existing import capacity for either source. The reported capacities reflect maximum imports from all sources throughout the year. In reality a much lower level of capacity is available as demand is seasonal, import capacity may be restricted to the capacity owners and availability of imports may also be limited.

Towards the end of the scenario period, high levels of LNG and/or Continental imports are needed in both scenarios. While we do not have any specific new import projects in our scenarios the capacity restrictions detailed above highlight the potential requirement for either new or expanded LNG facilities or further Continental capacity.

4.4 continued
Gas Supply

4.4.5
Gas Supply: Storage

To assess peak supply, the contribution from UKCS (including onshore gas sources) and imports at or near maximum supply/capacity needs to be considered. As in previous years, the storage position is dominated by an assessment of new storage projects that could be built over the next few years in addition to those under construction.

Recently commissioned storage sites and those under construction have tended to be facilities with high injection and withdrawal rates relative to their space. This enables them to operate flexibly and cycle within winter. Proposed new storage facilities are a mixture of flexible and higher duration seasonal sites.

For both scenarios, the development of further storage is shown in Figure 61 and Figure 62.

Figure 61
Storage development (space)

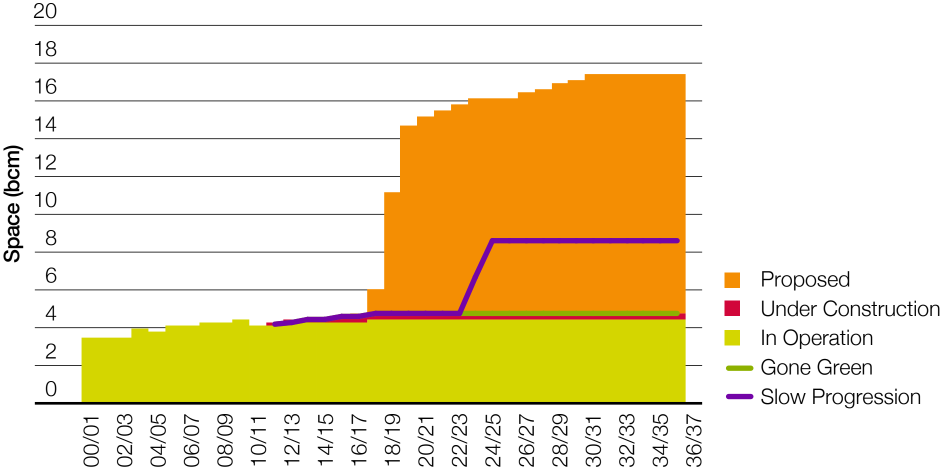
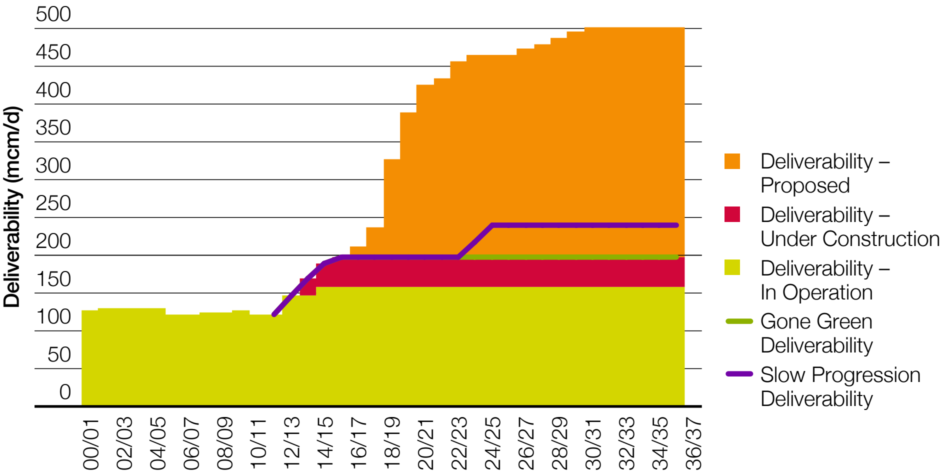


Figure 62
Storage development (deliverability)



For **Slow Progression** we assume additional seasonal storage comes online as import dependency increases. In **Gone Green**, more flexible supplies for balancing intermittent renewable generation are required. This is assumed in part to come from flexible storage facilities.

Alternatively, this could come from a range of sources including LNG, increased use of existing fast cycling storage sites and access to European storage including the Bergermeer facility in the Netherlands, commissioning around 2015.

4.4.6
Gas Supply: Peaks

Figure 63 and Figure 64 show the peak supply availability for **Slow Progression** and **Gone Green**.

