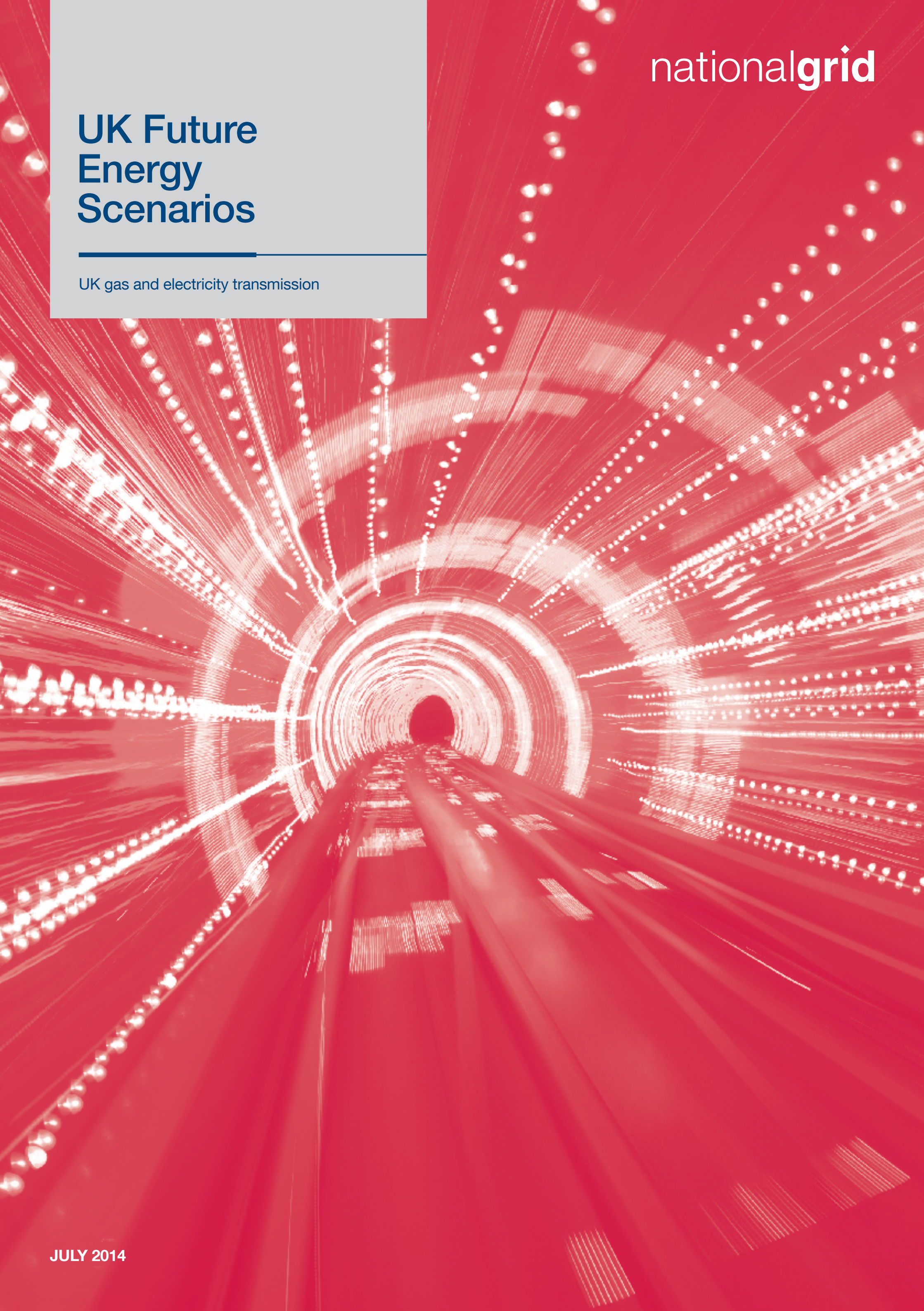
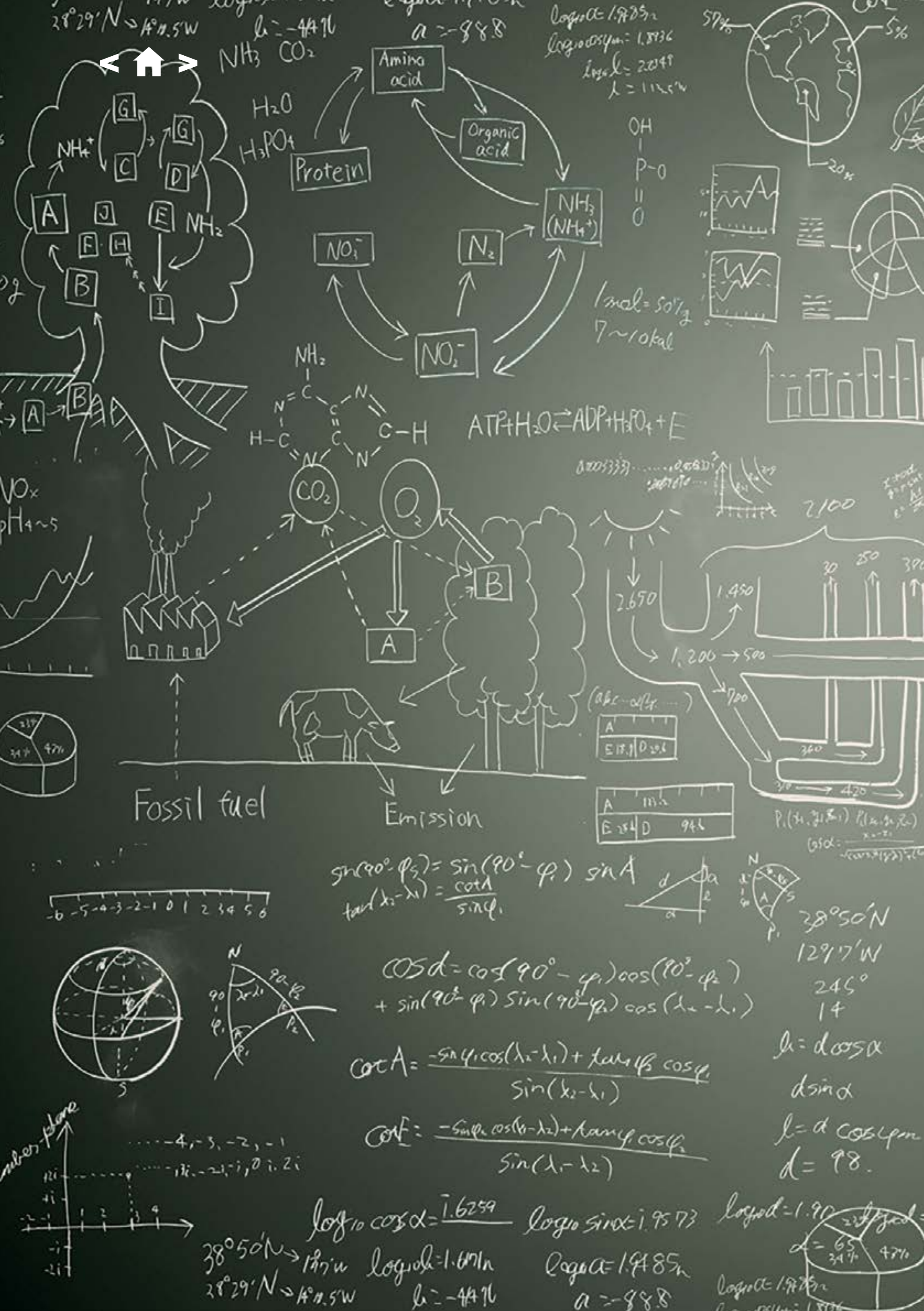
nationalgrid

UK Future Energy Scenarios

UK gas and electricity transmission



JULY 2014


Amino acid
Organic acid
Protein
NH3 CO2
H2O
H3PO4
NO3-
N2
NO2-
NH3 (NH4+)
ATP+H2O⇄ADP+H3PO4+E
1mol=507g
7~10kal
CO2
O2
A
B
Fossil fuel
Emission
NOx
pH4~5
2100
2,650
1,450
1,200 → 500
cos d = cos(90° − φ1)cos(90° − φ2) + sin(90° − φ1) sin(90° − φ2) cos(λ2 − λ1)
38°50'N
129°7'W
245°
14
d = 98.
38°50'N → 129°7'W
38°29'N → 14°17.5'W
a = −88.8

Welcome to our 2014 edition of the UK Future Energy Scenarios (UK FES) document. This annual publication describes our new analysis of credible future energy scenarios out to 2035 and 2050. I believe they are the most accessible, detailed, robust and consistent suite of scenarios we have ever produced.

Richard Smith
Head of Energy Strategy and Policy

transmission.ukfes@nationalgrid.com

Our scenarios are driven by our engagement with you throughout the year. Three main themes came through your feedback to us. Firstly you wanted us to reflect in our scenarios the high level of uncertainty regarding the future of energy. Secondly you told us to base our scenarios around the energy trilemma of security of supply, sustainability and affordability. Thirdly you wanted a clearer narrative in addition to our quantitative analysis.

We have listened to you. This year we have broadened the range of our scenarios from two to four, which flex the axes of sustainability and affordability. Also, we have improved the narrative around our scenarios to make them easier to understand and of more benefit to as broad a range of our stakeholders as possible.

We have continued to develop all aspects of our Future Energy Scenarios process ensuring that the output is as rich and robust as possible to provide a sound reference point for a range of modelling activities. This includes detailed network analysis, which enables National Grid to identify strategic gas and electricity network investment requirements for the future. We have revised and improved our modelling to reflect the rapidly changing energy landscape and will continue to do so. We have implemented a stage gate process to ensure rigorous challenge and review of all of the steps in the scenarios creation process. In particular we have continued to improve our axiom development process based on stakeholder views. We have also developed our stakeholder engagement process to ensure that we engage with as many of our stakeholders as possible in a way that is most appropriate for them.

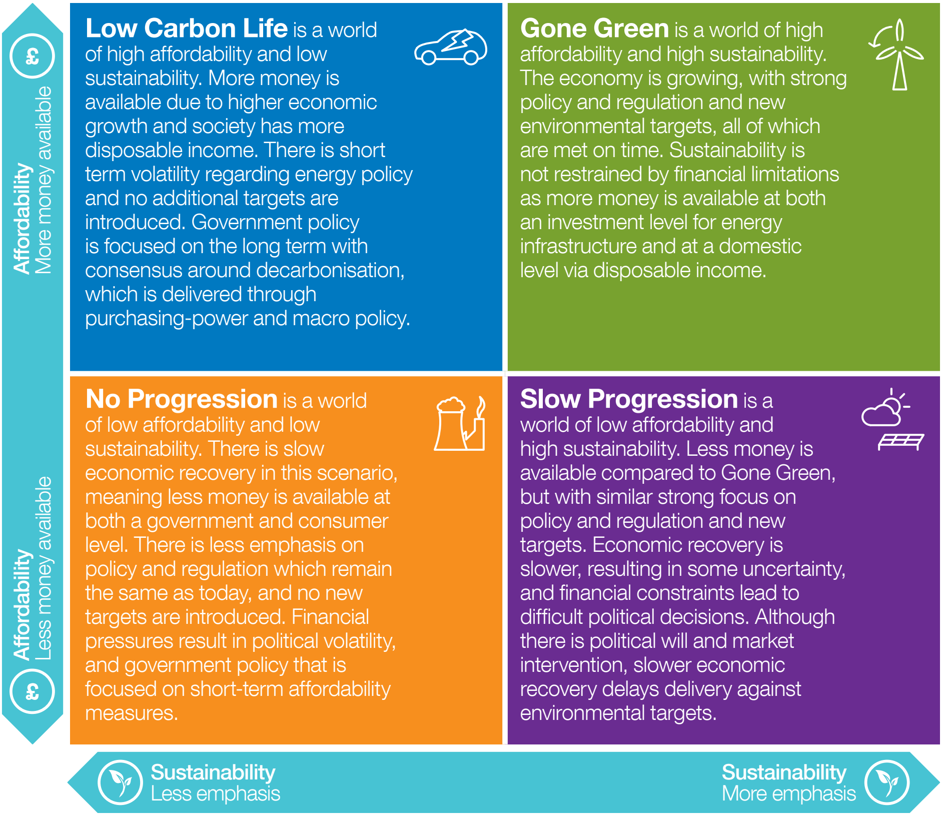
I hope you find this a useful and interesting document. The release of it in July marks the start of the next annual cycle of consultation. If you have supported our UK FES process by participating in our stakeholder engagement activities, I thank you. If you haven’t, I encourage you to get involved: we will listen to your views and you will help shape our next set of scenarios.

Executive Summary

Energy has become front page news; the future of energy for the UK has never been so important. Electricity Market Reform (EMR), the General Election in 2015, environmental legislation, energy costs and developments in the economy will all have a major impact on the future energy landscape. No one can be certain how the energy future will evolve and this uncertainty may continue for decades. Our Future Energy Scenarios (FES) represent transparent, holistic paths through that uncertain landscape to help Government, our customers and other stakeholders make informed decisions.

Our goal is for everyone who has an interest in the UK's energy future to engage with us so that we can develop the most rich, robust and plausible range of scenarios possible.

This year our stakeholders told us that our new scenarios should reflect the energy 'trilemma' of sustainability, affordability and security of supply, as well as having a rich and engaging story detailing the future of energy. Our stakeholders also told us to increase the number of scenarios to account for a broader range of uncertainty, so we have broadened the range from two to four:



Low Carbon Life is a world of high affordability and low sustainability. More money is available due to higher economic growth and society has more disposable income. There is short term volatility regarding energy policy and no additional targets are introduced. Government policy is focused on the long term with consensus around decarbonisation, which is delivered through purchasing-power and macro policy.

Gone Green is a world of high affordability and high sustainability. The economy is growing, with strong policy and regulation and new environmental targets, all of which are met on time. Sustainability is not restrained by financial limitations as more money is available at both an investment level for energy infrastructure and at a domestic level via disposable income.

No Progression is a world of low affordability and low sustainability. There is slow economic recovery in this scenario, meaning less money is available at both a government and consumer level. There is less emphasis on policy and regulation which remain the same as today, and no new targets are introduced. Financial pressures result in political volatility, and government policy that is focused on short-term affordability measures.

Slow Progression is a world of low affordability and high sustainability. Less money is available compared to Gone Green, but with similar strong focus on policy and regulation and new targets. Economic recovery is slower, resulting in some uncertainty, and financial constraints lead to difficult political decisions. Although there is political will and market intervention, slower economic recovery delays delivery against environmental targets.

Executive Summary

Our scenarios are driven by political, economic, social and technological uncertainty. 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.

Power Demand

- Policy is a major driver of change in the residential sector, causing changes in new technology take up and energy efficiency.
- Consumer affordability combined with government incentives will determine the adoption of electric vehicles (EV) and heat pumps (HP), which will drive the changes in demand in the future.
- The range of demand in the scenarios is narrower in the near term partly due to offsetting drivers, widening in the later periods as risk and uncertainty increases.

Flexible Power Sources

- The level of interconnection increases in all scenarios.
- Electricity storage has the potential to provide flexibility in balancing the system with increased levels of intermittent supply sources in the future. However significant cost reductions and access to multiple revenue streams are required to make storage a commercially viable solution.

Power Supply

- Future plant build for both renewables and thermal generation is subject to considerable uncertainty and Electricity Market Reform (EMR) will play an important role in delivering this through the Contracts for Difference and Capacity Market payments.
- Concerns regarding reduced ability to balance supply and demand are most acute in the short term due to the impact of plant closures, before improving in the latter half of the decade. Improvement is dependent on the return of mothballed plant and the connection of additional installed capacity in all scenarios, to ensure that the Department of Energy & Climate Change (DECC) security of supply reliability standard is met.

Gas Demand

- Gas demand fell sharply from 2010 mainly as coal became favourable to gas-fired power generation due to lower prices and gas has remained marginal within the GB power market.
- There remains a narrow range between our scenarios through to the end of this decade due to similar trends in efficiency, and economic trends offsetting demand levels between commercial and industrial sectors.
- Our scenarios diverge towards the end of this decade with power generation differences.
- By the mid 2020s, **Gone Green** further deviates from other scenarios with fuel switching from gas in the residential and commercial sectors.

Gas Supply

- UK Continental Shelf production has a brief renaissance in the period up to 2020 in all scenarios. Our shale gas projections cover a wide range of potential outcomes, reflecting Government support and interest from producers, but also the currently unproven nature of the UK reserves.
- Norwegian gas continues to make up a significant part of the total supply to the market.
- Import requirements vary significantly between scenarios and uncertainty in the global gas market makes it difficult to predict whether the requirement for imported gas will be met by LNG or continental gas.

Key statistics

Low Carbon Life

	2013	2020	2035
Electricity			
Peak demand/GW	60.5	61.4	65.0
Annual demand/TWh	347	353	375
Total capacity/GW	91	105	138
Low carbon capacity/GW	28	49	97
Interconnector capacity/GW	4	5	7
Residential HPs/Millions	0.1	0.3	0.7
EVs number/Millions	0.01	0.6	5.4
Residential gas demand/TWh	331	315	317
Annual gas demand/TWh	835	828	864
Renewable energy %	~6	~13	28
GHG reduction %	27	>34	~60

Gone Green

	2013	2020	2035
Electricity			
Peak demand/GW	60.5	59.3	68.1
Annual demand/TWh	345	338	366
Total capacity/GW	91	106	163
Low carbon capacity/GW	28	50	109
Interconnector capacity/GW	4	6	11
Residential HPs/Millions	0.1	1.2	10
EVs number/Millions	0.01	0.6	5.4
Residential gas demand/TWh	331	309	234
Annual gas demand/TWh	835	812	705
Renewable energy %	~6	15	32
GHG reduction %	27	>34	~60

No Progression

	2013	2020	2035
Electricity			
Peak demand/GW	60.5	60.3	59.2
Annual demand/TWh	349	345	337
Total capacity/GW	91	93	105
Low carbon capacity/GW	28	36	45
Interconnector capacity/GW	4	5	7
Residential HPs/Millions	0.1	0.3	0.7
EVs number/Millions	0.01	0.2	1.8
Residential gas demand/TWh	331	317	324
Annual gas demand/TWh	835	826	855
Renewable energy %	~6	11	21
GHG reduction %	27	~34	<6

Slow Progression

	2013	2020	2035
Electricity			
Peak demand/GW	60.5	59.5	57.4
Annual demand/TWh	346	337	324
Total capacity/GW	91	97	130
Low carbon capacity/GW	28	41	74
Interconnector capacity/GW	4	6	11
Residential HPs/Millions	0.1	0.3	0.7
EVs number/Millions	0.01	0.2	1.8
Residential gas demand/TWh	331	313	307
Annual gas demand/TWh	835	819	675
Renewable energy %	~6	~13	28
GHG reduction %	27	>34	<60

Contents

Key

Government Targets
Government Policy
Power Supply
Gas Supply
Progress Towards Targets
Heat
Consumer
Power Demand
Gas Demand
Flexible Power Sources
Economic Background
Transport

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. At National Grid we develop energy scenarios to help us visualise and plan how we might deliver energy in the future.

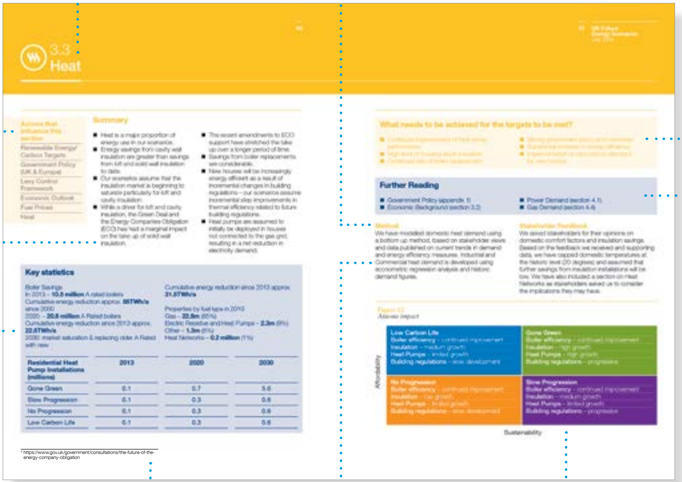
For 2014, the future energy scenarios envelope has been broadened to provide four scenarios, which consider a range of potential drivers that might have an impact on the future of energy in the UK.

In this document we describe the assumptions behind our scenarios and how they are developed. We look at the resulting energy demand and supply sources and examine the carbon dioxide (CO_2) emissions and contribution from renewable energy. We also describe what's changed since our 2013 analysis.

Our detailed scenario analysis is undertaken out to 2035 to enable decisions to be made on the future development of our electricity and gas networks. We also extend our analysis from 2035 to 2050, though beyond 2035 it becomes more difficult to model the scenarios in the same level of detail.

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.



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

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

Axioms
List to demonstrate which axioms have input to the scenarios.