Figure 63
*Peak day gas supply: **Slow Progression***

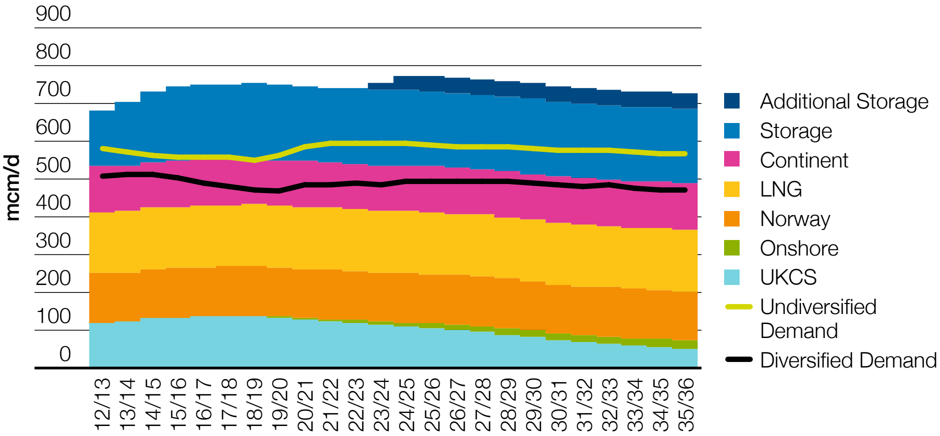
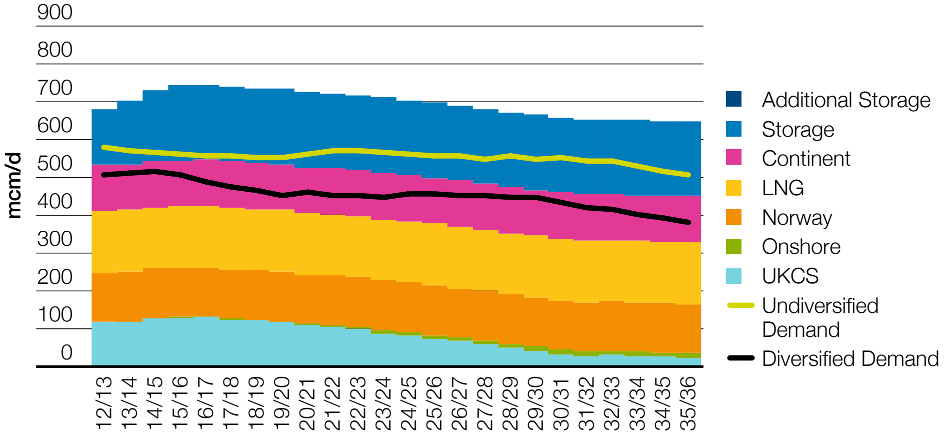


Figure 64
*Peak day gas supply: **Gone Green***



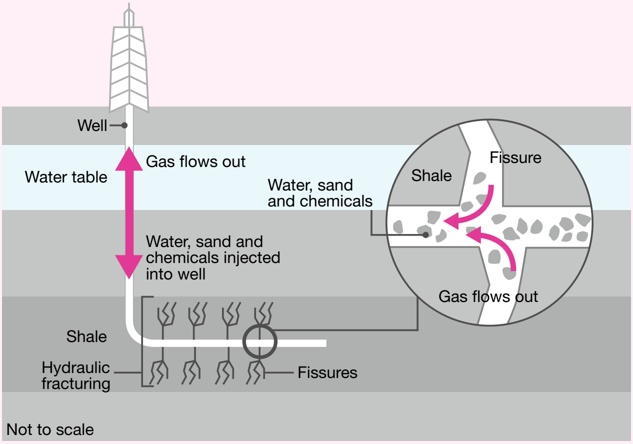
These charts show the supply components on a full capacity basis and storage is shown at maximum deliverability. While this shows the full potential of these components, the peak supply is overstated as not all components will necessarily provide supply at a given point in time for technical or commercial reasons. For example, for many storage sites maximum deliverability may be restricted to just a few days and in the winter storage may be depleted in advance of any peak day.

4.4 continued
Gas Supply

Case Study: Shale Gas

Shale gas is natural gas that is found trapped within shale formations. It can be recovered through a process called 'fracking' which involves drilling a hole deep into the dense shale rocks that contain natural gas, then pumping in at very high pressure vast quantities of water mixed with sand and chemicals (as illustrated in Figure 65). This opens up tiny fissures in the rock, through which the trapped gas can then escape. It bubbles out and is captured in wells that bring it to the surface, where it can be piped off.

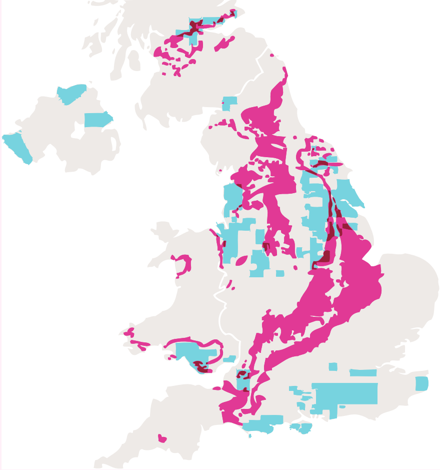
Figure 65
Shale Gas Extraction



Shale gas has become an increasingly important source of natural gas in the United States of America since the start of this century. In 2000 shale gas provided only 1% of US natural gas production; by 2010 it was over 20% and the United States government's Energy Information Administration (EIA) predicts that by 2035, approximately 50% of the United States' natural gas supply may come from shale gas. The evolution of shale gas production in the USA has altered the market dynamics of America's domestic gas market (downward pressure on wholesale gas prices) and global energy markets (US coal exports making gas-fired power stations the marginal fuel source for electricity generation in Europe).

Given the impact of shale production on the US domestic gas market, other countries, including those in Europe, have been investigating their indigenous shale gas sources. In the UK in 2010, a British Geological Survey/DECC Shale Gas report identified significant potential areas of shale gas reserves in northern England, including Widmerpool Gulf near Nottingham and a large area centred on the Elswick Gasfield, near Blackpool. Figure 66 provides an illustration of shale formation across the UK.

Figure 66
Shale formation across the UK



🟥 Black shale deposits*
🟦 Onshore licences**

* Shale data for Northern Ireland not shown
** Giving exclusive rights to exploratiom and drilling

Source: British Geological Survey

The exact volume of shale reserves within the UK is subject to considerable uncertainty. A recently published report[43] from the British Geological Survey (BGS) in association with DECC, stated shale gas reserves in central Britain[44] of 1,329 trillion cubic feet (tcf)[45], equivalent to over 37,000 bcm. It is anticipated that only a modest proportion of these reserves may be extracted, ranging from 10% to 30%. At a conservative recovery rate of 10% and annual UK gas consumption rates of about 80 bcm, this would provide 46 years of gas supply.

However there are considerable uncertainties regarding the development of UK gas supply, these include:

- Further clarity on UK shale gas reserves
- Government policy and initiatives
- Test drill results
- Environmental and planning consents
- Structure of UK gas market
- Production economics
- Supply chain logistics, for example availability of drilling rigs.

It is recognised that the development of shale gas reserves could provide a material contribution to the UK gas supply mix in the future. Therefore we have created a sensitivity (based on available data from the UK and the USA) to assess the impact of shale within the UK as illustrated in Figure 67.

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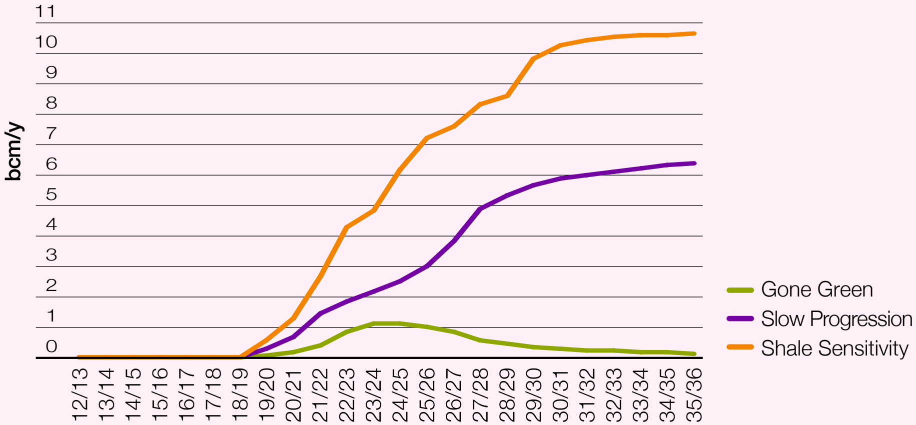
[43] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209021/BGS_DECC_BowlandShaleGasReport_MAIN_REPORT.pdf

[44] An area between Wrexham and Blackpool in the west, and Nottingham and Scarborough in the east.

[45] This is the central estimate quoted in the report.

4.4 continued
Gas Supply

Figure 67
Shale sensitivity



The chart also provides a comparison of the sensitivity against our shale gas levels for our **Gone Green** and **Slow Progression** scenarios. Our sensitivity suggests that by 2020, shale could contribute between 2%–4% of the UK gas demand requirements and between 15%–20% by 2035.

Shale gas could make a useful contribution to the UK's gas supply in terms of diversity and security of supply. For shale gas, existing network arrangements for gas entry to the NTS are applicable as they are for other 'unconventional' sources. Therefore, network entry (subject to meeting existing arrangements) should not be seen as a barrier for UK shale gas development, however it is important that developers provide clear information on the scale, timing and locations of shale gas developments.

What has changed since 2012?

- Introduction of new 'Global Gas Markets' axiom
- New approach highlighting the uncertainty in the source of gas imports
- Case study on the potential development of UK Shale Gas Reserves

Key uncertainties and areas for development:

- Development of new fields in the UKCS and Norway
- The development of UK shale gas reserves
- Further liberalisation of the European gas market and access to transmission and storage
- LNG market developments especially the extent and impact of Chinese demand.

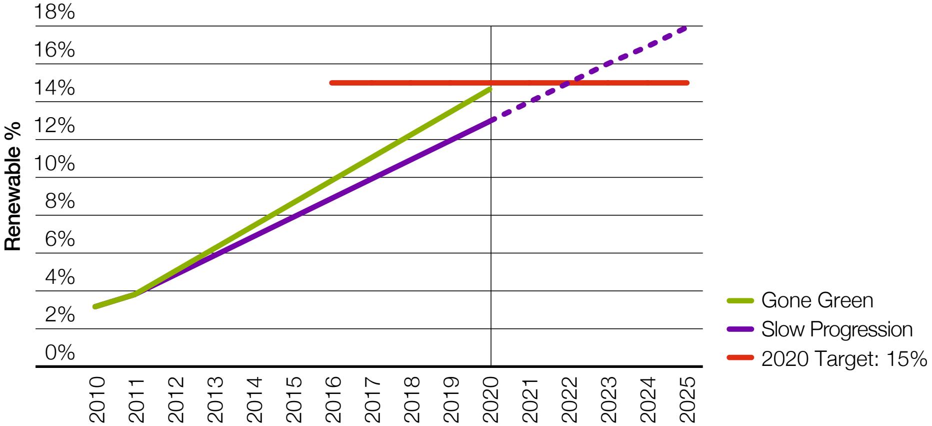
4.5

Progress Towards Targets

We have assessed Gone Green to ensure that it satisfies all the environmental targets. In Slow Progression there is no requirement to hit any of the targets but we have examined it in order to see how far short it falls.

Figure 68 shows the fraction of total energy met by renewable sources. Data from 2010 and 2011 are from DUKES[46]. **Gone Green** meets the 15% target by 2020, as required, but **Slow Progression** reaches this level sometime between 2020 and 2025, similar to last year's **Slow Progression**.