Break-out boxes
Highlight key pieces of information.

Summary
High level section summary outlining key points and statistics.

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.

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

Footnotes
Used for citations and further commentary.

Narrative
Including rich descriptions of plausible future scenarios, succinct results from our analysis as well as relevant breakout boxes and case studies.

Matrix
of how the scenarios are impacted by the axioms in this section.

What the Future Energy Scenarios document is...

Our Future Energy Scenarios provide a detailed analysis of a range of credible futures.

It covers developments in electricity generation and demand, and gas supply and demand.

The document covers the assumptions used in the analysis, new technologies, social and economic developments and progress against targets.

The scenarios are projected out from the present to 2050.

...and what it isn't...

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.

We do not include potential network developments: these are highlighted within the gas and electricity ten year statements.

We do not assign probabilities to our scenarios as these would be subject to individual judgement based on many variables.

We do not cost our scenarios; we believe there is too much uncertainty for any numbers to be credible. However we do provide new generation costs.

Chapter two
Creation of Scenarios

The views of our stakeholders are essential in shaping the direction and content of our new future energy scenarios. We are committed to continuous development of our stakeholder engagement, broadening the scope and type to ensure we provide an opportunity for all of our stakeholders to engage with us in a way that is appropriate for them.

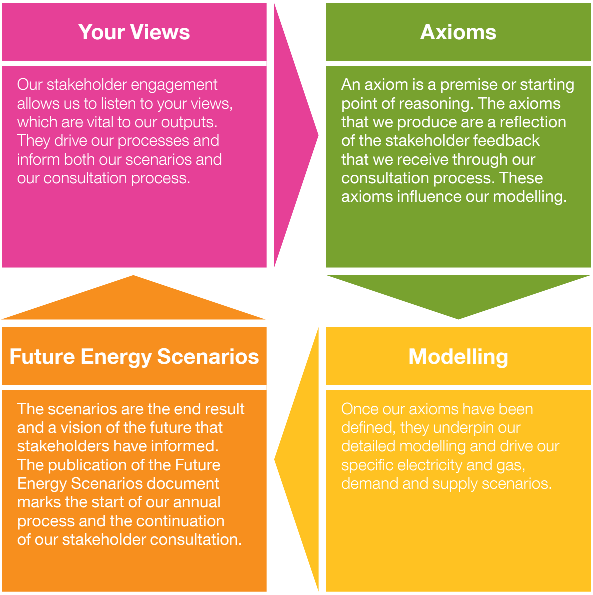
2.1
Stakeholder Engagement

In the last 12 months we have engaged with over 300 people from 187 organisations, including industry, government, regulators, professional and social interest groups, customers and consumers. Our forms of engagement consisted of our annual FES conference and other major energy conferences, bilateral meetings, videos, workshops, questionnaires, online surveys, feedback forms, website content[1] and Twitter.

The role of stakeholders is pivotal in the development of the Future Energy Scenarios. The publication of the 2014 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.

Our axioms[2] are the focal point for translating stakeholder feedback into the fundamental assumptions behind our scenarios. We will continue to improve the process for developing the axioms. By continuing to encourage debate with our stakeholders on the axioms, we can further refine them and improve the robustness of our scenarios.

Figure 1
The role of stakeholders in the scenarios



Your Views

Our stakeholder engagement allows us to listen to your views, which are vital to our outputs. They drive our processes and inform both our scenarios and our consultation process.

Axioms

An axiom is a premise or starting point of reasoning. The axioms that we produce are a reflection of the stakeholder feedback that we receive through our consultation process. These axioms influence our modelling.

Modelling

Once our axioms have been defined, they underpin our detailed modelling and drive our specific electricity and gas, demand and supply scenarios.

Future Energy Scenarios

The scenarios are the end result and a vision of the future that stakeholders have informed. The publication of the Future Energy Scenarios document marks the start of our annual process and the continuation of our stakeholder consultation.

---

[1] www.nationalgrid.com/fes

[2] An axiom is a premise or a starting point of reasoning (see section 2.3)

2.1 continued

Stakeholder Engagement

There will be an important development in our stakeholder engagement and scenario development processes in 2014/15 with the proposal by Ofgem to modify National Grid Electricity Transmission's licence, requiring submission of our proposed scenarios to Ofgem by the end of January each year[3].

While this proposal places a time-bound requirement on our stakeholder engagement, we also believe it provides us with an opportunity to work more closely with Ofgem throughout the Future Energy Scenario consultation and scenario development process. This should facilitate a more rigorous stakeholder engagement process and ultimately result in the creation of a suite of scenarios that are more robust, more credible and of more benefit to all our stakeholders.

To meet this commitment we intend to continue to develop and publish our UKFES Stakeholder Feedback Document[4], which summarises our stakeholder engagement each year. The document provides information on how we have engaged, what our stakeholders have been telling us, our thoughts on the feedback and how we intend to act on it, and the key milestones in the Future Energy Scenario development process.

---

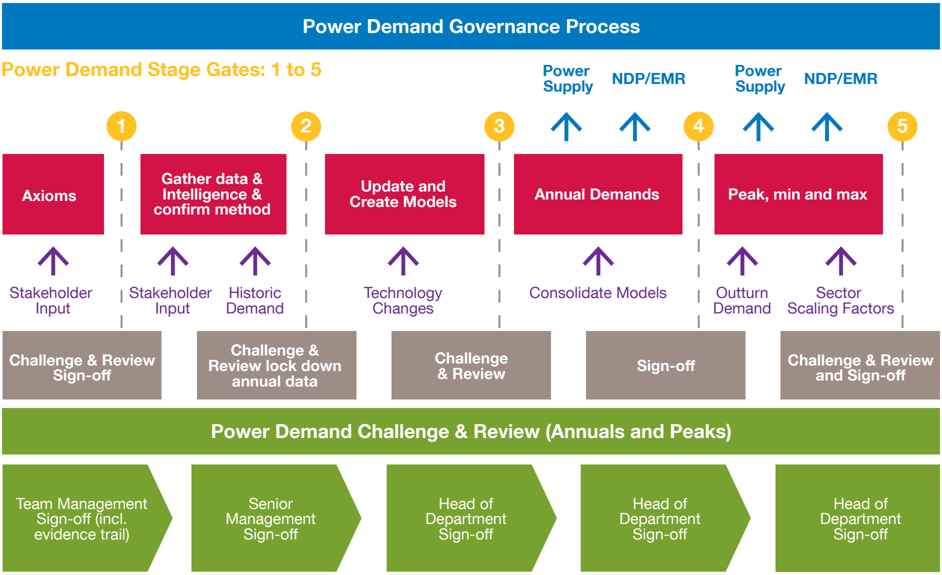
[3] At time of print it is still a proposal, the licence is yet to be changed but with due process we expect it to be applied to the UKFES 2015 process.

[4] www.nationalgrid.com/fes

Scenario development governance

Throughout the development of our scenarios a stage gate approach is employed to ensure quality and control of the outputs. Evidence-based stage gate sign-offs are undertaken by the Energy Strategy and Policy Management team. Typical evidence at a stage gate sign-off would consist of; base data sources, stakeholder input, analysis method and rationale, evidence of peer challenge and review , incorporation of feedback and benchmarking against other third party analysis. Only when the management team are satisfied that the analysis is robust and evidenced is progress to the next stage approved. As an example, the high level approach for Power Demand is illustrated below.

Figure 2
Internal Challenge and Review Process



2.1 continued

How the Scenarios are Made

UK FES 2013

July
Launch Conference

Sept–Oct
Workshops

300
Individuals Engaged

Power Demand

Power Supply

Gas Demand

Jan
Questionnaires
(Shippers, Producers, Developers, Storage Operators, Market Participants)

Jan
Stakeholder feedback document published

Sept–Jan
Bilateral Meetings

Stakeholder views collected

Sept–Jan
Axiom Development

26
Axioms

Views analysed and inputted

Jan–June
Scenario Modelling

Axioms finalised

Gas Supply

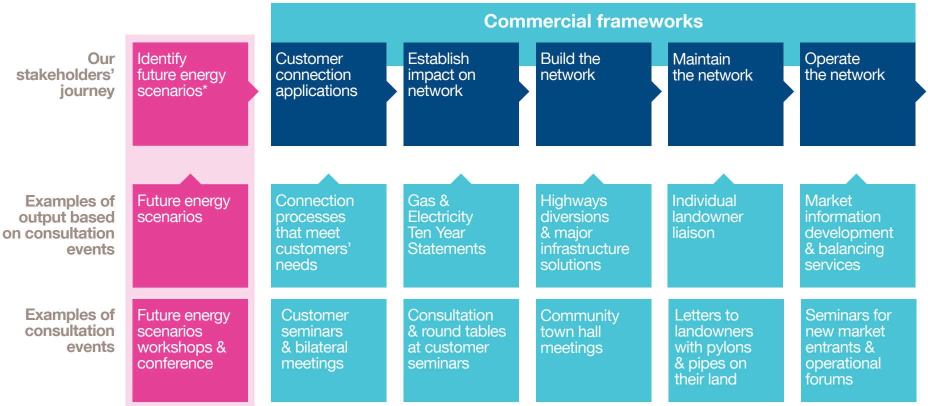
UK FES 2014

July
Launch Conference for 2014 Scenarios

2.1 continued
Involving Stakeholders in our Decision-making

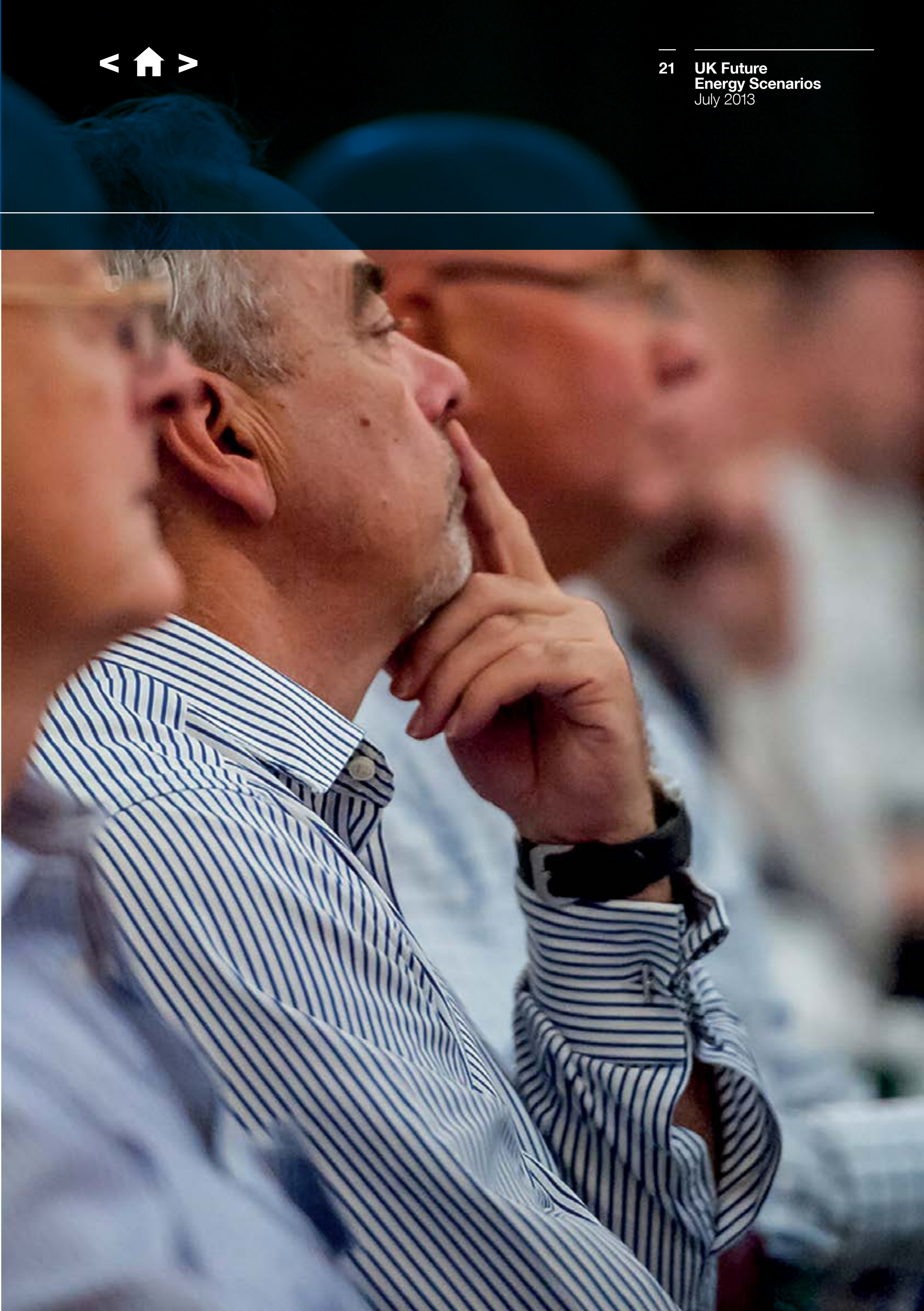
The Electricity and Gas Transmission businesses involve a very broad range of activities. As a result, we interact with a diverse range of stakeholders with a wide set of interests. **Stakeholders are impacted by our business and influence our decisions at every stage of our operation**; from identifying the energy mix of the future, through to building new pipes, overhead lines and cables and operating this new infrastructure.

This business process diagram shows the areas of stakeholder involvement



		Commercial frameworks				
Our stakeholders' journey	Identify future energy scenarios*	Customer connection applications	Establish impact on network	Build the network	Maintain the network	Operate the network
Examples of output based on consultation events	Future energy scenarios	Connection processes that meet customers' needs	Gas & Electricity Ten Year Statements	Highways diversions & major infrastructure solutions	Individual landowner liaison	Market information development & balancing services
Examples of consultation events	Future energy scenarios workshops & conference	Customer seminars & bilateral meetings	Consultation & round tables at customer seminars	Community town hall meetings	Letters to landowners with pylons & pipes on their land	Seminars for new market entrants & operational forums

***Identify future energy scenarios –** Providing a forum for the exchange of ideas and data that informs our view of how the energy landscape will look in the future.



2.2
The Scenarios

This year our range of scenarios is based on the energy trilemma of security of supply, affordability and sustainability.

Affordability
More money available

Low Carbon Life

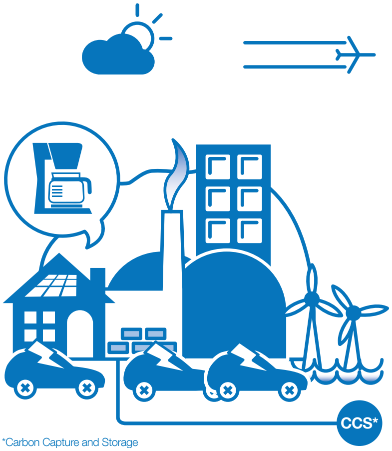
Economic – Growing UK economy.

Political – Short-term political volatility but long-term consensus around decarbonisation.

Technological – Renewable generation at a local level. High innovation in the energy sector.

Social – High uptake of electric vehicles but consumers not focused on energy efficiency. ‘Going green’ is a by-product of purchasing desirable items.

Environmental – Carbon target hit. No new environmental targets introduced.



*Carbon Capture and Storage

No Progression

Economic – Slow UK economic recovery.

Political – Inconsistent political statements within Government, resulting in investor uncertainty.

Technological – Gas is the preferred choice for generation over renewables. Little technological innovation occurs in the energy sector.

Social – Consumers not engaged with energy efficiency. Low uptake of electric vehicles and heat pumps.

Environmental – Targets are missed, no new environmental targets introduced.

Affordability
Less money available

Sustainability
Less emphasis

The Government has set a standard for electricity security of supply and through Electricity Market Reform put in place the framework to deliver to this standard. Therefore our scenarios flex the two variables of affordability and sustainability, giving a two by two matrix of our four scenarios: **Gone Green**, **Slow Progression**, **No Progression** and **Low Carbon Life**.

Gone Green

Economic – Growing UK economy.

Political – Domestic and European policy harmonisation, with long-term certainty provided.

Technological – High levels of renewable generation with high innovation in the energy sector.

Social – Engaged consumers focused on drive for energy efficiency. This results in high uptake of electric vehicles and heat pumps.

Environmental – All targets hit, including new European targets post-2020.

Slow Progression

Economic – Slow UK economic recovery.

Political – Political will for sustainability but financial constraints prevent delivery of policies.

Technological – Renewable generation chosen over low carbon generation. Low levels of innovation in the energy sector.

Social – Engaged consumers focused on drive for energy efficiency but with low uptake of electric vehicles and heat pumps due to affordability.

Environmental – Environmental targets missed but hit later. New European targets introduced.

Sustainability
More emphasis

2.2 continued

Gone Green

Gone Green is a future where more money is available, with strong policy and regulation and new environmental targets. The economy is growing, and environmental sustainability is not restrained by financial limitations as more money is available at both an investment level for energy infrastructure and at a domestic level via disposable income.

Government policy is strong and effective, and there is European harmonisation leading to the development of new environmental targets. The political pathway becomes clearer, providing long-term certainty and a clear route to achieving a sustainable future. There is consistent and joined-up policy across key sectors such as transport, heat and power. Electricity Market Reform (EMR) remains technology specific.

All renewable and environmental targets are met on time. The renewable energy target for 2020 and the carbon budgets are met as well as the 80% reduction in greenhouse gas emissions by 2050, due to a clear vision and a growing economy. New European renewables targets are established – which are assumed to be set at 23% renewable energy by 2030, and 39% by 2050 – which the UK signs up to and hits. There is a holistic approach to meeting the targets, with contributions to decarbonisation from the heat and transport sectors, as well as electricity. There is high technological innovation and organic improvements in existing technology, with the potential for disruptive technology. Electrification is high, with increased automation. Renewable generation is high and its contribution is driven by the new European targets.

'Going green' is a conscious decision: society is engaged and there is a more coordinated approach to engaging, educating and incentivising consumers.

Energy efficiency is high, and consumer purchases are driven by desire, as opposed to distress, resulting in higher numbers of heat pumps and electric vehicles.

Increases in energy demand due to growth in the economy and spending are offset by energy efficiency improvements in all sectors. In addition the drive towards the 2020 and 2050 targets causes higher levels of electrification of transport and heating in this scenario, which increases electrical load in the longer term. However, increased levels of micro-generation in this scenario, such as small scale wind and solar photovoltaic (PV), will decrease the net demand seen on the electricity networks.

The renewable and low carbon technology profiles within **Gone Green** are in line with spending limits imposed by the Levy Control Framework out to 2020/21 (see Appendix 1). A strong post-2020 policy landscape encourages continued investment in low carbon and renewable technologies, helping to meet new environment targets for the period between 2020 and 2050. Low carbon generation technology includes carbon capture and storage (CCS) and renewables, which range from on and offshore wind, through to hydro, marine and biomass. These intermittent technologies drive the requirement for a suite of options to balance the market and system when renewable sources are not available, for example interconnection, demand side response, storage and thermal plant such as gas-fired power stations.

2.2 continued
Slow Progression

Slow Progression is a future where less money is available compared to Gone Green, but with similar strong policy and regulation and new targets. Economic recovery is slower in this scenario than in Gone Green and Low Carbon Life, resulting in investor uncertainty. Financial constraints lead to difficult political decisions.

Although there is significant market intervention, this is less successful than in **Gone Green**; although there is political will, slower economic recovery prevents delivery. Secure, affordable and sustainable energy sources are the political objectives but economic conditions are less favourable than in **Gone Green**, so the successful implementation of carbon reduction policies happens at a slower rate.

EMR remains technology specific, and there is a clear political narrative around energy efficiency. A strong policy landscape is in place post-2020 but slower economic recovery reduces the pace at which those policies can be implemented, resulting in lower levels of low carbon and renewable technologies than in **Gone Green**.

Renewables are deployed at a slower rate than **Gone Green** but are preferred over other types of low carbon generation, such as CCS or nuclear. Renewable generation is mainly made up of wind and solar. Nuclear new build progresses and decommissioning of existing fleet is expected to remain in line with public announcements. Gas generation is also expected to receive financial support due to lower than historical utilisation rates. There is a focus on reducing energy consumption and energy efficiency is high on the agenda; economic investments are made with short paybacks. Consumers are more responsive to time-of-use tariffs and energy efficiency through smart meters, with behaviour driven mainly by price. Uptake of heat pumps and electric vehicles is low, due to lower affordability. Reduced affordability also affects the residential sector by delaying efficiency improvements, the smart meter roll-out and electrification of transport.

Like **Gone Green**, **Slow Progression** sees increased policy intervention and a drive towards targets, resulting in strong energy efficiency gains. The less favourable economic conditions compared to **Gone Green** result in lower demand.

Despite a desire to achieve the 2020 targets, the renewable energy target is likely to be missed and hit at a later date. The target of an 80% reduction in greenhouse gas emissions is not met by 2050. New European renewables targets are established – which are assumed to be set at 23% renewable energy by 2030, and 39% by 2050 – which the UK signs up to but hits at a later date.