Figure 68
Progress towards renewable energy targets



There is no target for renewable energy (or for carbon emissions) by sector. However, there is interest in the contribution each sector makes to meet the targets. In **Gone Green** these values are:

Power generation	34% renewable
Transport	7% renewable
Heat	11% renewable

Our modelling of greenhouse gas reductions is restricted to emissions of CO_2 from energy consumption in power generation, transport and heat. The 2050 greenhouse gas target is 160 MT CO_2 equivalent for all greenhouse gases emitted from all sources, including a hypothetical UK share of international aviation and shipping emissions. To make a valid assessment we have used a 2050 target from which 55 MT has been removed for non CO_2 greenhouse gases, and 42 MT has been removed to take into account process and non-energy emissions and abatement from industrial CCS.

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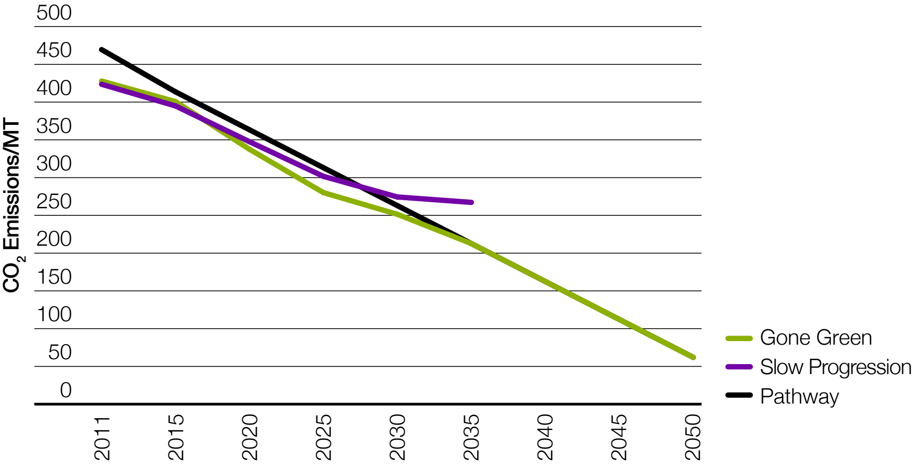
[46] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65850/5956-dukes-2012-chapter-6-renewable.pdf

4.5 continued
Progress Towards Targets

Figure 69 shows a pathway to this restricted 2050 target and the emissions for **Gone Green** and **Slow Progression** on the same basis. **Gone Green** has emissions below the indicative pathway until 2035, and then follows the pathway to 2050, as required by our axioms. **Slow Progression** emissions are below the indicative pathway until 2025, even with no constraint on the system to meet carbon or renewable targets. However, emissions are above the pathway by 2030, suggesting that the emissions allowed under the fourth carbon budget will be exceeded in this scenario; this is similar to last year's analysis.

Figure 69
Carbon emissions and progress towards targets



The government's 'National Statement of Emissions for 2011'[47] published in March 2013 confirms that over the period of the first carbon budget emissions will be well below the target, as shown in Figure 70.

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[47] https://www.gov.uk/government/publications/annual-statement-of-emissions-for-2011

Figure 70
Progress against the first Carbon Budget

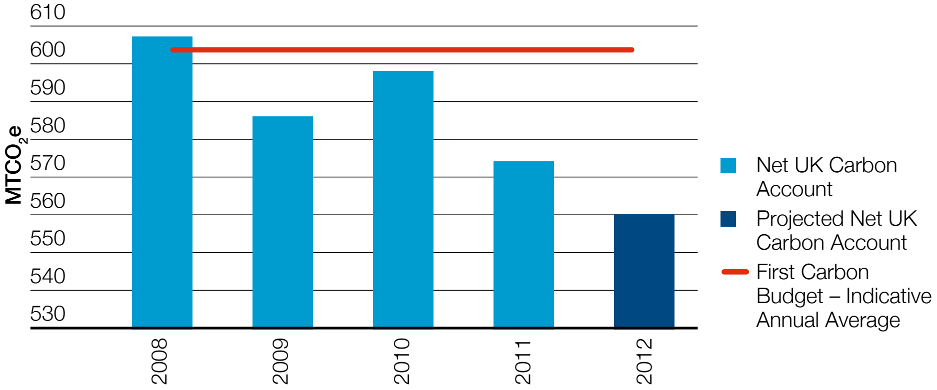
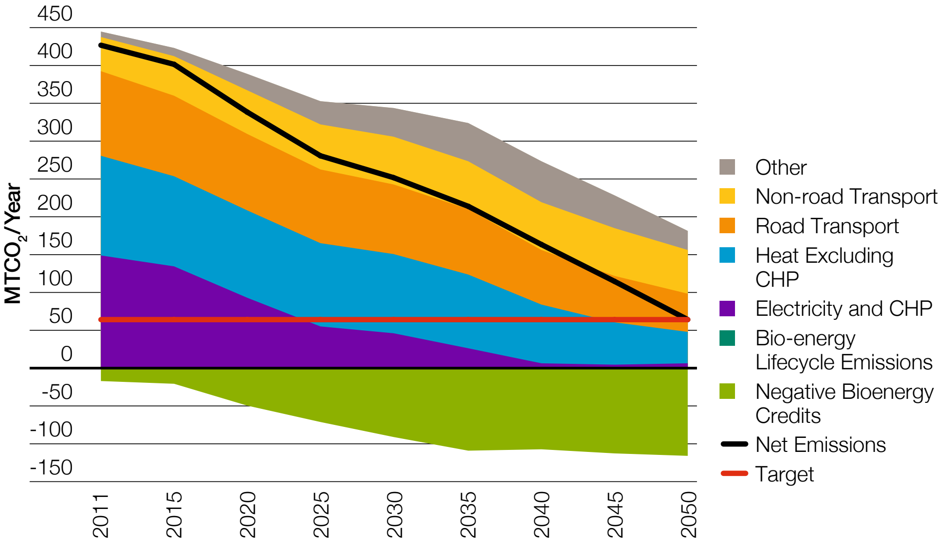


Figure 71 shows the carbon emissions by sector to 2050, and shows that power generation, road transport and heat all make significant contributions to the reduction.

4.5 continued
Progress Towards Targets

Figure 71
Emissions by sector



Note: negative bioenergy emissions represent carbon absorbed from the atmosphere during growth. Carbon emitted from burning bio materials is counted as a positive emission as normal in the electricity heat or transport sectors. For example, in 2011 bio fuel of various types removed around 20 MT CO2 from the atmosphere, but combustion of this released around 20 MT CO_2 back to the atmosphere, leading to a zero carbon net position. In later years when bio materials are burnt in units fitted with CCS which reduce the positive emission by around 90% the net position is for overall negative emission.

In summary, there are many factors that lead to uncertainty in our scenarios, including:

- Political uncertainty, including the effectiveness of policy interventions, particularly those that seek to influence consumer behaviour
- Economic uncertainty and the timing and strength of recovery and the nature of that recovery e.g. the balance of services vs. manufacturing industry
- Social uncertainty and how our choices as consumers will affect the timing and scale of changes in energy demand
- Technology uncertainty in both the supply and demand side and what 'disruptors' may emerge over the next 20 years and beyond.

Through our axioms and the development of our scenarios we have sought to better understand these uncertainties and our two scenarios, **Slow Progression** and **Gone Green**, identify credible, plausible outcomes for the future of energy and decarbonisation in the UK.

Appendix 1
Government Policy

CRC Energy Efficiency Scheme (CRC)

The CRC Energy Efficiency Scheme[48] 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[49] includes the introduction of new long-term contracts (CfDs) for new low carbon generation projects', a Carbon Price Floor (in place since April 2013), a Capacity Mechanism, to include demand response as well as generation, and an Emissions Performance Standard (EPS) set at 450g CO2/kWh to reinforce the requirement that no new coal-fired power stations are built without Carbon Capture and Storage (CCS), but also to ensure necessary investment in gas can take place. These elements of EMR (besides the Carbon Price Floor[50]) are dependent on the passage of the Energy Bill. Our analysis of EMR is ongoing. We have taken account of the main themes in deriving our electricity generation backgrounds, shown in section 4.2. 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[51] 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 (CHP) plants are also eligible up to 2kW.

Green Deal and Energy Company Obligation (ECO)

Green Deal[52] replaces the Carbon Emissions Reduction Target[53] (CERT) and 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 Which? showed that in May 2013, 52% of consumers were aware of the Green Deal. It is estimated that 26,000,000 homes could be eligible for Green Deal financing. By the end of April 2013, nearly 19,000 Green Deal assessments had been carried out, 55 authorised Green Deal providers had been registered and 942 organisations were signed up to carry out installations[54].

The Energy Company Obligation (ECO) commences in 2013 and will operate until March 2015 and is a legal obligation on energy suppliers to satisfy energy efficiency and fuel saving targets to households. ECO is primarily focused on households which cannot 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 solid walled properties.

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[48] https://www.gov.uk/crc-energy-efficiency-scheme

[49] https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform

[50] The carbon price floor was legislated for in the 2011 Finance Act

[51] https://www.gov.uk/feed-in-tariffs

[52] https://www.gov.uk/green-deal-energy-saving-measures

[53] http://webarchive.nationalarchives.gov.uk/20121217150421/www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx

[54] https://www.gov.uk/government/news/greg-barker-comment-on-the-publication-of-the-latest-green-deal-statistics and http://www.greendealcentral.com/news/?p=632, http://www.uswitch.com/green-deal/#step1

Industrial Emissions Directive (IED)

The Industrial Emissions Directive[55] is a European Union directive which commits European Union member states to control and reduce the impact of industrial emissions on the environment post-2015 when the 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 Oxide 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 Jan 2016 which will mean fitting selective catalytic reduction equipment or additional flue-gas desulphurisation technology for some plants.

Large Combustion Plant Directive (LCPD)

The Large Combustion Plant Directive[56] 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 50 megawatts) 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[57] caps the annual amount of money that can be levied on bills to support UK low carbon generation: £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 Feed-in Tariffs (CfDs).

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive[58] 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:

- The RHI Phase 1 – to commercial, industrial, public, not-for-profit and community generators of renewable heat
- The RHI Phase 2 – Premium Payment (RHPP) – to off gas grid householders generating renewable heat. Under RHPP householders receive a single payment for the installation of renewable heat technology
- The RHI Phase 3 – to householders generating renewable heat. Householders will receive regular annual or quarterly payments for heat generated.