2.2 continued
No Progression

No Progression is a future where there is less money available and less emphasis on sustainability. There is slower economic recovery in this scenario, meaning less money is available at both a government and consumer level. Government policy and regulation remains the same as today, and no new targets are introduced.

Financial pressures result in political volatility, and government policy that is focused on short-term measures. Affordable and secure energy sources are the major political objective under **No Progression** because the economic conditions are less favourable, leading to reduced political emphasis on sustainability. This results in the ambitious carbon reduction policies seen in **Gone Green** and **Slow Progression** not being implemented. As the scope for decarbonisation solutions lacks focus, the result is protracted and inconsistent political statements, and investor uncertainty.

The reduced political emphasis on sustainability leads to the carbon budgets not being met and the renewables target for 2020 likely to be missed. No new targets are introduced.

The Levy Control Framework is not extended beyond 2020 due to limited money available for energy polices and the Carbon Price Support Mechanism remains at 2015/16 levels over time, due to changes in government policy and less political emphasis on long-term decarbonisation. An inconsistent policy landscape results in uncertainty for investors in low carbon and renewable technologies. There is less money available for innovation and so there are only incremental improvements in existing technology. Thermal generation features in the generation mix over renewables and nuclear, with the focus being on the cheapest sources of energy. The limited money available is directed to ensuring security of supply, with particular emphasis on gas generation due to its assumed lower cost when compared to alternatives. A shift of focus away from long-term decarbonisation and limited financial support available for low carbon technologies in **No Progression** results in a restricted new build programme for nuclear and no deployment of CCS.

As there is less disposable income, energy consumption is constrained and consumers replace appliances when they fail on a like for like basis. There is a lower drive for energy efficiency, compared to **Slow Progression**, so that replacement efficiency benefits are less, particularly in residential lighting and appliances. There is limited uptake of heat pumps and electric vehicles, and investments in energy efficiency must be economic with short payback times.

Energy demand in **No Progression** shows a similar trend to **Slow Progression** but at higher demand levels. Gross domestic product (GDP) growth assumptions are lower which results in less industrial and commercial demand. Electrification of transport is lower due to the focus on near-term availability of finance rather than longer-term returns and so demand does not see a long-term increase in the same manner as **Gone Green** or **Low Carbon Life**.

2.2 continued

Low Carbon Life

Low Carbon Life is a future where more money is available and there is less emphasis on sustainability. There is higher economic growth. Society has more disposable income which results in higher uptake of electric vehicles, and more renewable generation at a local level. Government policy is focused on the long term.

There is short-term political volatility and no additional targets are introduced, however there is long-term consensus around decarbonisation. EMR is technology neutral in this scenario. More future economic prosperity but less political emphasis on sustainable energy policy is seen in **Low Carbon Life**. Both consumers and government have access to more money; however a lack of political will for centralised carbon reduction policy makes for different characteristics to **Gone Green**.

Funding is provided for Research and Development and innovation projects in order to discover alternative solutions for the future and reduce costs of existing solutions.

Local authority budgets allow for district heating and insulation programmes, and society has more disposable income. Uptake of heat pumps is relatively low, as is energy efficiency. Appliances are purchased out of desire rather than distress, and ‘going green’ is not a conscious decision.

The carbon budgets are likely to be met, as is the 80% reduction in greenhouse gas emissions by 2050. No new targets are introduced.

Greater economic prosperity results in higher demand under **Low Carbon Life**, with less emphasis on energy efficiency.

Increased industrial and commercial output and demand are the result of higher GDP growth and the residential sector experiences additional spending as people purchase and consume more. Energy efficiency improvements occur naturally with technology improvements, leading to downward pressure on demand. Greater affordability results in increased electrification of transport but with a lack of incentive, **Low Carbon Life** exhibits low take-up of heat pumps.

The low carbon technologies and renewable profile are in line with spending limits imposed by the Levy Control Framework out to 2020/21. The Carbon Price Support (CPS) mechanism is extended post-2020 to encourage continued investment in low carbon and renewable technologies. Resulting increases in nuclear, CCS and renewables focused at the local level ensures the pathway to the 2050 greenhouse gas reduction target remains achievable. Investment is underpinned by growth in the economy and Research & Development innovations facilitate cost parity for low carbon technologies during the late 2020s and early 2030s.

Long-term decarbonisation is focused on low carbon technologies such as nuclear and CCS, particularly after 2020. With no new environmental targets beyond 2020, there is a lower deployment of renewable technologies and the focus is on technologies which have cost parity with other forms of generation.


CCS

2.2 continued
How the Scenarios are Used

Our scenarios are used as a reference point for a range of modelling activities including network analysis that enables National Grid to identify potential gas and electricity network investment requirements in the future. In addition the scenarios feed into a range of other outputs, including those for security of supply, Europe and shorter-term supply demand analyses.

2.3
Axioms

To create our 2014 scenarios we have made extensive use of axioms, which have been developed and refined through a series of specifically designed stakeholder workshops and our wider stakeholder engagement.

An axiom is a premise or starting point of reasoning. It is a logical statement assumed to be true. We do not necessarily believe all our axioms to be true and accurate predictions of the future. However, as plausible and credible future outcomes, we accept them to be true foundations for our more detailed analysis.

Table 1 shows the Renewable Energy/Carbon Targets axiom as an example. The full list of axioms used can be found in Appendix 2.

Table 1
Extract from the scenario axioms

Number	Title	Low Extreme	High Extreme
1	**Renewable Energy/ Carbon Targets**	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.	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.

Chapter 3

Political and Economic Background

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

Renewable energy target >

15%

15% of all energy consumption to be from renewable sources by 2020

3.1 Policy Landscape

Legislation at UK and EU level forms the energy policy landscape which has a significant impact on the economic viability of the different sources of energy that are available and how society uses it once delivered.

Targets

Targets are set for renewable energy and emissions of greenhouse gases. Renewables are driven by the 2009 Renewable Energy Directive[5] which sets a target for the UK to achieve 15% of all its energy consumption from renewable sources by 2020.

The Climate Change Act 2008[6] 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).

Recent developments

Ongoing work by the European institutions on the 2030 Energy and Climate Change framework will eventually bring clarity on the long-term goals for pan-European energy policy, and provide a binding greenhouse gas reduction target at a 2030 horizon. Uncertainty could also be reduced by an international framework on climate change to succeed the Kyoto Protocol at the 2015 UNFCCC[7] negotiations in Paris.

The passing of the Energy Act 2013 provided more clarity on the future UK electricity market through the introduction of Contracts for Difference to support low carbon generation and a Capacity Market to ensure security of supply.

However, scope remains for political intervention and through successive UK and EU elections uncertainty remains in the policy landscape and presents a challenge when planning for the longer term. A comprehensive list of policies that affect the UK energy sector is included in Appendix 1.

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

---

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

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

[7] United Nations Framework Convention on Climate Change

3.2
Economic Background

Key statistics

- **3.7 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)
- Long run GDP ranges between **2% per annum** in our low economic growth and **2.5% per annum** in our high economic growth scenarios
- Wholesale oil prices have almost doubled between 2005 and 2013; wholesale gas prices have increased by a third and wholesale electricity prices, while volatile in 2007/08, have increased by ~20% since 2009.

Energy demand in the Industrial and Commercial sector is, to an extent, affected by the economy; energy demand in the residential sector is affected by growth in the housing market.

Our scenarios make use of 2014 economic and demographic forecasts by Experian Business Strategies, which form the basis for our own econometric modelling. We make use of two economic outlooks and align two of our four energy scenarios to each of them.

In both **Gone Green** and **Low Carbon Life** the economy quickly recovers to historic pre-recession levels. Annual growth averages 2.5% per annum over the scenario period.

In **Slow Progression** and **No Progression** the economy also recovers relatively quickly but remains on a lower economic growth trajectory. Annual growth averages 2% per annum over the scenario period.

We do not attempt to predict any cyclical features of the economy in any of our scenarios.

3.2.1

Demographic Background

Our scenarios are underpinned by common demographic projections.

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. During the recession, the number of construction completions fell sharply during 2008 and decreased to 128,900 in 2010 on an annual basis. The level of construction has since remained around 130,000–140,000 per annum since 2010.

The population in Great Britain is expected to continue to increase, reaching 73 million by 2035 (from 61.9 million in 2013). There are currently approximately 2.4 residents for every household across Great Britain, meaning an additional 3.7 million households would be required to maintain the present occupancy rate.

Therefore we project that housing completions will rise annually from the current relatively low levels, exceeding the pre-recession peak by 2025, and reaching over 250,000 by 2030, maintaining the current occupancy rate. Over the long term, we have assumed housing completions fall back to an annual level just above 200,000 per annum and maintain occupancy rates above 2.2 people per household.

There are currently approximately 2.4 residents for every household across Great Britain, meaning an additional 3.7 million households would be required to maintain the present occupancy rate.

3.2.2

Economic Background: GDP

The UK economy grew by over a third in the decade prior to the 2008 recession. However, UK GDP fell sharply in 2008 and 2009 and has been recovering losses since. During 2013 UK GDP remained slightly lower than pre-recession levels and is expected to increase above the 2007 GDP peak in 2014.

Public and private sectors account for approximately three-quarters of the UK economy and have contributed much of the growth in the past decade. Manufacturing constitutes roughly 10% of the economy with utilities, construction, agriculture, transport and mining making the balance.

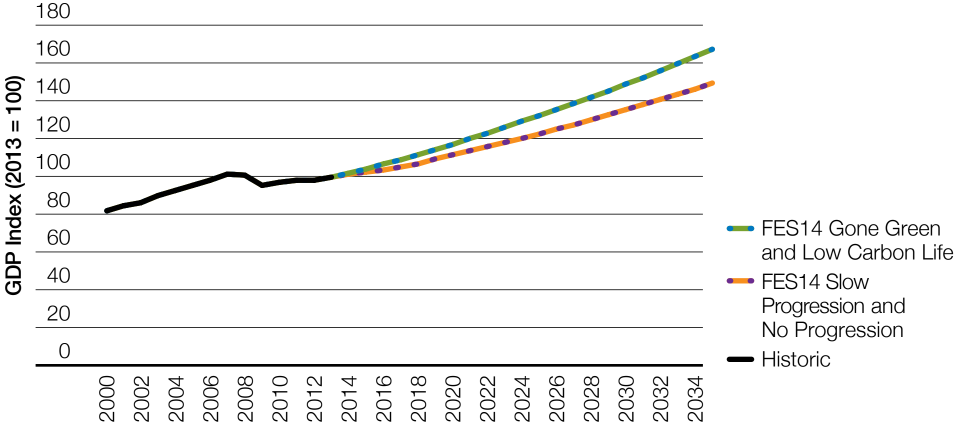
The recovery in the UK economic position remains tougher and more protracted than in previous recessions. A weakened financial service sector and efforts by the government and households to manage respective debts have stifled growth in recent years. With a depreciated Sterling, exports may improve if 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 our high economic growth scenario, we see Sterling appreciating modestly against the US Dollar and weakening against the Euro. This improves the export position over the short term as European economies recover. Residential demand improves and unemployment falls year on year, triggering base rate adjustments but coupled with continuous real disposable income growth.

In our low economic growth scenario, we have maintained Sterling at higher levels throughout the scenario reflecting weaker growth from our main trading partners, particularly targeting specific manufacturing and service sectors. Lower productivity feeds into residential demand, leading to higher inflation and associated tighter monetary policy, lower output and reduced purchasing power.

Figure 3
Indexed GDP growth



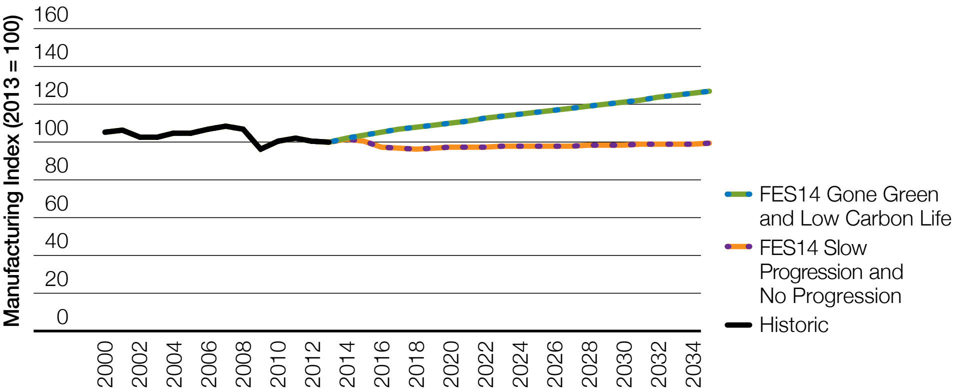
3.2.3
Economic Background: Manufacturing Output

Manufacturing output grew steadily until the year 2000, 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 below the level in 2000.

In our low growth scenarios, **No Progression** and **Slow Progression**, there is a general malaise in the manufacturing sector. These scenarios continue the recent historic trend in the sector with demand falling in the near term, associated with broader economic conditions.

Our high growth scenarios, **Gone Green** and **Low Carbon Life**, conditions improve in the short term with relatively high growth of 2% per annum for the sector, before a slowdown to an average of 1% per annum over the medium term (see figure 4).

Figure 4
Indexed manufacturing output



3.2.4

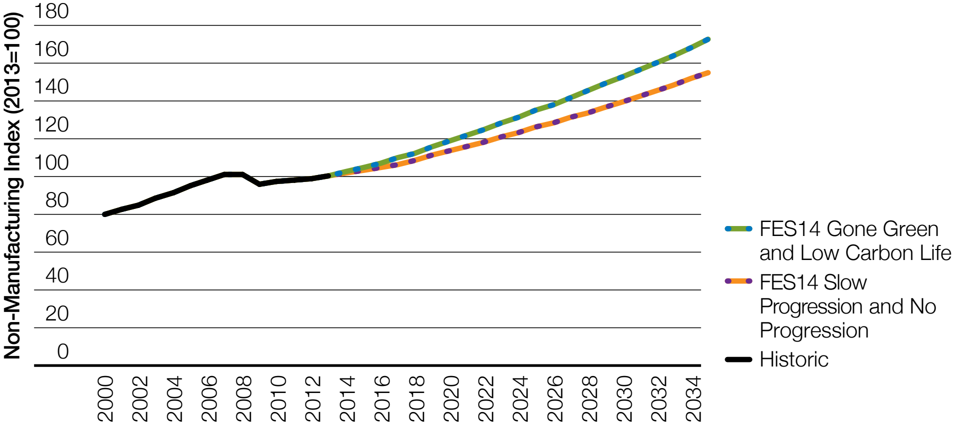
Economic Background: Non-Manufacturing Output

Non-manufacturing output growth has increased significantly between 2000 and 2008, with growth at 3.5% per annum on average over the period. During 2014 the sector is expected to have returned to pre-recession levels.

In our low growth scenarios, the sector continues to expand with year-on-year growth similar to that in 2013 at circa 1.4–1.8% per annum, with a longer-term growth of 2.2% per annum in the mid-2020s. The scenario differs from the 2013 scenario for **Slow Progression**, which assumed slow growth until the end of this decade.

In contrast, our high growth scenarios remain consistent with our 2013 scenario, with growth increasing in the short term by 2.2–2.7% per annum and a longer-term growth rate averaging 2.5% per annum.

Figure 5
Indexed non-manufacturing output



3.2
Economic Background

3.2.5
Economic Background: Fuel Prices

Fuel prices can influence 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.

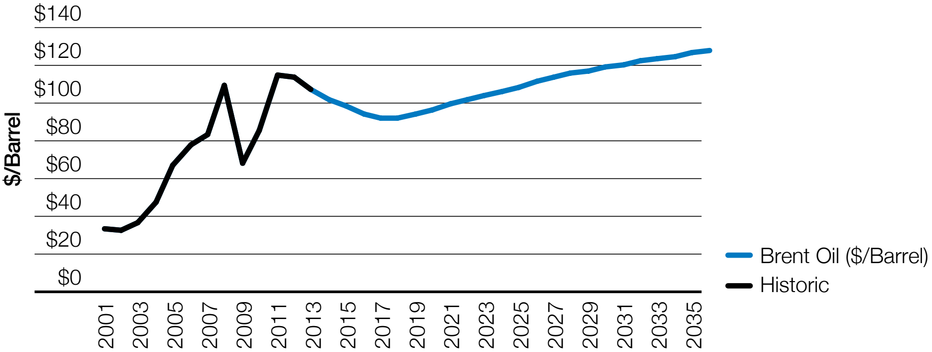
This year we have differing price assumptions for power, gas and carbon for the different scenarios.

All fuel prices have been adjusted for inflation to derive real prices applicable for 2014.

Oil

We have assumed relatively low underlying demand leading to oil prices reducing in the short term. Beyond 2018, oil prices increase steadily as global demand increases, particularly from Asia (see Figure 6).

Figure 6
Wholesale oil price (Brent)



Source: National Grid analysis and industry data

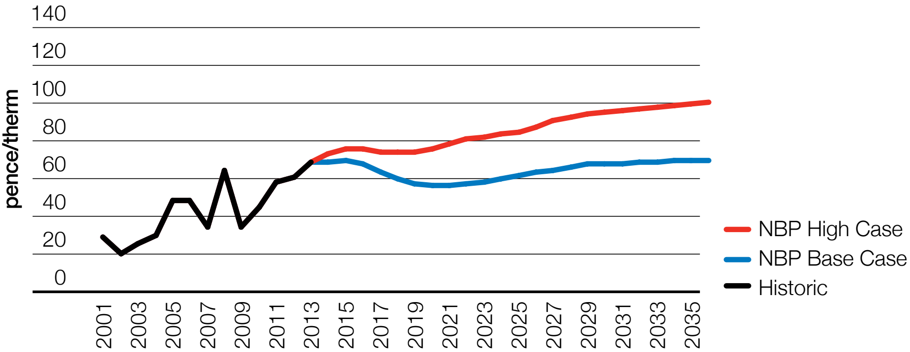
National Balancing Point (NBP) Gas

Gas prices decrease slightly until the end of the decade as global gas supply is increased by new LNG liquefaction plant commissioning while demand in European markets remains low. Prices increase post-2020 as global demands increase – particularly in south east Asia and India. The differences in the NBP gas price ranges reflect the uncertainty in:

- proposed liquefaction export projects in North America
- global economic recovery
- increasing gas demands in Asia (particularly China and India)
- potential restart of Japanese nuclear power generation as proposed in the Japanese New Basic Energy Plan[8].

Figure 7 shows the average annual wholesale gas price.

Figure 7
Wholesale gas price



Source: National Grid analysis and industry data

---

[8] https://www.gov.uk/government/publications/japans-new-energy-plan-less-nuclear-but-not-zero-april-2014/japans-new-energy-plan-less-nuclear-but-not-zero-april-2014

3.2 Economic Background

Electricity

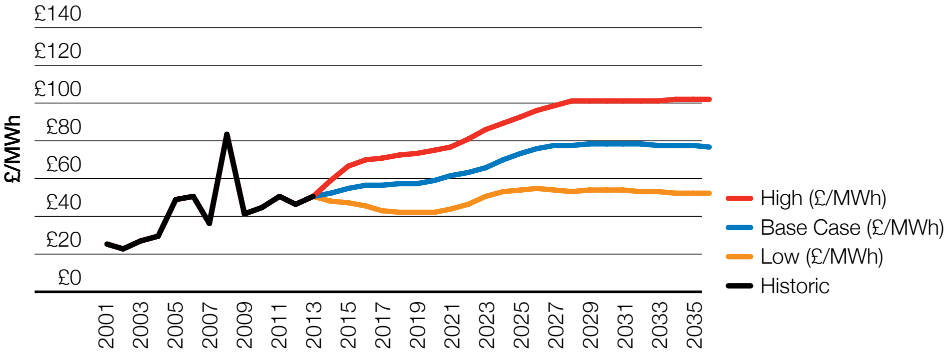
Electricity prices for the high case and base case scenarios are assumed to increase over the next few years due to decreasing margins as coal-fired plants retire due to the Large Combustion Plants Directive (LCPD) legislation, and some gas-fired plants are mothballed. The low price scenario assumes a bigger influence of gas-fired generation resulting from reduced gas prices.

All prices increase post-2020 as the costs of low carbon generation increasingly factor into the power price.

The differences in the UK power price ranges reflect the uncertainties with nuclear power generation in the UK and Europe and the costs of any alternative generation (low carbon or thermal) needed to maintain required margins (see Figure 8).

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 8
Wholesale UK power price (baseload)

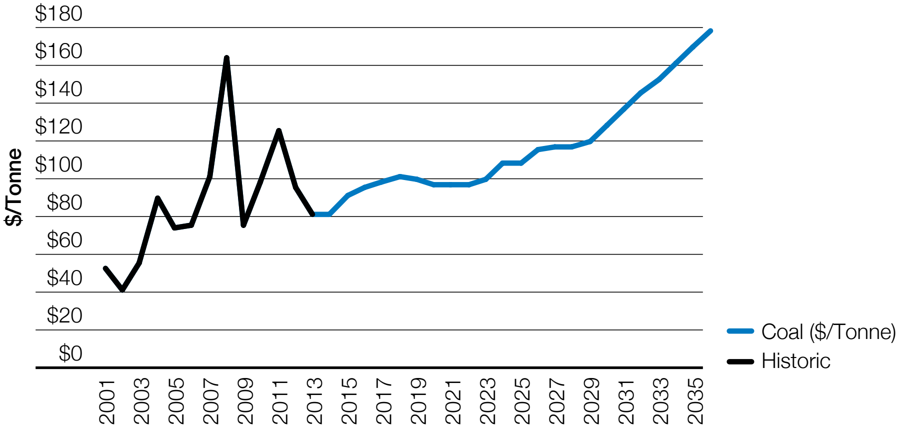


Source: National Grid analysis and industry data

Coal

Coal prices have decreased recently as more coal became available to the world market – particularly from the US, as a result of cheap shale gas replacing coal for electricity generation. Prices are expected to steadily rise throughout the scenario period predominantly due to extra demand in developing countries. This is most notably from Asia, although the increase in Chinese coal demand is expected to slow down as China moves to cleaner energy in an attempt to reduce air pollution concerns (see Figure 9).

Figure 9
Wholesale coal price



Source: National Grid analysis and industry data

3.2 Economic Background

Carbon

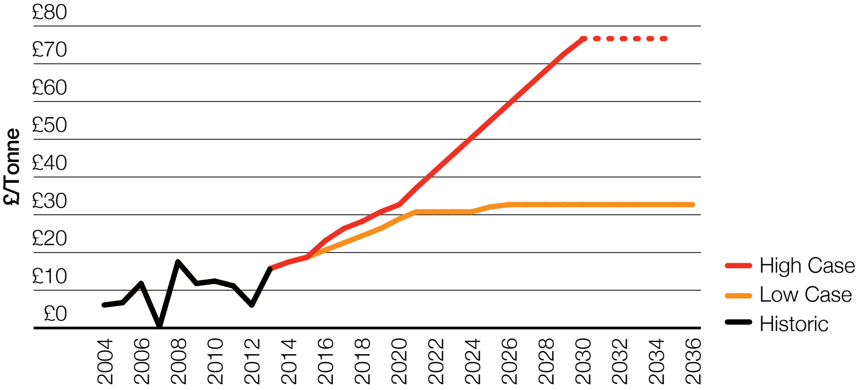
As part of its commitment to the 1997 Kyoto protocol, the EU set up the EU Emissions Trading System (ETS) in 2005. The EU ETS operates as a cap and trade system designed to incentivise cost-effective reductions in greenhouse gas emissions from large industries and electricity generators. It puts a cap 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.

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 was set at £16/tonne for 2013 rising to £30/tonne in 2020.

The Government has recently announced that the CPS rates will be capped at a maximum of £18 from 2016–17 until 2019/20. However, the EU has also proposed delaying the auctioning of some 900 million carbon credits in an attempt to tackle oversupply and raise the price of EU allowances. We expect that the opposing effects of the UK and EU announcements are likely to result in little overall change on the overall UK CPF.

In our low case the carbon price follows the CPF until 2020 but is not allowed to rise much further because of the adverse effect on UK business competitiveness. Our high case is taken from analysis published by DECC[9]. (see Figure 10).

Figure 10
Wholesale UK carbon price



Source: National Grid analysis and industry data

---

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/240095/short-term_traded_carbon_values_used_for_UK_policy_appraisal_2013_FINAL_URN.pdf

A combination of different fuel prices has been used to help derive the gas and power demands for each of the different scenarios.

Figure 11 summarises which fuel price has been used in each of the scenarios[10].

Figure 11
Fuel prices summary

Low Carbon Life	**High/Low /Base used**
Power Peak	Base Power (Peak)
Power Base Load	Base Power (Baseload)
Gas	Base Gas
Oil	Base Oil
Coal (ARA)	Base Coal
Carbon	Base Carbon

Gone Green	**High/Low /Base used**
Power Peak	High Power (Peak)
Power Base Load	High Power (Baseload)
Gas	Base Gas
Oil	Base Oil
Coal (ARA)	Base Coal
Carbon	Base Carbon

No Progression	**High/Low /Base used**
Power Peak	Low Power (Peak)
Power Base Load	Low Power (Baseload)
Gas	High Gas
Oil	Base Oil
Coal (ARA)	Base Coal
Carbon	Base Carbon

Slow Progression	**High/Low /Base used**
Power Peak	High Power (Peak)
Power Base Load	High Power (Baseload)
Gas	High Gas
Oil	Base Oil
Coal (ARA)	Base Coal
Carbon	Base Carbon

---

[10] A high carbon price has been used in the power econometrics analysis (see Section 4.3 Power Supply).

3.3
Heat

Axions 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 proportion of energy use in our scenarios.
- Energy savings from cavity wall insulation are greater than savings from loft and solid wall insulation to date.
- Our scenarios assume that the insulation market is beginning to saturate particularly for loft and cavity insulation.
- While a driver for loft and cavity insulation, the Green Deal and the Energy Companies Obligation (ECO) has had a marginal impact on the take-up of solid wall insulation.
- The recent amendments to ECO support have stretched the take-up over a longer period of time.
- Savings from boiler replacements are considerable.
- New houses will be increasingly energy efficient as a result of incremental changes in building regulations – our scenarios assume incremental step improvements in thermal efficiency related to future building regulations.
- Heat pumps are assumed to initially be deployed in houses not connected to the gas grid, resulting in a net reduction in electricity demand.

Key statistics

Boiler Savings
In 2013 – **10.5 million** A-rated boilers
Cumulative energy reduction approx. **55TWh/a** since 2000
2020: – **20.8 million** A-rated boilers
Cumulative energy reduction since 2013 approx. **22.5TWh/a**
2030: market saturation and replacing older A-rated with new
Cumulative energy reduction since 2013 approx. **31.5TWh/a**

Properties by fuel type in 2010
Gas – **22.5m** (85%)
Electric Resistive and Heat Pumps – **2.3m** (9%)
Other – **1.3m** (5%)
Heat Networks – **0.2 million** (1%)

Residential Heat Pump Installations (millions)	**2013**	**2020**	**2030**
Gone Green	0.1	1.2	5.6
Slow Progression	0.1	0.3	0.6
No Progression	0.1	0.3	0.6
Low Carbon Life	0.1	0.3	0.6

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 3.2)
- Power Demand (section 4.1)
- Gas Demand (section 4.4)

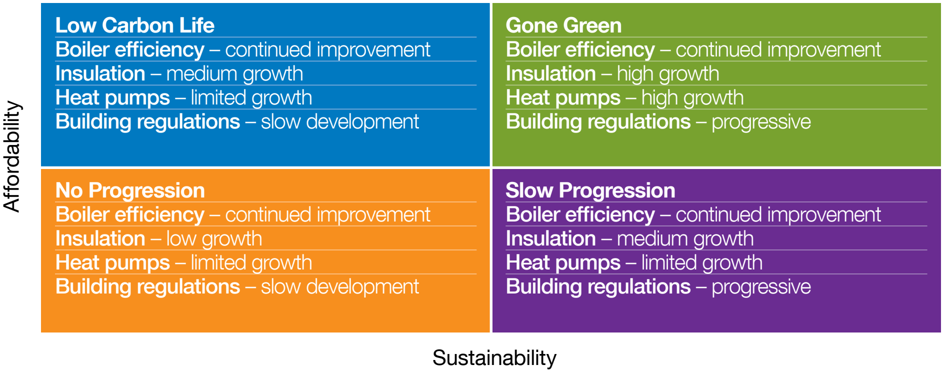
Method

We have modelled domestic heat demand using a bottom-up method, based on stakeholder views and data published on current trends in demand and energy efficiency measures. Industrial and Commercial heat demand is developed using econometric regression analysis and historic demand figures.

Stakeholder feedback

We asked stakeholders for their opinions on domestic comfort factors and insulation savings. Based on the feedback we received and supporting data, we have capped domestic temperatures at the historic level (20 degrees) and assumed that further savings from insulation installations will be low. We have also included a section on Heat Networks as stakeholders asked us to consider the implications they may have.

Figure 12
Axioms' impact



Low Carbon Life
Boiler efficiency – continued improvement
Insulation – medium growth
Heat pumps – limited growth
Building regulations – slow development

Gone Green
Boiler efficiency – continued improvement
Insulation – high growth
Heat pumps – high growth
Building regulations – progressive

No Progression
Boiler efficiency – continued improvement
Insulation – low growth
Heat pumps – limited growth
Building regulations – slow development

Slow Progression
Boiler efficiency – continued improvement
Insulation – medium growth
Heat pumps – limited growth
Building regulations – progressive

3.3.1
Efficiency Improvements: Heat

Heat accounts for a significant proportion of total UK energy demand. 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 focus on the residential sector as this remains the largest source of natural gas demand 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. Energy demands from new houses are analysed separately and this is described in further detail later in the section. Fuel use is described later in this section and specifically discusses gas boiler uptake and demand, resistive heating demand, heat pump uptake and demand, as well as residential heat network uptake.

Insulation

Our insulation analysis covers cavity wall, solid wall 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 marginal, with the majority of benefits already realised.

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, the Carbon Emissions Reduction Target (CERT)[11], Warm Front[12], and the Community Energy Saving Programme (CESP)[13]. These schemes have heavily influenced the uptake of loft and cavity wall insulation and CESP contributed to an increase in solid wall insulation that was mostly instigated by Local Authorities in social housing.

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. However, we assume the insulation market is beginning to saturate, in particular for loft and cavity wall insulation. This is based on statistics from the Energy Fact File[14] and stakeholder feedback.

Solid wall insulation is more challenging to install and significantly more expensive. There remains a significant opportunity for further efficiency savings associated with solid wall insulation: incentives, consumer appetite, fuel prices and costs will influence future take-up.

The difference in insulation rates in our scenarios is driven by the effectiveness or otherwise of the ECO and the Green Deal, as well as the remaining market potential up to the saturation levels of each insulation measure. Installation rates of insulation measures are shown for our scenarios in Figure 13 to Figure 15.

---

[11] Energy Efficiency Commitments 1 & 2

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

[13] http://webarchive.nationalarchives.gov.uk/20120109090353/http:/www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx

[14] https://www.gov.uk/government/collections/domestic-energy-fact-file-and-housing-surveys

At the start of 2013, the Green Deal and the Energy Company Obligation ECO were introduced and replaced CERT and CESP. During that period, the majority of all insulation measures associated with incentives were supported by the ECO and there remains considerable uncertainty as to the effectiveness of the Green Deal. In December 2013, the ECO was extended to March 2017 from March 2015. The level of funding and efficiency targets remain but the rate of insulation take-up has slowed to reflect the extension and funding deferral.

In 2013, we assumed rates consistent with the ECO approved and notified rates reported by the 2013 Ofgem compliance updates and with consideration to the government's Impact Assessment[15]. Following our 2014 assessment, we have revised down the higher uptake rate levels for loft and solid wall insulation. Cavity wall insulation uptake rates remain comparable to our scenarios in 2013.

Gone Green has the highest rate of insulation uptake for solid wall insulation, loft and cavity wall insulation, with **No Progression** having the lowest rate of uptake for these measures.

For both **Slow Progression** and **Low Carbon Life**, we have assumed a high rate of uptake for loft and cavity wall insulation and a low rate of uptake for solid wall insulation.

---

[15] https://www.gov.uk/government/consultations/the-future-of-the-energy-company-obligation

3.3 continued
Heat

Figure 13
Take-up of loft insulation

Figure 14
Take-up of cavity wall insulation

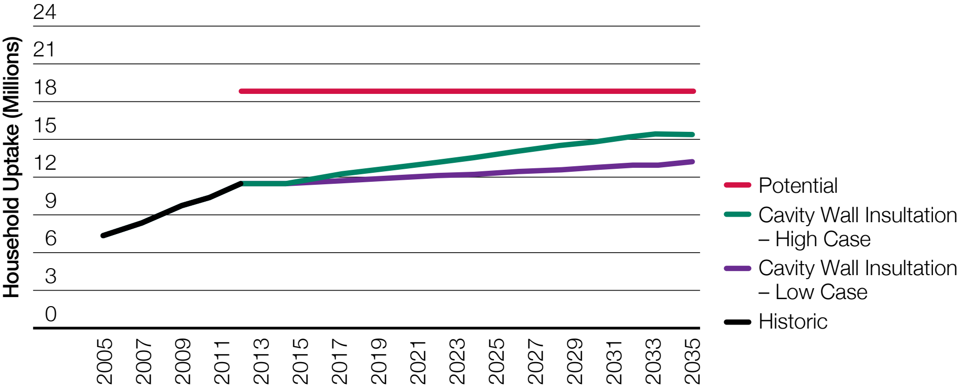
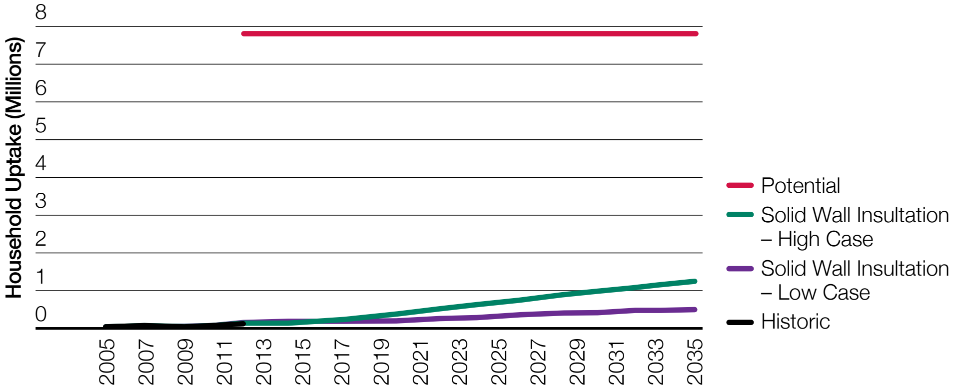
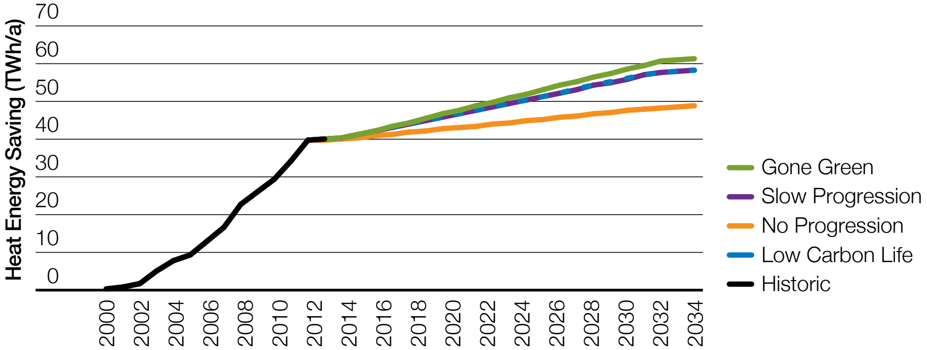


Figure 15
Take-up of solid wall insulation



Although the impact of the efficiency savings will depend on the age and property type, we have applied a simple average allocation of efficiency savings to each property. Figure 16 shows the total insulation saving for our scenarios.

Figure 16
Total residential insulation savings by scenario
(note that Low Carbon Life and Slow Progression are comparable)



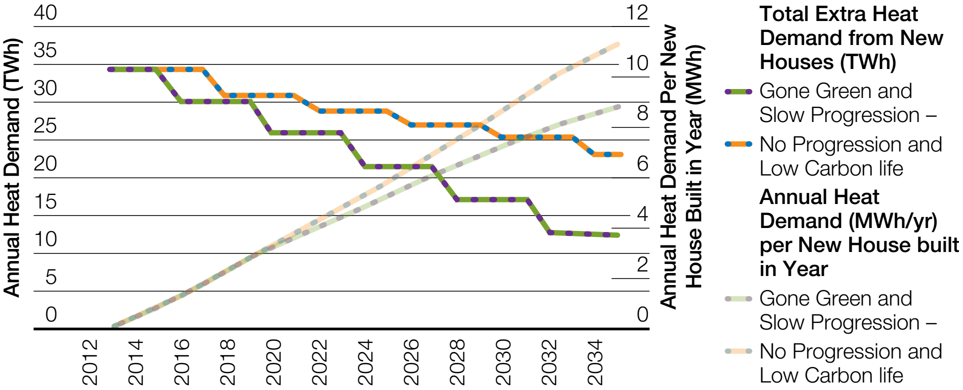
3.3 continued
Heat

New houses

Changes in building regulations are expected to continue to encourage successive thermal efficiency measures. We have assumed that building regulations will be tightened every four years from 2018, due to an average of a two-year timeline between achieving planning permission and household completion, with regulations pending for 2016. We have also assumed that Passivhaus standards[16] are reached by 2030 in our **Gone Green** and **Slow Progression** scenarios.

The **No Progression** and **Low Carbon Life** scenarios see half the rate of thermal efficiency improvements through building regulations in comparison to **Gone Green** and **Slow Progression**. We have assumed that hot water demand remains constant in all scenarios at 2.5MWh per annum. Figure 17 shows the total extra heat demand from new houses and the annual heat demand per new house built within a given year.

Figure 17
Heat demand from new houses



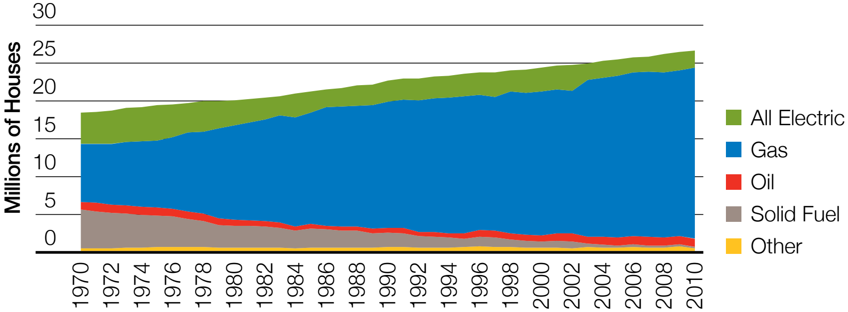
---

[16] http://www.passivhaus.org.uk/standard.jsp?id=122

Type of heating for residential properties (Great Britain)

Since the early 1960s, Great Britain has progressively adopted gas heating, displacing solid fuels and some resistive electric heating. By 2010, 85% of homes in Great Britain used gas for heating, 9% used electric, 4% used oil and just over 2% used solid fuel (coal, wood etc.), LPG, district heat or other sources. These proportions have been used to allocate insulation saving to each of our energy scenarios (see Figure 18).

Figure 18
Household fuel types



3.3 continued
Heat

Heating appliances in our scenarios

Gas heating dominates the residential heating market where the gas network has been deployed and there are continued improvements that can be made through upgrading older appliances with new A-rated boilers. Similar improvements can also be made for LPG and oil boilers. Resistive or night storage heaters are assumed to have an efficiency of 100%. The detailed assumptions concerning the adoption of A-rated gas boilers are discussed below.

In **Gone Green**, there is a transition to electrified heating via heat pumps where there are significant opportunities to further enhance the efficiency of heat delivery. This combined with the decarbonisation of energy generation, will result in reduced greenhouse gas emissions from the residential heating sector over the medium to long term. In this scenario we have assumed that air-source heat pump technology will be dominant, due to the higher cost of installation of ground-source heat pumps. Heat pumps could have significant implications for both the electricity and gas networks as their widespread uptake represents a shift in demand from gas to electricity. Similarly, we have reviewed our assumptions on potential growth in district heating and provide an overview towards the end of this section.

There remains significant uncertainty around the developments of future district heating and while we reflect a high electrification scenario in **Gone Green**, we have also reflected a high district heating and Combined Heat and Power (CHP) scenario in **Low Carbon Life**.

Gas boilers

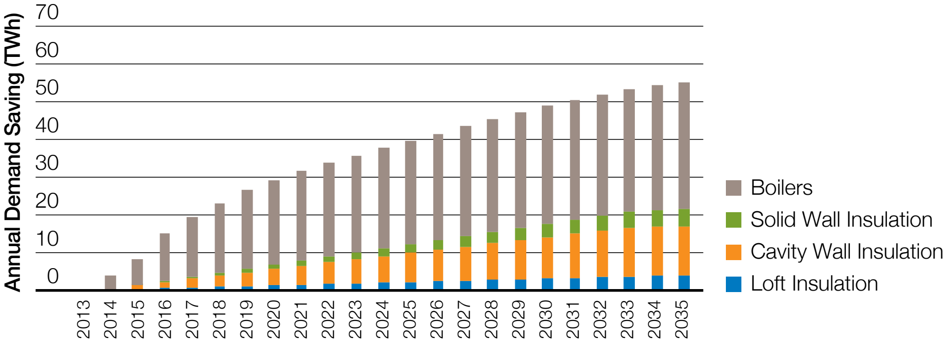
Savings from boiler replacements are considerable in all scenarios. Differences between scenarios are marginal as gas boilers tend to be replaced due to the failure of an existing unit. The efficiencies of new boilers are legislated and well documented. A relatively consistent number of boilers are purchased annually. We assume that 1.5m new boilers are purchased each year, displacing predominantly non-condensing ageing appliances. The same demand savings have been assumed in all scenarios.