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

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

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

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

Appendix 2
Axioms

<table>
<tr><th colspan="4">2013 Axioms</th></tr>
<tr><th>No.</th><th>Axiom</th><th>Slow Progression</th><th>Gone Green</th></tr>
<tr><td>1</td><td>Renewable energy / carbon targets</td><td>UK 2020 renewables target is missed. Pathway to 2050 falls short of carbon targets and 4th carbon budget. Pressure for UK carbon targets to be abandoned grows.</td><td>Targets met. Scenario based on meeting targets. Balanced approach across all market sectors, no carbon trading. No change to EU and UK policies.</td></tr>
<tr><td>2</td><td>Government policy (UK & Europe)</td><td>Global climate agreements are not secured, leading to a lack of coordination and national policy harmonisation across Europe.
Differing goals across government departments results in multiple policy interventions, increased uncertainty and perceived political risk for investors in GB energy markets.</td><td>Global accord on climate change action via international agreements leads to increasing policy harmonisation across Europe.
Consistent goals across government departments results in minimal policy interventions and few changes to policy. Certainty facilitates a positive climate for renewable / low carbon investment.</td></tr>
<tr><td>3</td><td>Levy Control Framework</td><td colspan="2">The Levy Control Framework (LCF) caps the annual amount of money that can be levied on bills to support UK low carbon generation: £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 feed-in tariffs (CfDs). Both scenarios comply with the LCF.
No assumptions are made on the outcome of DECC’s CfD strike price negotiations. For the purpose of estimating LCF the actual low carbon support nominal strike price is calculated assuming that CfDs provide a similar level of support to the RO in its final year (2016/17) for existing technologies; or a level similar to DECC’s published levelised costs for low carbon technologies not currently supported by the RO.</td></tr>
</table>

4	Economic outlook	Low economic growth (benchmarked against external economic forecasts).	Moderate economic growth (benchmarked against external economic forecasts).
5	Energy efficiency	Lower drive for energy efficiency. Green Deal domestic energy efficiency improvements are limited.	Drive for energy efficiency. Green Deal domestic energy efficiency improvements are significant.
6	Fuel prices	The prices of oil, gas and coal are the same for **Slow Progression** and **Gone Green** and are a mid-case scenario benchmarked to a suite of external forecasts. Dark spreads initially remain favourable vs. spark spreads.	
		The carbon price (includes carbon price support mechanism) falls to a level lower than the proposed EMR carbon floor price and remains lower for the duration of the scenario.	The carbon price (includes carbon price support mechanism) is and remains equal to the carbon price floor for the duration of the scenario.
7	Wind generation	Pre-2020, onshore and offshore transmission connecting projects that are currently under construction or consented proceed. Onshore deployment rates reduce on lack of planning approval. Offshore growth is limited and within Round 2 and Scottish Territorial Waters (STW) zones only.	Pre-2020, onshore and offshore transmission connecting projects include those in **Slow Progression** plus those projects in planning. Deployment favours onshore wind relative to offshore, which is made up of additional Round 2, Round 2 extensions and STW capacity and limited Round 3 capacity.
8	Wave & tidal generation	Minimal deployment by 2030 (demonstration projects only).	Demonstration projects pre-2020. Limited build-up of capacity post-2020 as costs start to fall. No barrage/ lagoon projects.

Appendix 2 continued
Axioms

9	Biomass generation	Limited new build due to financing / fuel source restrictions. Existing/ announced projects are completed with some delays. No new dedicated biomass plants. Co-firing is phased out and some (but not all) converted coal plants are re-licensed.	Pre-2020 there is stronger development than in **Slow Progression**; conversions are favoured over co-firing and dedicated plants. Post-2020, there is modest build of new dedicated plants, converted coal plants are re-licensed. Modest deployment of embedded biomass.
10	Nuclear generation	Average additional 10-year Advanced Gas-cooled Reactor (AGR) life extensions. First new nuclear plant delayed to mid-to-late 2020s with limited deployment thereafter.	Average additional 7-year AGR life extensions. First new nuclear plant slightly delayed to early 2020s. New nuclear deployment increases from late 2020s, as part of a mixed low carbon and renewable generation fleet. New nuclear plant is more flexible than existing nuclear plant.
11	CCGTs / OCGTs (unabated)	There is limited new build in the very near term and existing CCGTs and OCGTs stay open longer. Limited deployment of other forms of generation results in gas being the default new build plant into the longer term. Increased dependence on gas markets for electricity Security of Supply.	There is limited new build in the very near term and some existing CCGTs close earlier than in **Slow Progression**. CCGTs are run more flexibly to provide back-up to variable generation. Deployment of renewable and low carbon generation limits new build of unabated CCGTs, with no new plants post 2030. Some new OCGT capacity is built (mainly post-2020) to cover variable generation.

12	Coal generation	No new build. Gradual shift from coal to gas generation driven by closure of coal plants. Majority of existing plants opt out of IED and close before 2023 or opt into the Transitional National Plan (TNP) to 2020 and take the limited life option thereafter until closure.	No new unabated coal plants. Broader range of IED outcomes than in **Slow Progression**, including some plant opting into the IED (also benefiting from capacity payments). Some additional existing plants converted to biomass. Majority of unabated plant closed by mid-2020s.
13	Carbon Capture & Storage (CCS) generation	CCS is not commercially viable for coal or gas.	Commercial deployment of coal / gas CCS occurs during the 2020s as part of a mixed low carbon and renewable generation fleet, with some deployment of biomass with CCS in the later years.
14	Electricity interconnection (imports/exports)	GB interconnector capacity in 2030 broadly consistent with ENTSO-E Vision 1.	GB interconnector capacity in 2020 broadly consistent with ENTSO-E EU2020 scenario. GB interconnector capacity in 2030 broadly consistent with Vision 3 submission to ENTSO-E.
15	CHP	Limited to existing industrial sites. No domestic district heating schemes.	Continued moderate growth in on-site industrial/commercial CHP deployment. Domestic district heating (new build and urban redevelopment projects) trial projects pre-2020, moderate growth post-2020.