The relative saving in gas demand from boilers and insulation are shown in Figure 19 for **Gone Green**. Figure 19 shows the significance of continued replacement of ageing appliances with new condensing models. **Gone Green** shows the higher insulation rates applied between our scenarios. Despite the higher insulation rates in this scenario the savings from new boilers dominate residential efficiency.

1.5m

We assume that 1.5m new boilers are purchased annually, displacing predominantly non-condensing ageing boilers. The same demand savings have been assumed in all scenarios.

Figure 19
Gas demand savings from residential energy efficiency measures: Gone Green



3.3.2
Heat Pumps

Our modelling has used sales figures from the Building Services Research and Information Association (BSRIA), together with stakeholder views, to create deterministic and stakeholder focused scenarios of the number of heat pumps installed each year. Our analysis also considers expected improvements in heat pump technology, as well as the changes in household insulation levels discussed above. Combined, these give us a view of the potential number of heat pumps that could be deployed in our scenarios and the annual electricity demand that would be associated with these.

Our research this year has also provided insight into the house types that are likely to see heat pump installations in the near-term, and the heating technologies which will likely be replaced. This has enabled us to model the expected impact of heat pump deployment on existing gas and electricity demand.

Due to the current high prices of heat pumps relative to other heating technologies, we believe that widespread uptake will depend on consumer wealth and a combination of government incentives, such as the Renewable Heat Incentive (RHI). Heating technology is often purchased at times of stress for consumers and so they typically purchase known technology that can be installed quickly and with the lowest capital cost (often favouring a gas boiler over a heat pump). We subsequently created both high and low growth scenarios, with the high growth applied to **Gone Green**, reflecting stronger policy incentives and measures and higher affordability. The other three scenarios experience much lower growth.

Figures 20 and 21 show the total potential number of installations and associated annual power demand in our scenarios. Our projection levels have remained similar to last year’s as we have seen no fundamental change in sales and have received positive stakeholder feedback on our assumptions in 2013.

Figure 20
Number of heat pumps

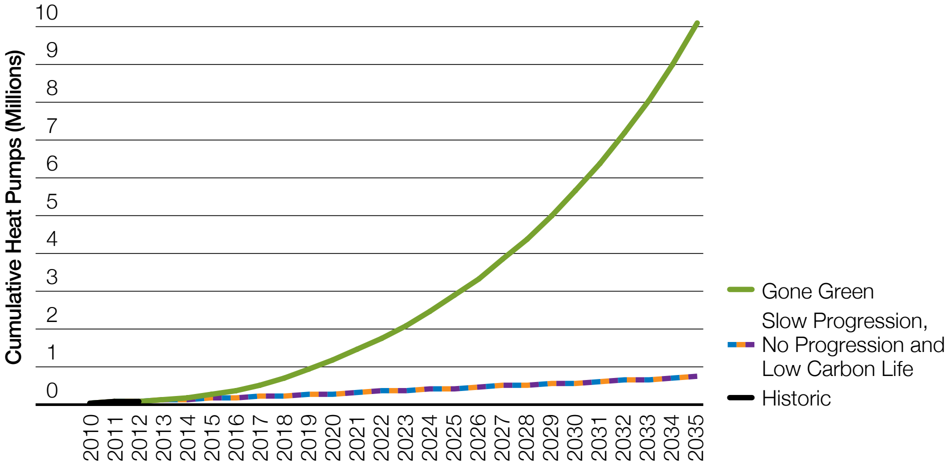
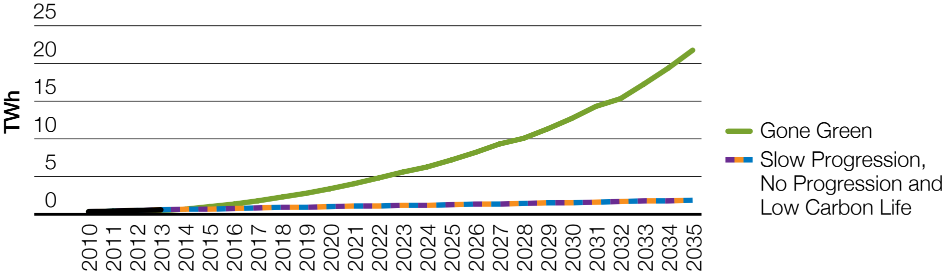


Figure 21
Demand (excluding effect of removing old resistive heating)



3.3 continued
Heat

The expected technology replacements are shown in Figure 22 and Figure 23. This analysis has been informed by an independent report which we purchased from Delta Energy & Environment in 2014. It shows that oil and electric systems are expected to be replaced before gas boilers.

This is due to heat pumps representing a good investment for many homeowners, as they are cheaper to run than oil or electric resistive systems. The respective falls in demand in resistive heating and gas will be covered in sections 4.1 and 4.4.

Figure 22
Gone Green heat pump installations and heating types replaced

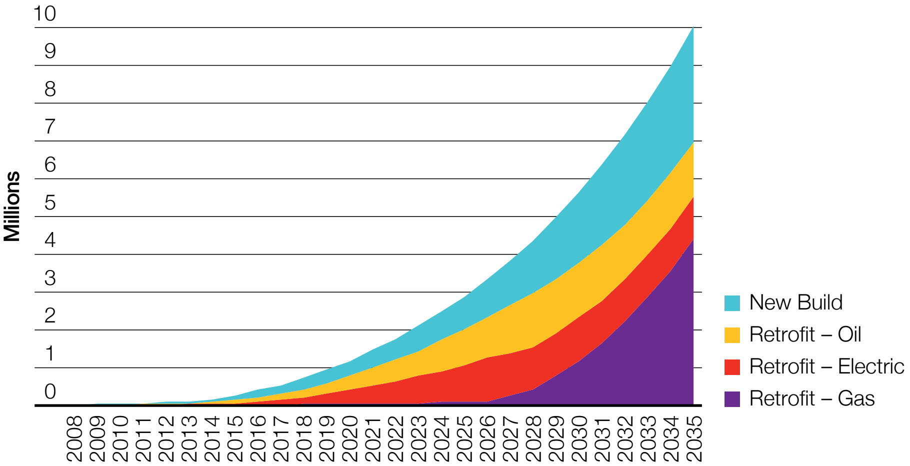


Figure 23
Slow Progression, No Progression and Low Carbon Life heat pump installations

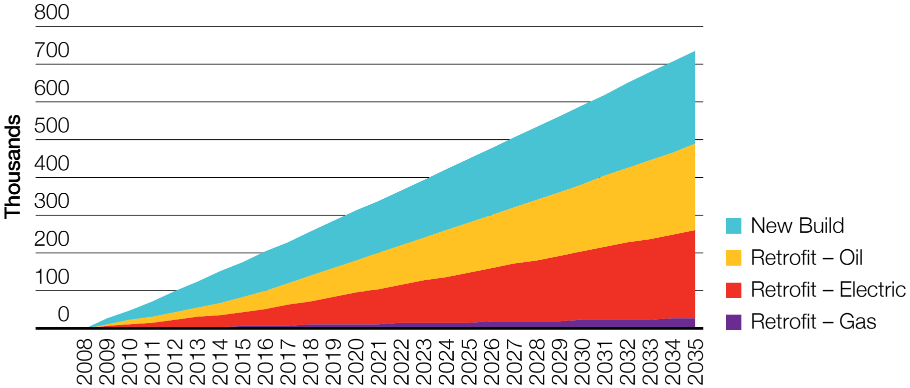
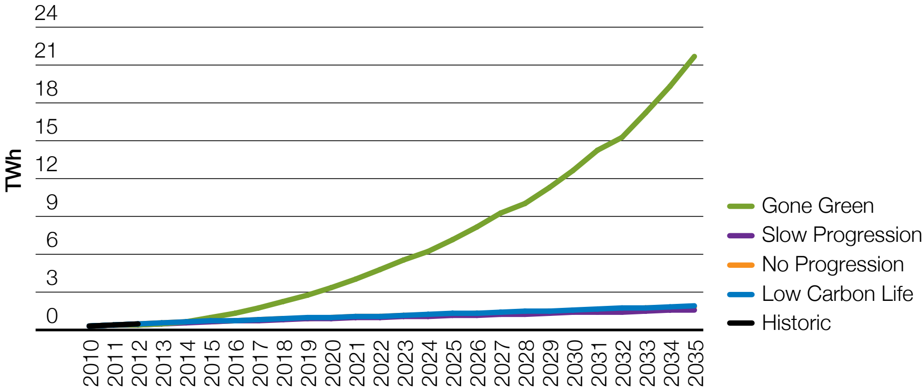


Figure 24
Heat pump electricity annual demand



3.3.3
Residential Resistive Electrical Heat Demand

Data from the Department of Energy and Climate Change (DECC) shows that approximately 2.1 million homes used electricity as the primary home heating source for heat and hot water in 2011[17]. For simplicity, the scenarios assume no growth in the number of homes heated by resistive heating via electricity, and assume numbers fall over time due to installation of heat-pumps.

Figure 25 shows DECC historic data for the number of homes with electric heating and the projections from the 2014 scenarios. In **Gone Green**, numbers fall due to heat-pump installations. The numbers in the remaining three scenarios fall more slowly over time due to a much lower rate of heat pump installation.

Figure 25
Number of homes with electric heating

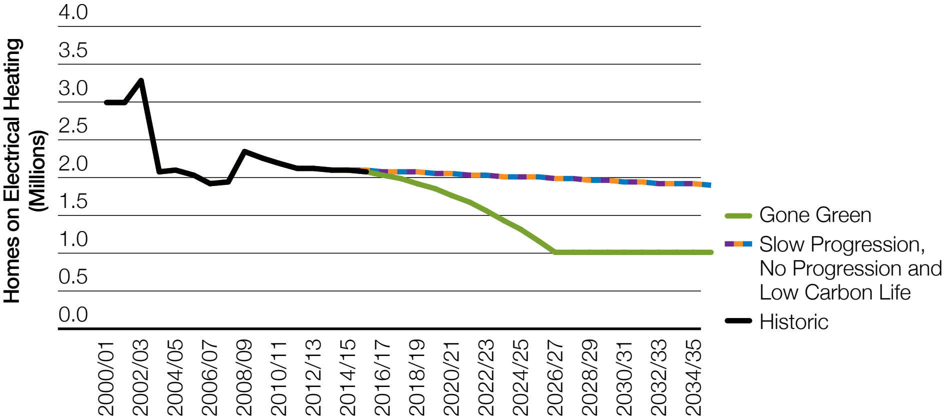


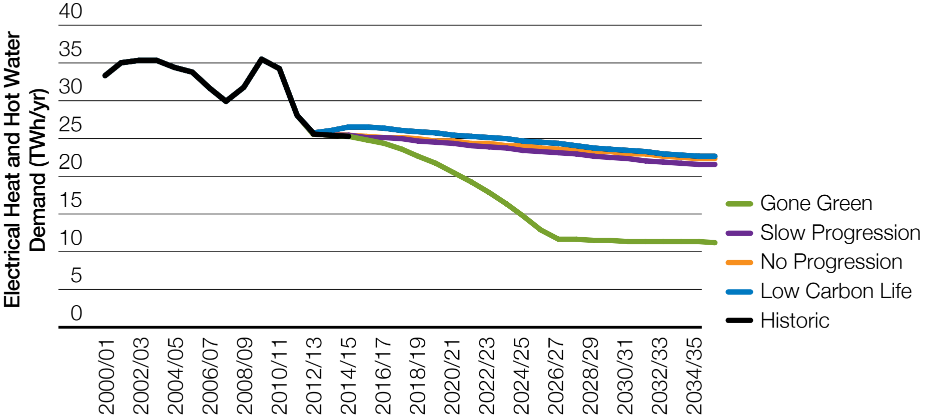
Figure 26 shows historic DECC heat demands and the 2014 scenarios. Demand mainly falls in **Gone Green** due to heat-pump installations which replace resistive heating.

In all scenarios, homes remaining on electrical heating are assumed to change their demand due to differing insulation and behaviour changes which cause heat demand to slowly fall over time.

---

[17] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/238797/domestic.xls

Figure 26
Annual resistive electric heat and hot water demand



Heat networks

Our scenarios include assumptions about the growth in non-power and gas appliances. Oil, LPG and other fuels tend to be associated with new housing not connected to the gas network due to the favourable economics of gas appliances where the gas grid is located. Heat networks have been highlighted in the Government Heat Strategy 2013[18] as a potential method of reducing emissions at the point of use. The majority of heat consumed by district heating schemes to date is associated with larger 'anchor loads' including public service, commercial, medical, educational and leisure buildings alongside a smaller proportion of energy consumed for residential heating.

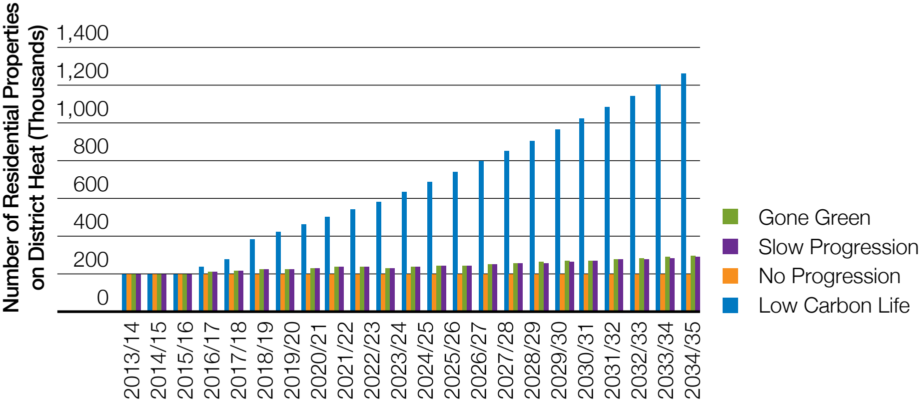
Information relating to district heat has been taken from public sources and through stakeholder feedback. We have assumed there are 86 schemes currently in operation across Great Britain serving 200,000 residential properties. This is based on statistics from the Digest of UK Energy Statistics and DECC's Heat Strategy 2013 – The Future of Heating: Meeting the Challenge. The majority of district heating energy is assumed to come from gas, oil, coal or renewable Combined Heat and Power (CHP) systems. While there are some technological opportunities associated with district heating including large-scale heat pumps and seasonal storage we have assumed that schemes are developed initially using gas and renewable CHP. Accordingly, we have developed our district heating numbers to align with our CHP scenarios.

We see CHP growth in all scenarios, with the lowest development in **No Progression** due to lower economic development. **Slow Progression** and **Gone Green** have stronger policy drivers, both favouring the development of gas and renewable CHP; however growth is limited by the carbon intensity of CHP emissions. **Low Carbon Life**, with higher economic growth, represents a high growth case for CHP and therefore is the high growth case for district heating. We have assumed the majority of new district heating connections are associated with new build housing developments, rather than more expensive retrofit city schemes.

---

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

Figure 27
Number of residential properties using district heat



3.3.4
2035–2050

From 2035 to 2050 the heating market changes considerably in **Gone Green**, **Low Carbon Life** and **Slow Progression**, due to the potential contribution the heating market can make regarding progress towards the renewable and carbon targets. The changes mostly consist of replacing gas heating with electric heat pumps, due to their efficiency and ability to use electricity from low carbon and renewable sources. However, they are more expensive to purchase than gas boilers, hence **No Progression**, with less money available and less focus on sustainability sees very little increase in electrification of heating. **Low Carbon Life**, and **Gone Green** have the highest electrification of heat, driven by the 2050 greenhouse gas reduction target and more money being available to invest in them. **Gone Green** and **Slow Progression** have the highest uptake of bioenergy heating in the medium term, mainly via biomass, due to its ability to heat renewably before there is enough spare renewable electricity to be used for renewable heating. Towards the end of the period, hybrid heating systems, with an electric heat pump for baseload heating, and gas for periods of colder weather are prevalent in **Gone Green**, **Low Carbon Life** and to a lesser extent **Slow Progression**. This is a more cost effective solution as existing gas infrastructure can be used to meet the increase in heat demand in the coldest weather, rather than building power generation to be used only at times of peak demand.

Other fossil fuels decrease considerably in all scenarios except for **No Progression**, as these tend to be the most polluting form of heating. There is currently no hydrogen in any scenario, as we think any hydrogen that may be generated is best suited to be utilised in transportation, due to its ability to store energy in a vehicle tank.

Figures 28 to 31 show the supply of heat aggregated across all market sectors to 2050 in all four scenarios.

3.3 continued
Heat

Figure 28
Low Carbon Life heat supply to 2050

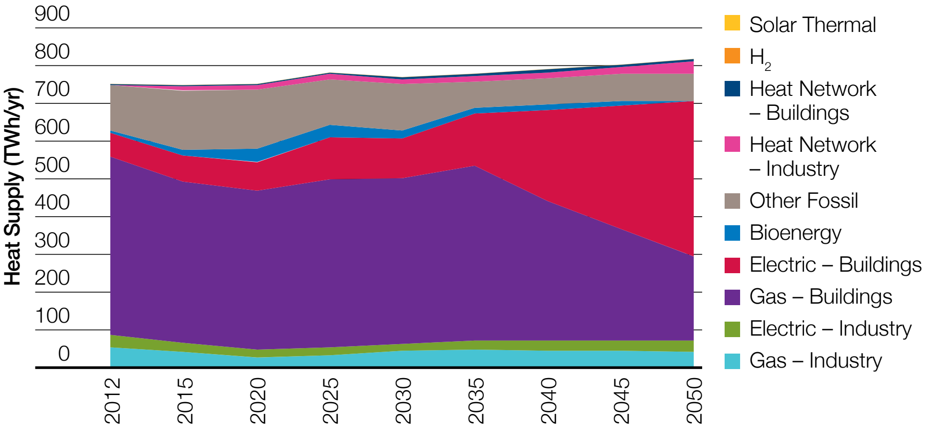


Figure 29
No Progression heat supply to 2050

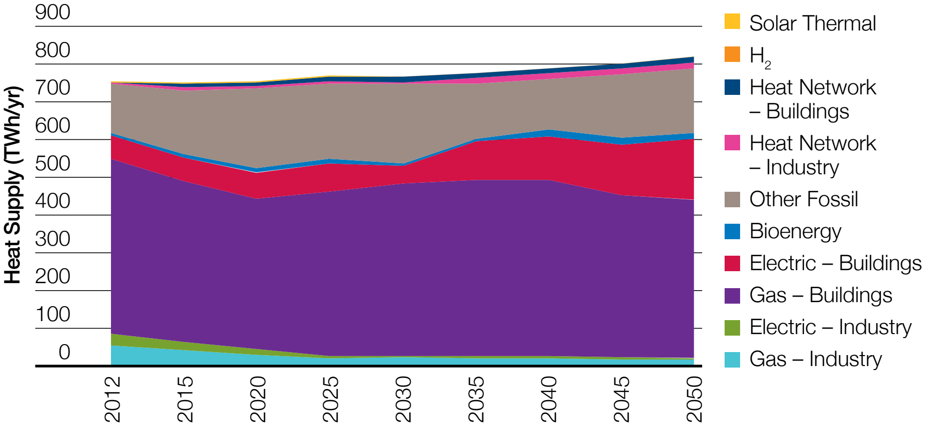


Figure 30
***Gone Green** heat supply to 2050*

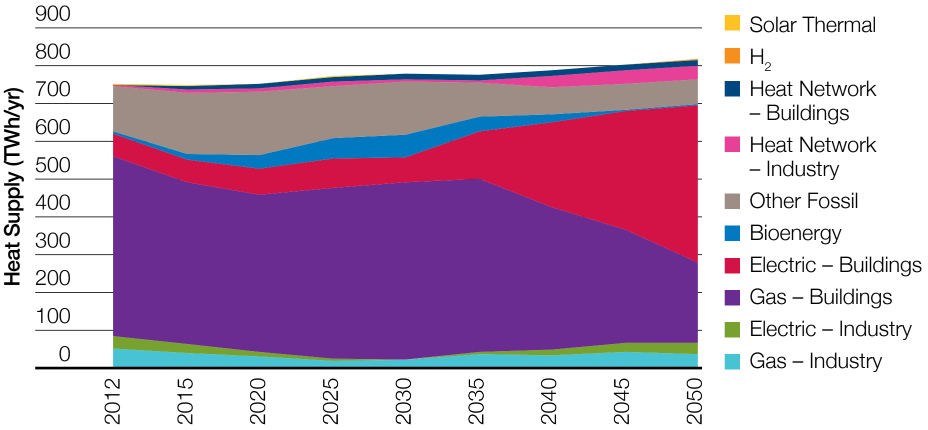
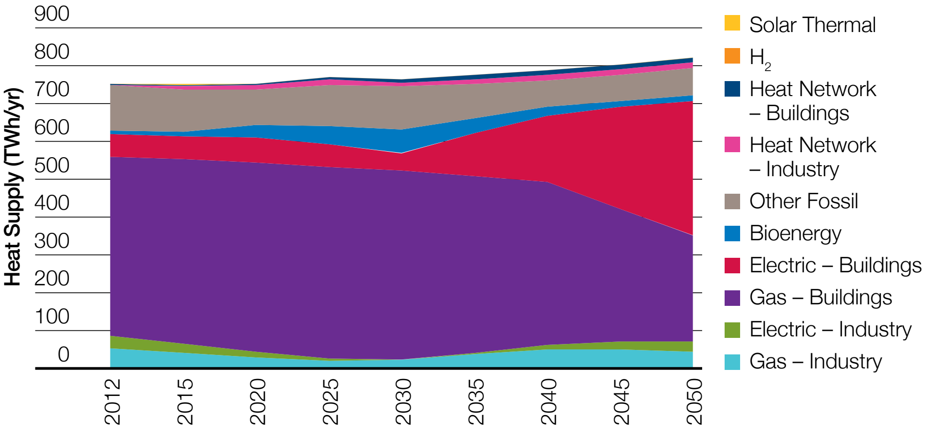


Figure 31
Slow Progression heat supply to 2050

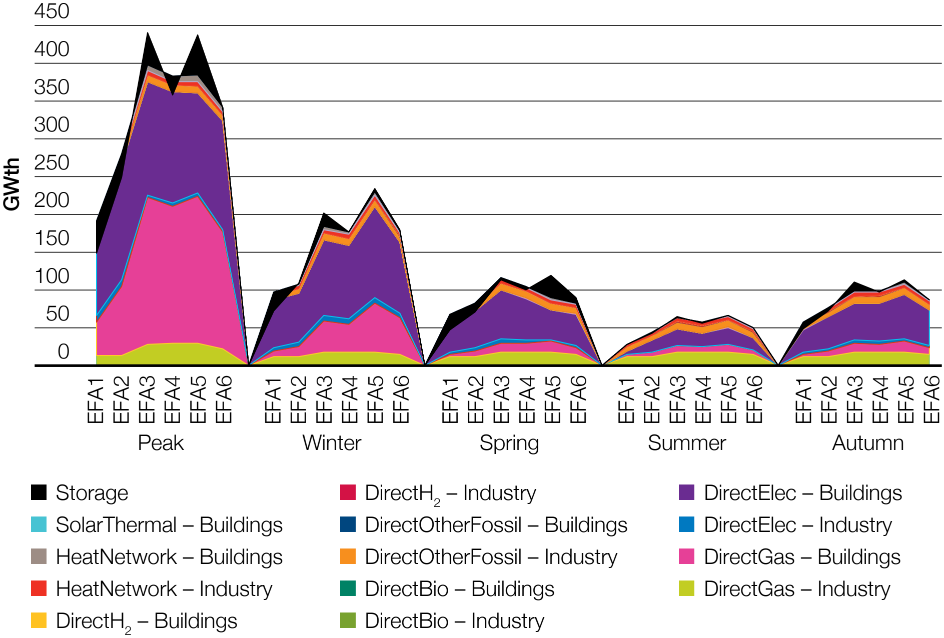


3.3 continued
Heat

Seasonality of heat

We have once again explored the optimal way of heating the UK across seasons and at peak times. This is illustrated with the seasonal heat requirements from the **Gone Green** scenario in 2050. 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 generation and electricity network capacity. Figure 32 illustrates how heat is supplied over a peak day and an average day for each season. Each Electricity Forward Agreement (EFA – 4 hourly time periods into which an electricity day is split) timescale represents 4 hours of the day (EFA1 is 23:00–03:00, EFA2 is 03:00–07:00, etc). This chart shows that whilst the majority of heat is met by non gas heating in warmer periods, on colder days and at peak a significant amount of gas is required for heating. The same conclusion occurs when looking at **Low Carbon Life** and **Slow Progression** in 2050, hence hybrid systems are included in these three scenarios. **No Progression** needs gas for heating all year around, as this scenario has little electrification of heating in 2050, as can be seen in Figure 32.

Figure 32
Heat duration supply curve for 2050



3.4

Consumer

Summary

- Lighting and appliances are the predominant consumers of electricity in the home.
- The largest change in recent years and the near term in the residential electricity sector is around lighting and efficiency improvements instigated by European policy.
- Increases in the number and size of some appliances will be offset by their efficiency improvements.
- Consumer affordability combined with government incentives will determine the adoption of electric vehicles and heat pumps, which will drive the changes in demand in the future.
- The impact of smart meters is small in comparison to the above changes and is bound by the speed of the roll-out and the adoption of time-of-use tariffs (TOUTs).

Axioms that influence this section

Carbon Targets

Government/EU Policy

Energy Efficiency

User Behaviour

Economic Outlook

(Smart Meter) Targets

Key statistics

Lighting

Average bulb annual demand in residential buildings (annual cost (£), assuming constant electricity price at £0.15/kWh)

	2013	2020	2030
Gone Green	18.77kWh (£2.81)	9.18kWh (£1.38)	6.80kWh (£1.02)
Slow Progression	18.77kWh (£2.81)	17.45kWh (£2.62)	9.43kWh (£1.41)
No Progression	18.77kWh (£2.81)	17.45kWh (£2.62)	13.42kWh (£2.01)
Low Carbon Life	18.77kWh (£2.81)	18.86kWh (£2.83)	16.54kWh (£2.48)

Appliances

Annual consumption per single appliance (kWh)

Scenario	Year	Fridge Freezer	Washing Machine	Television
Gone Green	2013	414	211	135
	2020	327	201	121
	2030	265	194	103
Slow Progression	2013	414	211	135
	2020	327	201	121
	2030	204	201	103
No Progression	2013	417	211	136
	2020	362	207	127
	2030	296	204	115
Low Carbon Life	2013	414	211	135
	2020	327	201	121
	2030	327	201	103

3.4 continued
Consumer

Key statistics continued:

Smart meter roll-out completed by:
Gone Green – **2020**
Slow Progression – **2032**
No Progression – **2032**
Low Carbon Life – **2032**

Households with TOUTs by 2030:
Gone Green – **47%**
Slow Progression – **4%**
No Progression – **4%**
Low Carbon Life – **4%**
For households with TOUTs, peak demand is shifted by **5%**

In Gone Green we have assumed an EU standard for smart appliances is agreed in 2020 and that smart appliances are adopted.

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

- Efficiency improvements are required and need to be driven by policy.
- Increased consumer spending to accelerate the replacement cycle.
- Technological developments.
- LED bulbs need to reduce in price and become the default option.
- The smart meter roll-out needs to be completed.
- The support and development of the electrification of heating and transport is required including the infrastructure required to support it.
- Integration and engagement with smart meter infrastructure and TOUTs.
- Changing consumer energy use is an important element to achieving the 2050 carbon emissions target; improvements in energy efficiency will be central to this.

Further reading

- Government Policy (Appendix 1)
- Economic Background (section 3.2)
- Electricity Demand (section 4.1)
- Gas Demand (section 4.4)

3.4.1
Lighting

Lighting currently accounts for approximately 12% (14TWh) of residential demand, down from approximately 15% (18TWh) in 2007. Changes in European and UK Government legislation and consumer choice have driven rapid and significant change in the way homes are lit and the amount of power consumed. The 4TWh reduction in lighting demand is around half of the total 9TWh reduction in the weather corrected residential demand seen since 2007 and so the effect from lighting should not be underestimated.

EU standards for lighting are continuously evolving with the intention of improving sustainability through reduced carbon emissions. The ban on larger incandescent bulbs was responsible for much of the change between 2007 and 2012. Manufacturers may continue research and development in existing technologies, halogens and Compact Fluorescent Lights (CFL), in order to meet legislation. Alternatively, they may decide to concentrate on light-emitting diode (LED) development or other technologies.

Table 2
Assumed annual power consumption per bulb

Technology	Traditional Incandescent	Halogen	Compact Fluorescent Light (energy saving)	LED
Assumed Annual Consumption kWh/yr	21	26	11	7

Consumer preference has a huge impact, with government data showing rapid adoption of halogen lighting since 2009 (halogen demand increasing from 4TWh/yr to 7TWh/yr between 2009 and 2012) as consumers adopt spot-lights and replace single downlighters with multiple halogens. LEDs could fill this role if prices continue to fall and this would cause significant falls in power demand (the average halogen is assumed to consume 26kWh/yr compared to 7kWh/yr for an equivalent LED).

Table 3 shows the legislation which drove the phase-out of traditional bulbs after 2012 and future legislation from 2016 which may impact halogens.

3.4 continued
Consumer

Table 3
EU Lighting Directives[19]

Stage	Date	Phase-out	Replace with
1	1/9/2009	75W	Class C, minimum 1000 hours lifespan
2	1/9/2010	60W	Class C
3	1/9/2011	40W	Class C
4	1/9/2012	<40W	Class C
5	1/9/2013	Increase quality	Class C, minimum 2000 hours lifespan
6	1/9/2016	All clear bulbs	Class B

Stakeholder feedback

Stakeholders indicated that our 2013 lighting scenarios were too narrow in range and that assuming all halogen lighting would be replaced by LEDs was too extreme. To acknowledge this, for 2014 we have assumed that halogens continue to be used in **Low Carbon Life**, and that consumer behaviour remains similar to today in **No Progression**. The 2014 scenario range is wider and captures an energy efficient future (**Gone Green**) and an energy prolific future (**Low Carbon Life**).

Method

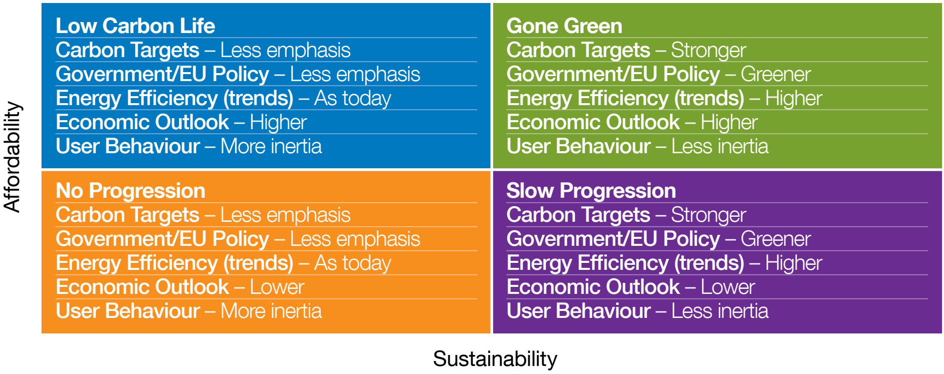
We used regression analysis on published data[20] on the number and associated power consumption of residential light bulbs. We have used these trends, in conjunction with the axioms, to flex technology penetration, consumer decisions and potential new legislation, in order to develop a range of lighting scenarios varying the bulb types, numbers and associated consumption. We have assumed the same number of houses in each scenario, and more light bulbs per household in **Low Carbon Life** due to consumer choice around aesthetic lighting.

---

[19] http://www.gelighting.com/LightingWeb/emea/products/lamps/halogen/technology/erp-legislation-for-halogen-lamps.jsp

[20] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/238797/domestic.xls

Figure 33
Axioms' impact



Low Carbon Life
Carbon Targets – Less emphasis
Government/EU Policy – Less emphasis
Energy Efficiency (trends) – As today
Economic Outlook – Higher
User Behaviour – More inertia

Gone Green
Carbon Targets – Stronger
Government/EU Policy – Greener
Energy Efficiency (trends) – Higher
Economic Outlook – Higher
User Behaviour – Less inertia

No Progression
Carbon Targets – Less emphasis
Government/EU Policy – Less emphasis
Energy Efficiency (trends) – As today
Economic Outlook – Lower
User Behaviour – More inertia

Slow Progression
Carbon Targets – Stronger
Government/EU Policy – Greener
Energy Efficiency (trends) – Higher
Economic Outlook – Lower
User Behaviour – Less inertia

3.4 continued
Consumer

Figure 34
Residential lighting technology – Low Carbon Life

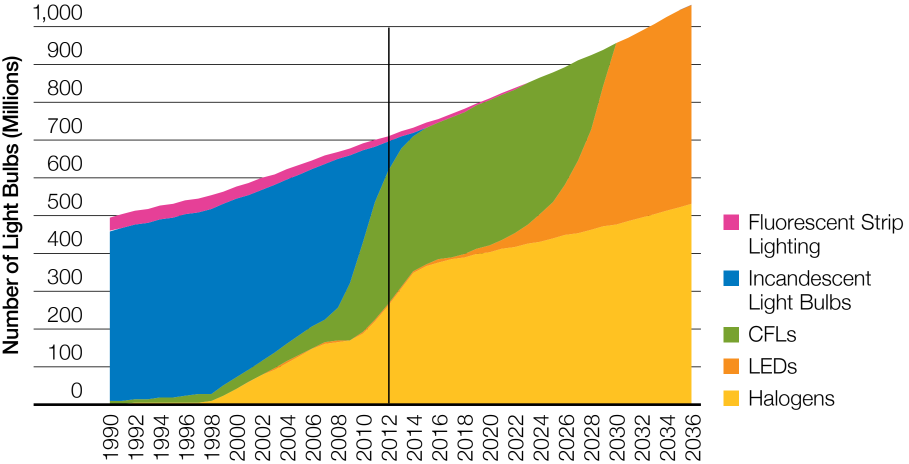


Figure 35
Residential lighting technology – No Progression

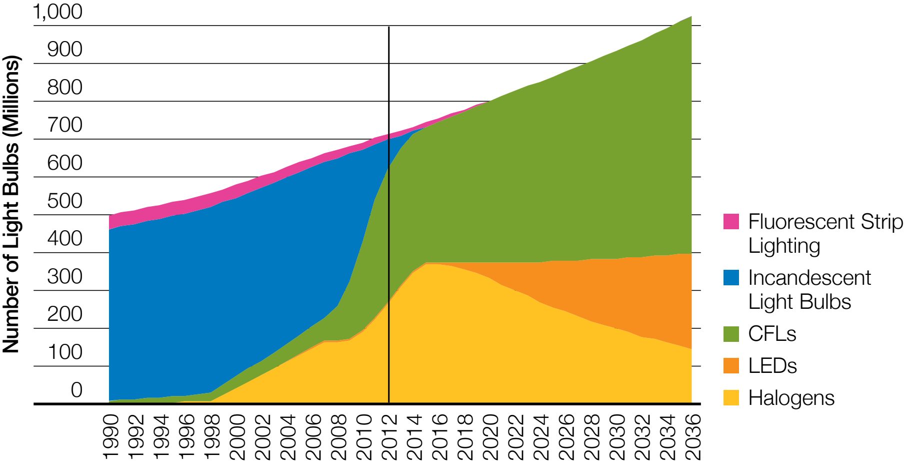


Figure 36
Residential lighting technology – Gone Green

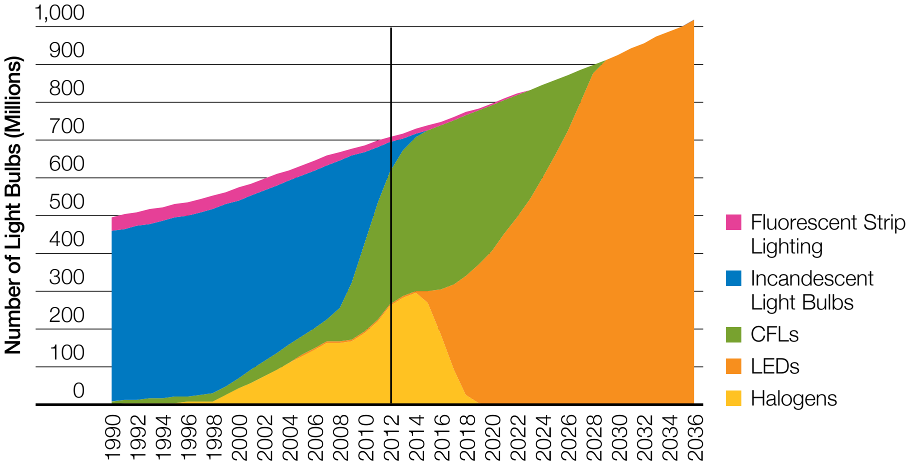
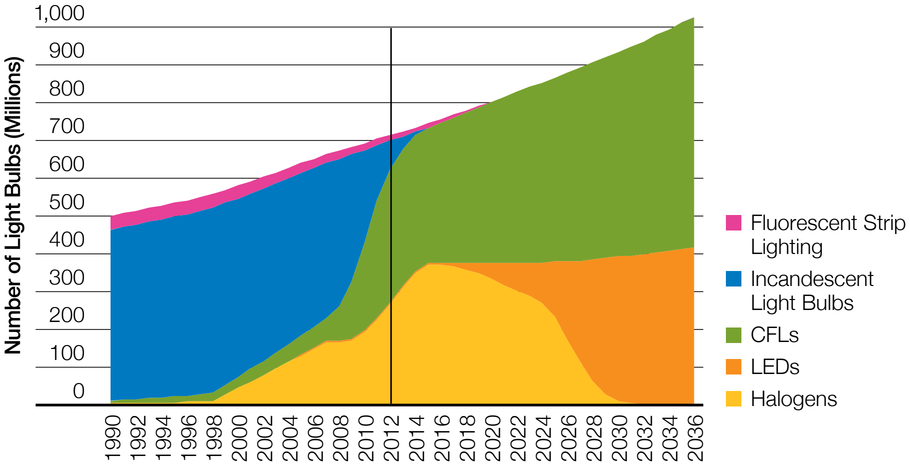


Figure 37
Residential lighting technology – Slow Progression



3.4 continued
Consumer

Results

In **Gone Green** consumers continue to adopt halogen lighting until the quality and cost of LED bulbs improves, at which point they favour LED technology. In the EU, C-rated halogens are due to be phased out in 2016 and **Gone Green** assumes manufacturers decide to substitute LED technology for halogens, further increasing the adoption rates of LEDs.

In **Slow Progression** halogens begin to be replaced in favour of LEDs in 2025. This is slightly later than in **Gone Green** to allow for LED costs to fall further under the decreased affordability axiom. CFLs continue to be part of the lighting mix due to lower costs compared to LEDs.

No Progression assumes consumers continue to adopt halogen bulbs, which are replaced slowly by LEDs. CFLs continue to dominate residential lighting due to lower costs compared to LEDs.

In **Low Carbon Life**, consumers continue to rapidly adopt halogen lights throughout the home and LEDs are adopted for general illumination and for aesthetic purposes.

In all scenarios, except **No Progression**, power demand increases from approximately 2030, due to increased housing numbers. In **No Progression**, demand continues to fall as halogens are slowly replaced by LEDs.

Figure 38
Light demand scenarios pre-weather correction

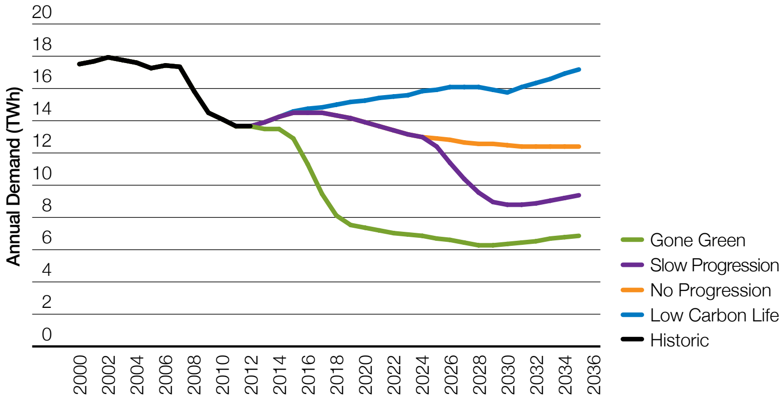


Figure 38 shows the effect of lighting choices on annual power demand for each of the scenarios. Government data shows falls in annual power consumption between 2007 and 2011 due to the phase-out of traditional bulbs. This has stabilised over the last few years, due to a mix of increased halogen usage and increased light usage by residential consumers.

3.4.2

Appliances

Appliances currently account for over 60% of residential annual power demand with usage peaking between 4pm and 8pm, the period of peak power demand.

Method

We use regression analysis on government data[21] which shows the number and estimated energy consumption of electrical appliances. For the 2014 scenarios we have started to consider smartphones, tablets and wireless routers using Ofcom's 2013 Communications Market Report[22]. Caps are applied to the number of appliances where appropriate e.g. one washing machine, kettle or microwave in full use per household. This determines the number of appliances in use and the associated annual power consumption. Experian's housing and population numbers were also used to cap appliance adoption.