Appendix 2 continued
Axioms

16	Micro-generation (solar/ wind/hydro)	Hydro / wind deployment broadly static. Low solar PV growth as incentives (hence returns) reduce.	Hydro / wind deployment minimal growth. Modest continued growth in solar PV driven by falling installation costs.
17	Transport (road & rail)	Conventional road transport efficiency improvements continue. Low EV/ plug-in hybrid car uptake rates. Negligible change in HGV/ bus fuel sources. Electrification of rail reflecting Network Rail historic trends.	Conventional road transport efficiency improvements continue. Modest EV/ plug-in hybrid car uptake rates pre-2020 driven by incentives. Uptake rate increases through to 2030 as costs become comparative to conventional vehicles. Incremental growth in transition of HGV/bus fleet to CNG/LNG by 2030. Electrification of Rail reflecting Network Rail aspirations and extending to all passenger miles by 2050.

18	Heat	No conversion of on gas grid properties. Replacement of conventional boilers with condensing boilers continues at current rates. Incentives promote electric heat pump deployment in off gas grid properties at current rates. Electric heat pump deployment (mainly in new build properties) maintained at current rates. Incremental off gas grid deployment of heat pumps and biomass boilers.	Incentives promote wider uptake of electric heat pumps in new build properties post-2016 (competing with district heat solutions for some larger urban estate developments), and in off gas grid properties (competing with biomass boilers). Costs fall and supply chains develop enabling a wider uptake in suitable on gas grid properties. Replacement of conventional boilers with condensing boilers continues in properties unsuitable for heat pumps.
19	Energy user behaviour	The smart meter roll-out is delayed and tariff simplification limits the potential of time-of-use tariffs and home area networks. The lack of capability or economic incentive at point of use results in high behavioural inertia and little change to energy usage patterns.	The smart meter roll-out programme is delivered enabling time-of-use tariffs and increasing automation through home area networks. Over time, the resulting capability and economic incentives reduce behavioural inertia and drive demand reduction / shifting.
20	Commercial energy efficiency	Historical rates of energy efficiency improvements continue.	Carbon Reduction Commitment Energy Efficiency Scheme and fuel prices drive energy efficiency above historic levels.

Appendix 2 continued
Axioms

21	Global gas markets	Gas becomes increasingly important as the lowest carbon fossil fuel. Gas demand in China and other emerging markets increases significantly. Uncertainty in supply sources to meet this demand leads to an uncertainty in global LNG trade and therefore LNG and Continental imports to the UK. NTS exports are subject to balance of LNG imports.	The role of gas in power generation and heat is diminished due to increased deployment of lower carbon technologies. Future gas developments are held back due to uncertainty in the future market for gas, leading to uncertainty in global LNG trade and therefore LNG and Continental imports to the UK. NTS exports subject to balance of LNG imports.
22	Gas supply (UKCS)	Further development of smaller fields (including development of West of Shetland) due to government initiatives drives higher UKCS supply and lower rate of decline than compared to **Gone Green**.	Limited development of smaller fields leads to lower UKCS supply and more acute decline than in **Slow Progression**.
23	Gas supply (Norway)	Higher Norwegian production and development than in **Gone Green** (due to the certainty of market for gas in UK). Comparatively higher Norwegian supply to UK (more still going to the Continent) due to completion and softening of contractual positions.	Lower Norwegian production than in **Slow Progression** due to market uncertainty. Comparatively lower Norwegian supply to UK than to the Continent (which has higher flows).

24	Gas supply (LNG)	Global gas market uncertainty requires a high and low case for each scenario. Each case is primarily dependent on the balance between LNG deliveries and Continental imports.	
		Increased global liquifaction production facilities (from Australia, USA, East Africa, Israel etc). High case – assumes increased LNG supply to the UK. Low case – assumes lower LNG supply to the UK due to increased global demand, notably in China and possibly India.	Lower level of global LNG production facilities (compared to **Slow Progression**). High case – assumes increased LNG supply to the UK. Low case – assumes lower LNG supply to the UK due to lower production and global demand in other markets.
25	Gas supply (Continent inc. Russian gas)	Global gas market uncertainty requires a high and low case for each scenario. Each case is primarily dependent on the balance between LNG deliveries and Continental imports.	
		Increased gas supplies to Europe via numerous routes (mainly through increased Russian gas to Europe). High case – assumes increased Continent supply to the UK and increased use of Continental storage. Low case – assumes lower Continent supply to the UK due to high UK LNG supplies.	Decreased gas supplies to Europe. High case – assumes increased Continent supply to the UK and increased use of Continental storage. Low case – assumes lower Continent supply to the UK due to high UK LNG supplies

Appendix 2 continued
Axioms

26	UK shale gas, Coal Bed Methane (CBM) & Biogas	Both scenarios will have a limited amount of (UK) shale, CBM and biogas. CBM supply is the same in both scenarios (low amount).	
		UK shale gas extraction (increase from 2012 analysis) favoured over biogas.	Biogas production favoured over UK shale gas extraction.
27	Gas storage	Security of supply and Government gas storage strategy drives increased seasonal storage.	Lower gas demand (although more volatile within day due to electricity generation mix) and access to European storage sites drives increase use of fast cycling flexible storage sites.
28	Irish gas	Irish supplies for both **Slow Progression** and **Gone Green** follow the same narrative to that depicted in UKCS, Norway, LNG & Continent. The Irish economy is aligned to the UK in both scenarios.	
		Irish gas demand (non-power generation) increases slightly. Irish gas demand (power generation) moderately increases. Inch production reduces, Corrib is late (post-2017), no domestic storage or LNG, drives remaining supplies through Moffat.	Irish gas demand (non-power generation) is broadly flat and Irish gas demand (power generation) increases slightly, but is more variable. Irish gas supply: Corrib gas field online 2016/17, domestic storage required for peak demand in mid-2020s, remaining supplies through Moffat.