Table 4
Appliance Types Modelled

Appliance Type	Appliances
Cold	Chest freezers, fridge-freezers, upright freezers, refrigerators
Wet	Washing machines, washer-driers, dishwashers, tumble-driers
Consumer electronics	Televisions, set-top boxes, DVD/VCRs, games consoles, power supply units
Home computing	Desktops, laptops, monitors, printers, multi-function devices
Cooking	Electric ovens, electric hobs, microwaves, kettles
Telecommunications (subset of consumer electronics)	Wireless routers. Mobile connections: internet enabled, broadband only, voice-only (smart phones, mobile phones and 'tablets')

Stakeholder feedback

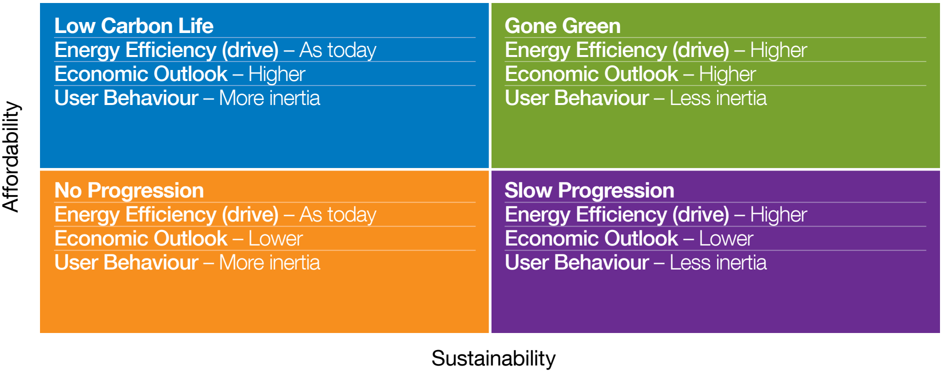
In order to create a scenario range, our 2013 scenarios deterministically assumed that in **Gone Green** all appliances would improve by two energy efficiency bands, and for **Slow Progression** by one energy efficiency band. However, different appliances have different life-spans and improve in efficiency at different rates, making this approach too broad. Feedback supported the need to change this approach as many stakeholders thought energy efficiency could improve by more than two bands. We therefore moved to the regression-based method described above.

---

[21] Energy Consumption in the UK: https://www.gov.uk/government/publications/energy-consumption-in-the-uk

[22] Ofcom Communications Market Report: http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr13/

Figure 39
Axioms' impact



Low Carbon Life
Energy Efficiency (drive) – As today
Economic Outlook – Higher
User Behaviour – More inertia

Gone Green
Energy Efficiency (drive) – Higher
Economic Outlook – Higher
User Behaviour – Less inertia

No Progression
Energy Efficiency (drive) – As today
Economic Outlook – Lower
User Behaviour – More inertia

Slow Progression
Energy Efficiency (drive) – Higher
Economic Outlook – Lower
User Behaviour – Less inertia

Energy Efficiency Trends: Efficiency improves through the technology development cycle and through the introduction of policy standards. Efficiency improvements drive more change between the scenarios than the number of appliances. The standards imposed by the EU energy labelling scheme are designed to become more rigorous over time, and this is generally assumed to drive power consumption down. These efficiency improvements are greater in **Gone Green** and **Slow Progression**.

Economic Outlook: This is assumed to affect the number and rate of appliances purchased and therefore the rate of energy efficiency improvement within the home. The impact from this will vary between scenarios based on the axioms and between the appliance groups. For example, in **Gone Green** and **Low Carbon Life** consumers are assumed to purchase more, and bigger, appliances than they do in the low GDP growth scenarios e.g. larder-style fridge freezers and larger televisions. This drives demand up, despite these devices being more energy efficient than they would be in **No Progression** or **Slow Progression**. In the high GDP scenarios, consumers are assumed to replace their laptops/desktops for smart devices which reduces power demand, but in the low GDP scenarios replacement rates are low and consumers retain a larger proportion of desktops, laptop and monitors which leaves power demand high.

User Behaviour: This is assumed to affect the rate of change of power consumption and how often a consumer may replace an appliance or purchase additional ones.

Figure 40
Gone Green number of appliances by type

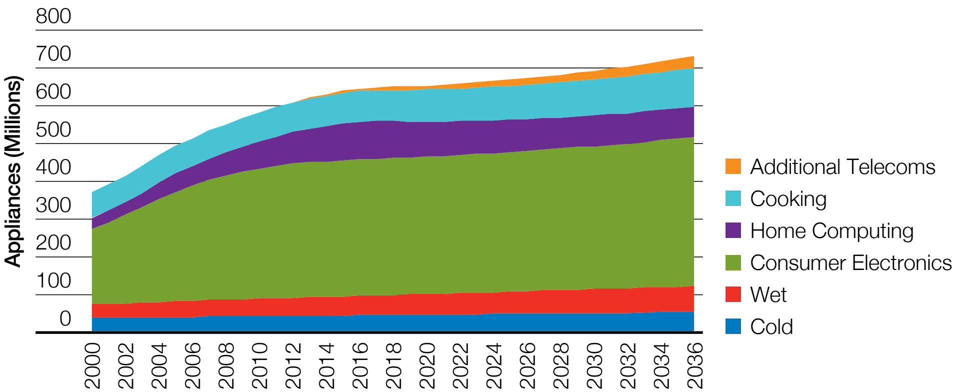
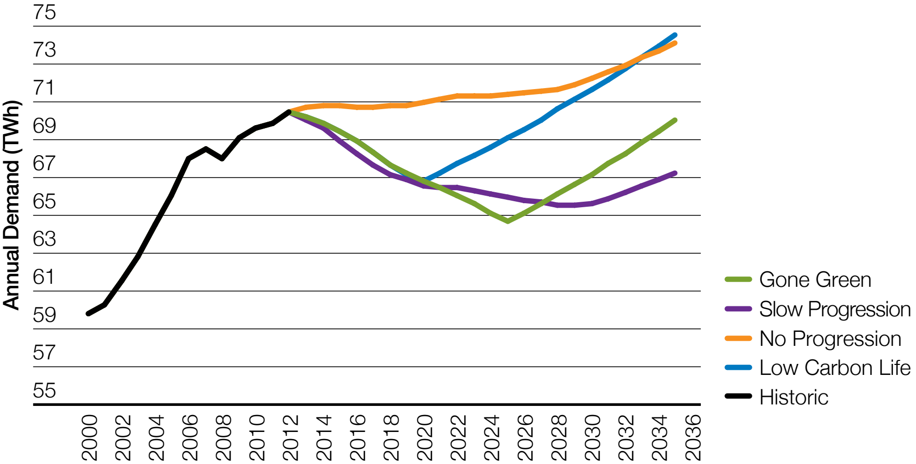


Table 5
Sample power consumptions by appliance

		Annual Power Consumption kWh/yr			
Appliance	Scenario	2012	2020	2030	Comment
Fridge-Freezer	Gone Green	426	327	265	High energy efficiency but larger appliances
	Slow Progression		327	204	High energy efficiency with existing sized appliances
	Low Carbon Life		327	327	Capped at 327, large luxury unit
	No Progression		362	296	Low energy efficiency gain
Washing Machine	Gone Green	212	201	194	Highest energy efficiency gain
	Slow Progression		201	201	High energy efficiency gain
	Low Carbon Life		201	201	High energy efficiency gain
	No Progression		207	204	Lowest energy efficiency gain
Electric Oven	Gone Green	179	121	85	Highest energy efficiency gain
	Slow Progression		121	121	High energy efficiency gain
	Low Carbon Life		121	121	High energy efficiency gain
	No Progression		165	165	Lowest energy efficiency gain

3.4 continued
Consumer

Figure 41
Residential appliance demand pre-weather correction



The largest differences between the scenarios are driven by cold and wet appliances, and consumer electronics. How these affect the scenarios is described below.

Gone Green

- Cold appliance demand drops more rapidly on the back of increased efficiency gains.
- The flex between the scenarios for wet appliances is driven mainly by the number of dishwashers and tumble driers which are purchased in greater numbers due to increased consumer affordability.
- The demand caused by the increase in consumer electronics is offset by increased efficiency gains through the adoption of new technology. Demand sharply increases after 2025 due to a mix of assumed limits of energy efficiency (e.g. cooking) and increasing household numbers.
- Computing shows lower demand as desktops are replaced with more efficient laptops and tablets.

Low Carbon Life

- Cold appliances see efficiency gains but this is overtaken by growth due to the purchase of larger cold appliances and the increase in the number of homes.
- Wet appliances see growth similar to **Gone Green** due to increased affordability, although this is slightly higher in **Low Carbon Life** due to fewer efficiency improvements.
- The demand caused by the increase in consumer electronics is offset by increased efficiency gains through the adoption of new technology.
- Computing shows lower demand as desktops are replaced with more efficient laptops and tablets.

Slow Progression

- Cold appliances demonstrate efficiency gains on a slower basis than **Gone Green** and **Low Carbon Life** as appliances are replaced only on failure due to the lower economic growth axiom.
- Wet appliances see low growth due to consumer affordability limiting the uptake of additional tumble driers and dishwashers.
- Consumer electronics demand shows little change as fewer appliances are owned due to limited disposable income. This is offset by the fact that the retained appliances are older and less efficient.
- Computing shows higher demand as older higher consuming desktops are retained for longer.

No Progression

- Cold appliances in **No Progression** demonstrate the lowest efficiency gains of the four scenarios as there is less policy pushing improvements and replacements are slow on a breakdown basis.
- Wet appliances see lower growth due to consumer affordability limiting the uptake of additional tumble driers and dishwashers.
- Consumer electronics shows little change as fewer appliances are owned due to limited disposable income. This is offset by the fact that the retained appliances are older and less efficient.
- Computing shows higher demand as older higher consuming desktops are retained for longer.

Appliance uncertainty

The largest driver of change between the scenarios is based on the usage per appliance which is a function of consumer behaviour but predominantly energy efficiency. Therefore policy decisions at a UK, European or global level, or technological improvements, are most important in their consideration.

A small number of appliance categories are evolving rapidly and for these we have used the scenarios to capture a range of future assumptions.

There is uncertainty around how appliance changes will affect each other. For example government data indicates there is almost one television per person in the UK. Anecdotal evidence suggests mobile computing could affect this demand trend into the future as people choose to view television on their smart devices or use both at the same time.

3.4.3
Smart Meters and Time-of-Use Tariffs

One of the aims of the government's roll-out of smart meters and in-home displays is to increase consumer awareness of how and when energy is used. If combined with time-of-use tariffs (TOUTs) and smart appliances, this technology could facilitate smoothing of within-day demands (demand management at time of system peak or minimum), or enable enhanced use of intermittent renewable generation such as wind or solar, reducing generation and network costs.

In 2013 the Smart Meter Central Delivery Body was established[23]. The group's remit is to ensure that smart meters are rolled out and the benefits from the smart meter programme are fully realised. Areas of focus include establishing appliance and communications standards to realise the goal of smart homes and to facilitate a smart energy future. Consumer engagement is key and they are considering an education campaign.

The smart meter roll-out presents a significant logistical challenge due to the need to install them in over 26 million homes by 2020. The roll-out is split into two stages; foundation and mass roll-out. To date, the mass roll-out completion date has been delayed to 2020.

Method
We used information from suppliers via the Energy Networks Association to determine roll-out scenarios. In order to determine the impact of the programme on power consumption, we have drawn on the 2011 Energy Demand Research Project commissioned by Ofgem[24] to create scenarios on annual and peak power demand. We used information from several consumer behaviour studies to approximate how many consumers may or may not engage with this technology and lifestyle and the effect that this engagement could have on their consumption.

Annual and peak reductions are on top of the efficiency gains already assumed for more efficient appliances and for the peak reductions already assumed for electric vehicles, heat-pumps and existing TOUTs such as Economy 7. We have not split the smart meter impacts within our residential bottom-up sectors and so do not define which load may be decreased or shifted as this will largely be at consumers' discretion.

---

[23] Central Delivery Body: http://www.energy-uk.org.uk/publication/finish/5/893.html

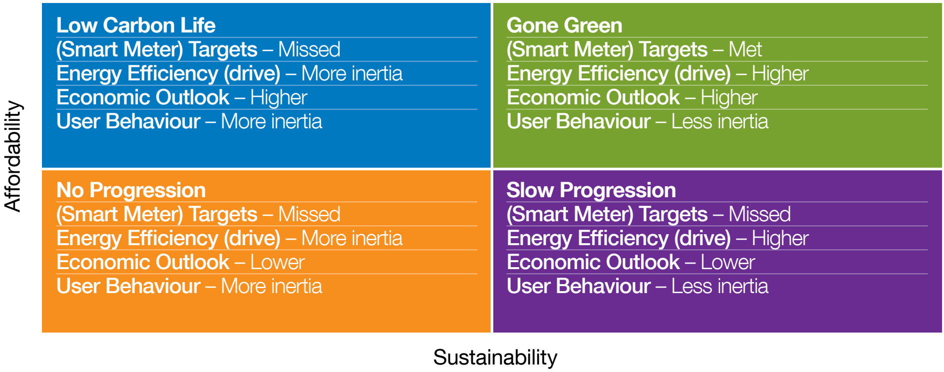
[24] AECOM Energy Demand Research Project https://www.ofgem.gov.uk/ofgem-publications/59105/energy-demand-research-project-final-analysis.pdf

Stakeholder feedback

Generally stakeholders indicated the 2013 scenarios were pragmatic starting assumptions. Some stakeholders indicated the impact could be higher or lower than shown: we will draw on the Low Carbon Networks Fund studies to enhance the scenarios and will capture wider ranges when further evidence becomes available.

In **Gone Green** 2013, some stakeholders believed the assumptions for engagement with, and roll-out of, TOUTs were optimistic. Using information published by Ofgem on consumer switching rates, in **Gone Green** 2014 we have staggered consumer adoption rates, resulting in a slight delay to consumers reducing demand at peak.

Figure 42
Axioms' impact



Low Carbon Life
(Smart Meter) Targets – Missed
Energy Efficiency (drive) – More inertia
Economic Outlook – Higher
User Behaviour – More inertia

Gone Green
(Smart Meter) Targets – Met
Energy Efficiency (drive) – Higher
Economic Outlook – Higher
User Behaviour – Less inertia

No Progression
(Smart Meter) Targets – Missed
Energy Efficiency (drive) – More inertia
Economic Outlook – Lower
User Behaviour – More inertia

Slow Progression
(Smart Meter) Targets – Missed
Energy Efficiency (drive) – Higher
Economic Outlook – Lower
User Behaviour – Less inertia

Results

In **Gone Green**, smart meters are rolled out to 95% of UK homes by 2020. In **Slow Progression**, **No Progression** and **Low Carbon Life**, smart meters achieve 95% penetration post-2030, assuming 1.5million homes obtain smart meters a year on a replacement basis.

Annual demand reduction

In **Low Carbon Life**, only 25% of the UK population (cost conscious and green consumers) reduce their annual power demand by 1% through use of the in-home display. This is due to a better economic outlook allowing less focus on energy costs, and existing behaviour around energy efficiency.

In the other scenarios 50% of the UK population (cost conscious, green and partially engaged consumers) reduce their annual power demand by 4%, due to greater focus on home budgets.

Peak demand shifting

While the annual results show a reduction in demand within the home, the peak demand analysis shows a shift away from the peak period, driven by TOUTs, where the total demand figure is not changed. This is similar to the effects seen in Economy 7, for example, whereby someone would still choose to run a washing machine but would run it at a different time of the day.

We assume that on average the TOUT is in place and causing an effect in engaged households 5 years from the point of receiving a smart meter. We assume it will reduce peak demand by 5%.

3.4 continued
Consumer

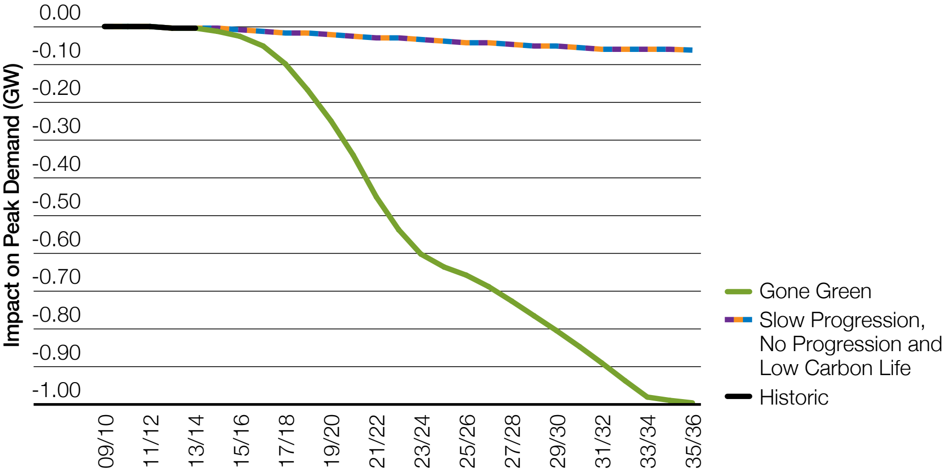
In **Gone Green**, 50% of the population engages with TOUTs (cost conscious, green and partially engaged consumers). Smart appliances become available from 2020 and these same consumers choose, and can afford, to purchase them. Peak demand for these consumers falls by a further 5% staggered over 13 years to allow for appliance replacement cycles.

In all other scenarios the green consumer segment (approximately 12.5% of the population) engages with TOUTs and reduce their peak demand by 5% on a sustained basis. Smart appliances are not rolled out in any meaningful way.

Results on peak power demand are shown in Figure 43. Whilst the peak response (prior to 2020 and smart appliances) is the same at 5% the peak reduction is greatest in **Gone Green** due to faster roll-out rates. The rate of response in **Gone Green** drops post 2020 as roll-out is completed, and engaged consumers gradually adopt smart appliances. The fall flattens post 2030 as smart appliances saturate the market amongst engaged consumers.

In all other scenarios, the rate of peak demand reduction is low due to lower levels of consumer engagement and a delayed roll-out programme.

Figure 43
Peak demand impact from residential smart meters and time-of-use tariffs



Potential variation

There is significant uncertainty as to how many, to what extent and whether consumers will engage with smart meters and TOUTs on a long-term basis. Trials, to date, have shown varied results. Responses to TOUTs are dependent on pricing structure and reward, consumer choice and the information supplied as part of the roll-out.

We have assumed that consumers will retain choice in whether to sign up to a TOUT or purchase smart appliances. If these tariffs and appliances become standard, either through government policy or by industry consensus, then demand reductions could be higher and achieved sooner than postulated in the scenarios.

In the longer term, as the take up of heat-pumps, electric vehicles and solar increases, the effects of demand on the network will change and may provide further incentive for change in the residential sector.

Consumer behaviour (heat)

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 moved by 1–2°C as a result of changing consumer behaviour. At present internal temperatures are circa 1°C below the peak level.

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.

The only scenario which assumes any change in internal temperatures is **Low Carbon Life**, which allows for growth in temperatures with improving disposable income, up to 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.

We have assumed that **Gone Green**, **Slow Progression** and **No Progression** show no consumer behaviour change as consumer awareness and lower economic developments rein in growth.

Key uncertainties:

- 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

3.5
Transport

Axioms that influence this section

- Transport
- Government Policy
- Energy User Behaviour
- Economic Outlook
- Renewable Energy/ Carbon Targets
- Energy Efficiency

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
- Trial results showing the impact of time-of-use tariffs (TOUTs) on EV charging have been incorporated in our modelling. This has reduced potential peak demands.
- Rail transport is assumed to grow and undergo further electrification in all scenarios.
- Whilst demand for maritime transport is assumed to change a little to 2050, aviation experiences sustained growth to 2030, after which there is little change.

Key statistics

Approximately **9,000** electric vehicles are on the road today: **63%** Pure-electric (PEV), **37%** Plug-in hybrid (PHEV)/Range-extended (E-REV). This equates to an annual demand of **16.75GWh** and a peak demand of **2.38MW**.

2020:
Number of electric vehicles
Gone Green and Low Carbon Life **0.57 million** (of which 29% PEV, 71% PHEV/E-REV)
Slow Progression and No Progression **0.17 million** (of which 24% PEV, 76% PHEV/E-REV)

2030:
Number of electric vehicles
Gone Green and Low Carbon Life **3.19 million** (of which 20% PEV, 80% PHEV/E-REV)
Slow Progression and No Progression **1.0 million** (of which 13% PEV, 87% PHEV/E-REV)

Demand	**Gone Green**	**Slow Progression**	**No Progression**	**Low Carbon Life**
Annual 2020 (GWh)	1,445	393	393	1,445
Annual 2030 (GWh)	8,225	2,366	2,366	8,225
ACS* Peak 2020MW	156	45	45	156
ACS Peak 2030MW	888	262	262	888

* Average Cold Spell

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

- EVs need to become more comparable in price whether this be through market changes and technological advancements or government support.
- Increased consumer awareness in order to make them a consideration at point of purchase and to tackle perceived issues such as range anxiety.
- The continued development and offer of a range of vehicles at different pricing points in the market.
- Infrastructure needs to be developed in order to support EV charging.
- TOUTs need to be adopted and responded to in order to prevent large increases to peak demand.