Appendix 3
Key Data

This table shows selected key facts from both scenarios. Greater detail is available on the National Grid website at http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/Future+Energy+Scenarios/

	Slow Progression		Gone Green	
	2020	2030	2020	2030
Electricity				
GB Peak Demand (GW)	57.5	56.7	59.7	62.7
GB Annual Demand TWh)	303	297	317	323
Total Capacity (GW)	96.2	115.8	111.6	153.6
Offshore wind (GW)	7.5	20.8	12.1	36.0
Onshore wind (GW)	10.1	13.6	14.2	21.0
Biomass* (GW)	5.1	4.8	6.7	6.7
Solar PV (GW)	3.4	6.1	6.9	15.8
Renewable (GW)	28.1	47.3	41.9	82.5
Nuclear (GW)	9.0	9.3	9.0	12.7
CCS capacity (GW)	-	-	-	4.6
Low carbon (GW)	37.0	56.6	50.9	95.2
Interconnector (GW)	5.2	7.2	6.2	7.6
Unabated coal (GW)	13.7	-	15.6	2.0
Unabated gas (GW)	36.7	48.5	35.2	40.0
Heat				
Domestic HP/Millions	0.3	0.6	1.2	5.7
Domestic HP electricity demand net change/TWh	-0.2	0.2	-1.7	-2.5

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* Biomass capacity includes all forms of biomass including conversions, dedicated biomass and embedded biomass CHP.

Appendix 3 continued
Key Data

	Slow Progression		Gone Green	
	2020	2030	2020	2030
Transport				
EV Number/Millions	0.2	0.9	0.6	3.2
EV Electricity demand/TWh	0.4	2.3	1.5	8.3
Rail Transport/TWh	4.7	5.4	5.1	6.5
Gas				
Domestic gas demand/TWh	317	324	298	254
Annual demand/TWh	875	838	795	647
Renewable Energy	13%	23%	15%	34%
GHG reduction	> 34%	< 60%	> 34%	~ 60%

Appendix 4
'Day in the life of…'

Within this document you will find 'Day in the life' narratives to illustrate the technologies consumers are using today and the effect of these on their lives. These narratives are based on the experiences of real people living with these technologies.

National Grid UK employees were invited to share their stories, 30 employees responded to this request. These employees were interviewed to discuss the advantages and disadvantages of the technologies, as well as consider how it influenced their behaviour. Their experiences were combined to create each narrative. From the employees who shared their experiences:

- 19 had solar PV
- 8 had or were considering a heat pump
- 3 had solar hot water
- 2 drove an electric vehicle (12-month trials)
- 5 had smart meters
- 2 were on time-of-use tariffs
- Many had invested in more than one of the technologies.

We acknowledge that these stories may not be representative of how the general public will adopt and interact with these technologies. The intention is to provide insight into what an experience of these technologies may look like.

Appendix 5
Margin Calculation Methodologies

Margin calculations in this publication and those within the 2013 Winter Consultation Report are slightly different.

The following table compares the two methodologies.

Comparison of Margin Calculation Methodologies:

	UKFES	Winter Consultation
Time Horizon	The UKFES looks from winter ahead to many years in the future.	The Winter Consultation only looks at the coming winter.
Generator Capacity (other than wind and hydro)	Based on forecast generator capacities (from the current generation mix, their expected operating life and assumptions of future new generator build), which are de-rated to account for losses due to planned unavailability and breakdown unavailability.	Based on generator notified availabilities (under OC2 of the Grid Code) which include planned outages. These are de-rated to account for average breakdown losses.
Wind	Two measures are used: ■ "1 in 10" low wind ■ Equivalent firm capacity (EFC)*	Two measures are used: ■ "1 in 10" low wind ■ Median wind
Hydro	■ Based on analysis of historic data	■ Based on analysis of historic data
Small Embedded Generation (invisible to National Grid)	Estimations included in both the Generator Capacity and the Demand figures.	Not included in the Generator Capacity figures and the forecast Demand figures are reduced by their estimated output.

Demand Definition	Transmission Restricted Demand** Includes: ■ Irish interconnector exports Excludes: ■ Continental interconnector exports ■ Station demand	Includes: ■ Station demand Excludes: ■ All interconnector exports
Types of Demand	■ Average Cold Spell demand	■ Normal demand ■ "1 in 20" demand ■ Average Cold Spell demand
Reserve	■ Reserve requirements for the largest single loss of generation	Reserve requirements vary depending on the scenario, including: ■ Operational Planning Margin Requirement (OPMR) ■ Adjusted OPMR (operating reserve) for de-rated scenarios ■ Reserve requirements for the largest single loss of generation
Margin Calculation	Demand and reserve requirements are subtracted from generator availability and expressed as a percentage of demand and reserve. A number of different figures are quoted depending on inputs.	Demand and reserve requirements are subtracted from generator availability and expressed as a percentage of generator availability for the traditional winter outlook calculations (normal demand & notified generation, normal demand & assumed generation, 1 in 20 demand & assumed generation). For the UKFES aligned calculation (ACS demand & assumed generation) it is expressed as a percentage of demand and reserve. A number of different figures are quoted for each depending on inputs.

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* For further information explaining the theory behind the EFC, see: http://pio.sagepub.com/content/226/1/33

** Note that the Plant Margin calculation within FES uses Transmission demand. It does not include embedded generation or micro-generation.

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