Further reading

- Government Policy (appendix 1)
- Economic Background (section 3.2)
- Power Demand (section 4.1)

3.19m
1.0m

Number of electric vehicles by 2030:
Gone Green and Low Carbon Life (3.19 million)
Slow Progression and No Progression (1.0 million)

3.5.1
Electric Vehicles

The majority of vehicles on UK roads are currently fuelled by petrol or diesel. Transport is responsible for a significant portion of the UK's greenhouse gas end user emissions: 23% in 2012, almost entirely through carbon dioxide emissions with road transport being the most significant source[25]. The government is therefore promoting the electrification of transport in order to enable emissions reduction as electricity becomes lower carbon. This is being achieved by the provision of grants and other incentives, such as a £5,000 discount on the cost of a vehicle and exemption from congestion charging in London.

Method

As in last year's analysis, we have focused on pure-electric (PEV), range extended (E-REV) and plug-in-hybrids (PHEV), considering their potential for deployment in both personal and commercial settings.

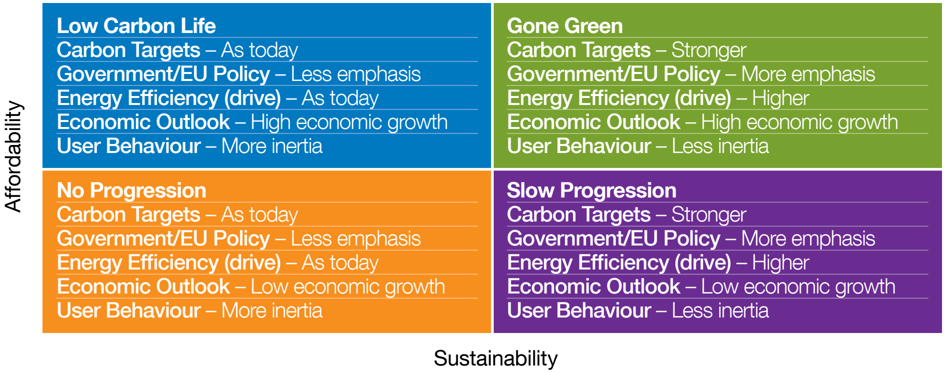
Our modelling has used historic sales figures from the Society of Motor Manufacturers & Traders, together with stakeholder views, to create a deterministic stakeholder-centric set of scenario projections for the number of EVs in circulation each year. The impact of these vehicles on the network at peak is assessed by examining their charging characteristics, along with an understanding of the typical annual mileage of UK car owners, using the outputs of real-world studies.

Due to the current cost of EV batteries and consumer range anxiety, we believe that PHEVs and E-REVs will achieve higher deployment levels quicker than PEVs. We expect initial growth to be highest in London and with second-car consumers, partly as a result of their reduced anxiety over vehicle range.

---

[25] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295968/20140327_2013_UK_Greenhouse_Gas_Emissions_Provisional_Figures.pdf

Figure 44
Axioms' impact



Low Carbon Life
Carbon Targets – As today
Government/EU Policy – Less emphasis
Energy Efficiency (drive) – As today
Economic Outlook – High economic growth
User Behaviour – More inertia

Gone Green
Carbon Targets – Stronger
Government/EU Policy – More emphasis
Energy Efficiency (drive) – Higher
Economic Outlook – High economic growth
User Behaviour – Less inertia

No Progression
Carbon Targets – As today
Government/EU Policy – Less emphasis
Energy Efficiency (drive) – As today
Economic Outlook – Low economic growth
User Behaviour – More inertia

Slow Progression
Carbon Targets – Stronger
Government/EU Policy – More emphasis
Energy Efficiency (drive) – Higher
Economic Outlook – Low economic growth
User Behaviour – Less inertia

A higher growth rate is experienced in **Gone Green**, due to increased government intervention, and **Low Carbon Life**, due to increased disposable income and EVs being considered a desirable luxury good. **Slow Progression** and **No Progression** experience lower growth rates due to slower economic recovery in these scenarios, resulting in less disposable income and EVs therefore not being affordable to the majority of consumers. Even with further government incentives in **Slow Progression**, we believe a low level of near-term disposable income will prevent potential future savings from providing enough of an incentive for consumers to purchase EVs.

Results

The 2013/14 sales figures were within the 2013 scenario range, no factors have changed significantly in the last year, and on the back of favourable stakeholder feedback, we have applied similar high and low growth scenarios to those in our 2013 scenarios.

Figure 45 and Figure 46 show our 2014 scenario projections for the number of EVs and associated annual electricity demand.

3.5 continued
Transport

Figure 45
Number of electric vehicles

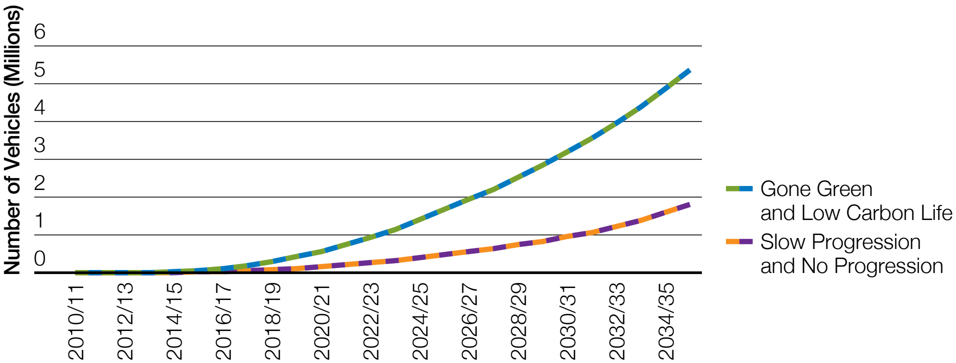
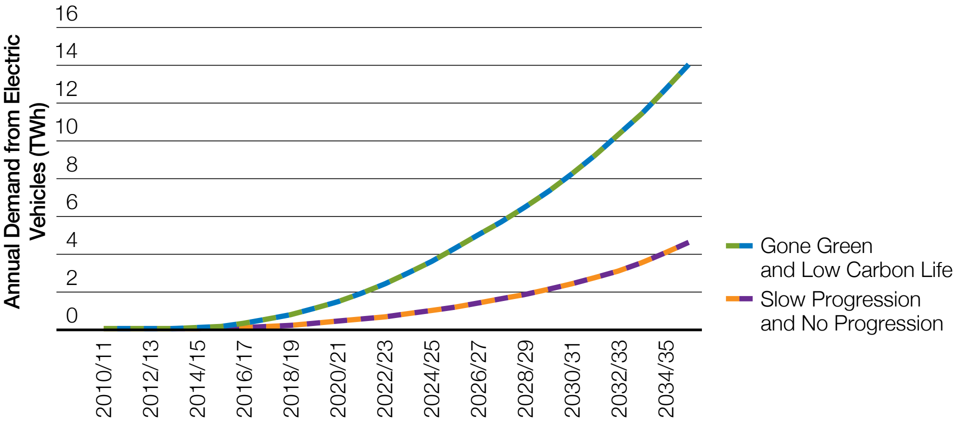


Figure 46
Annual demand from electric vehicles



Peak

Method

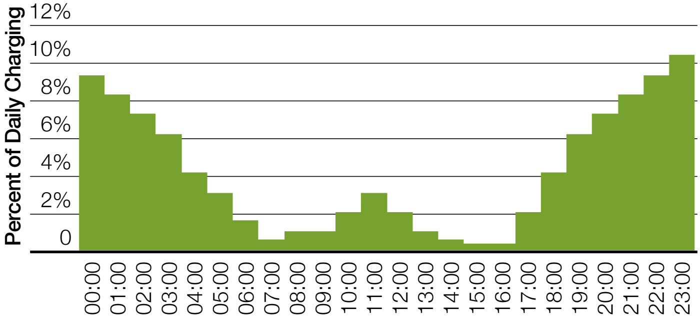
We assume that when people purchase an EV they will adopt a time-of-use tariff (TOUT) and that people will 'top-up' charge on a regular basis, in a similar manner to mobile phone charging habits. The impact of TOUTs will differ between consumers based on their natural charging preference, consumer choice and response to the pricing incentive. We have therefore broken our projections down into groups of consumers, for example, London commuters and second-car users assessed when they would naturally charge, and applied the response rates and profile information from observed studies[26].

Based on this we have created two charging profiles:

Figure 47 shows the assumed profile for commuters who may plug in at car parks, at lunchtime and when they get home at the end of the day, and charge overnight. Charging levels are lower during commuting hours. Figure 48 shows the assumed profile for shorter distance car users who can charge during the day either at home, car parks or at work. Charging levels are slightly higher during working hours and the bulk of charging is assumed to occur overnight.

We believe the indirect encouragement of these charging profiles via TOUTs could significantly reduce demand from electric vehicles and network stress at peak.

Figure 47
Commuter EV charging profile



---

[26] EPRI, Total Cost of Ownership for Current Plug-in Electric Vehicles:
http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002001728

SSE, Mini E Field Trial:
http://www.mini.co.uk/about-us/miniefficiency/mini-e/

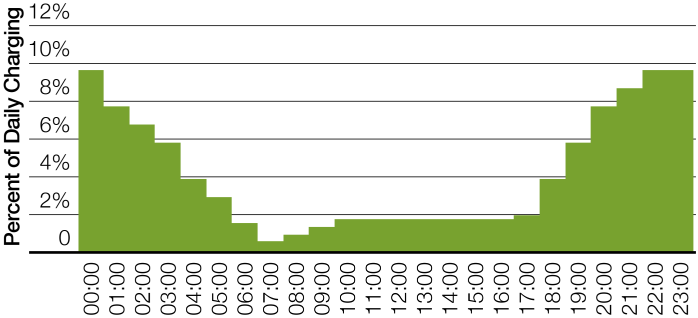
INTECH, Integration of Electric Vehicles in the Electric Utility Systems:
http://www.intechopen.com/books/electric-vehicles-the-benefits-and-barriers/integration-of-electric-vehicles-in-the-electric-utility-systems

http://vbn.aau.dk/files/55733132/Electric_Vehicles_Modelling_and_Simulations.pdf

ARUP, Cabled:
http://www.arup.com/Home/Projects/CABLED.aspx

3.5 continued
Transport

Figure 48
Shorter distance EV charging profile



Results

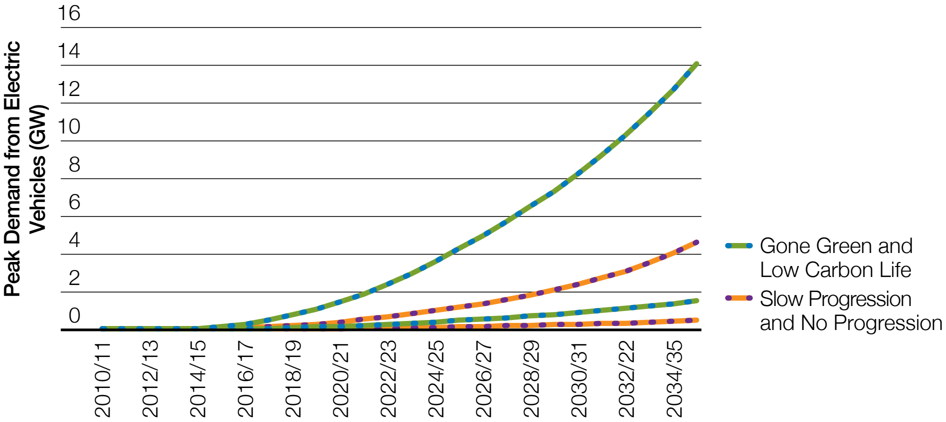
Using the charging profiles, Figure 49 shows the peak 5pm EV demand in each of our scenarios. **Gone Green** is slightly lower this year than last, due to the updated and further segmented analysis we have conducted. By 2030 peak demands reach 0.9GW in **Gone Green** and **Low Carbon Life** and 0.3GW in **No Progression** and **Slow Progression**. By 2030 if this charging behaviour was unconstrained, peak demand could be around 8GW in **Gone Green** and **Low Carbon Life** and 2GW in **No Progression** and **Slow Progression**.

Further information on the potential impact of electric vehicles may be found on-line in an article published by National Grid in October 2013.[27]

---

[27] http://www.nationalgridconnecting.com/journey-of-discovery/

Figure 49
Peak demand scenarios with assumed TOUT response



3.5.2
Rail, Shipping and Aviation

In the period from now to 2035/36, gas and electricity demand for shipping (ports) and aviation (airports) is captured within our econometric modelling processes (see section 3.2).

Projections for aviation and shipping are unchanged from last year. Aviation is based on the 'likely' scenario[28] published by the Committee on Climate Change (CCC), while shipping is based on trajectory 2 from the DECC 2050 calculator. As with last year, our UK energy system model carbon target has been adjusted to include a proportion of these international aviation and shipping emissions. We use the same assumptions for these elements of transport in all four of our 2014 scenarios.

The 2014 assumptions for rail demand are unchanged from 2013, as our review found these to still be appropriate. In all of our scenarios we have assumed further electrification of the UK rail network, and that electricity demand from rail transport grows by 2.5% per year. This is based on government ambitions[29] (which aspire to develop strategic infrastructure in order to facilitate economic growth, and reduce the running costs and carbon intensity of the network). Further electrification of the rail network meets these aims in the four scenarios, and we do not assume full electrification in any scenario as it would not be economic to do so.

---

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

[29] http://www.networkrail.co.uk/publications/strategic-business-plan-for-cp5/

3.5.3
2035–2050

Over the period 2035 to 2050 electric vehicles, both pure EVs and hybrids, make further inroads into the private car market in **Slow Progression**, **Gone Green** and **Low Carbon Life**. In these scenarios, whilst there is still fossil fuel in the car market, almost all of the cars on roads in 2050 are either EVs or hybrids. This technology leads to continuation of the significant improvements in efficiency that has been seen in recent years, which is why the total amount of energy input for car transport reduces considerably, in these scenarios. This is especially notable considering the car fleet is assumed to grow significantly. In **No Progression** the total energy for transport increases, because efficiency gains are less, due to a limited change away from the standard internal combustion engine powertrain that is prevalent today. The efficiency gains made in these vehicles are outweighed by the growth of the car fleet to 2050.

In the scenarios the change in fuel is not just due to electrification (or not) of vehicles. There is also an element of change of fuel type from petrol and diesel to hydrogen and gas. Our modelling in this area is still relatively immature, hence the detail behind the potential for hydrogen and gas is not specified, but some common themes occur. Any instances of gas and hydrogen are seen more for HGVs and buses, whilst electrification is considered more in the cars and vans due to the relative suitability of each sector for each type of fuel. An HGV is not thought so suitable for electrification due to the large energy requirement to carry the heavy loads over the longer distances. Cars and vans are more suited to electrification, due to generally shorter distances and lighter loads, for which battery storage in vehicles is more applicable.

Electrification has the greatest potential for transport to aid renewable and carbon targets out to 2050. An extra area where this could contribute is via the large battery stock in a largely electrified car fleet. These batteries may offer additional value and opportunities for energy and system balancing.

What's changed since 2013?

- Growth in numbers remained within our 2013 scenario range and stakeholder feedback did not change dramatically and hence the number of electric vehicles has remained very similar.
- Our modelling of peak demand and the impact of TOUTs has become more granular slightly increasing the impact of EV charging at peak.

Key uncertainties

With current low purchase numbers there is significant uncertainty in our projections. Purchase cost is a major determining factor in the adoption of electric vehicles. This will be influenced mostly by government incentives, reducing costs and improving performance. Other factors will include infrastructure developments and reaching a scale whereby desirability may increase or greater consumer exposure counteracts range anxiety.

3.5 continued
Transport

Figure 50
Energy inputs to transport Gone Green

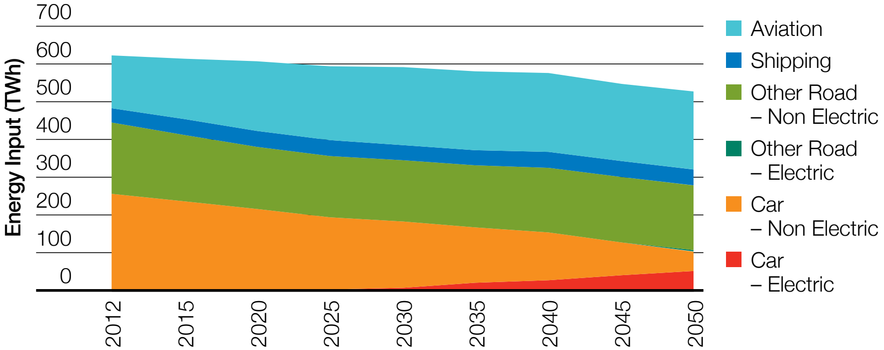


Figure 51
Energy inputs to transport Slow Progression

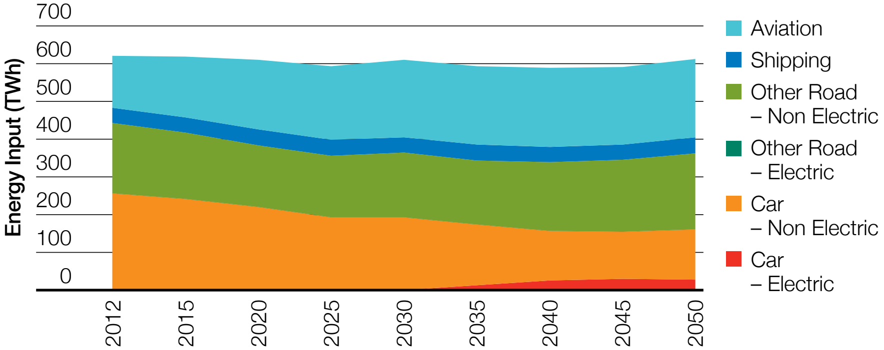


Figure 52
Energy inputs to transport No Progression

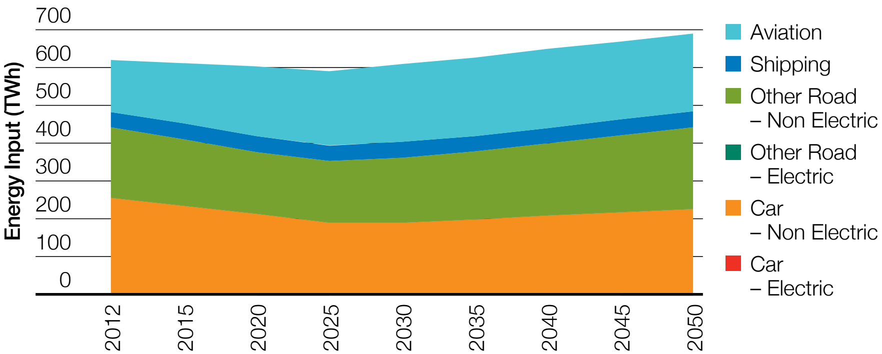
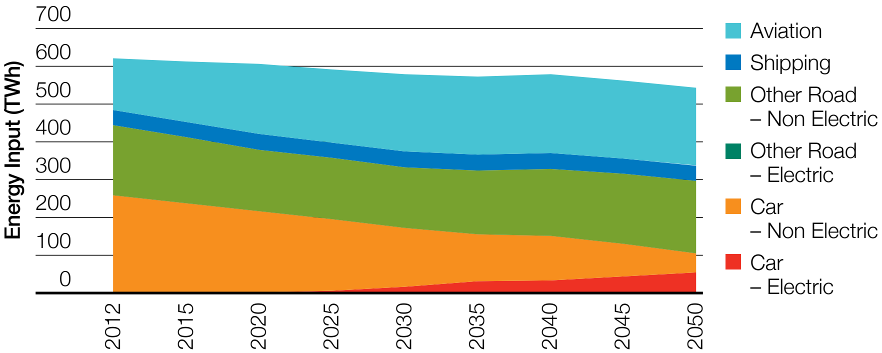


Figure 53
Energy inputs to transport Low Carbon Life



Chapter four
Scenarios

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

4.1

Power Demand

Summary

- The range of peak demand in the scenarios is narrower in the near term, widening in the later periods as risk and uncertainty increases.
- Initial declines in peak demand are seen in **Slow Progression** and **Gone Green** driven mainly by energy efficiency.
- Initial increases in demand in **Low Carbon Life** are driven by increased consumer spending, economic growth and comparably less energy efficiency.
- Growth in the later period is driven by increased numbers of houses in all scenarios.
- Further increases in demand in **Gone Green** are driven by the electrification of heat and transport, and in **Low Carbon Life**, by the electrification of transport
- Slow Progression, Low Carbon Life and Gone Green all increase due to electrification of heat and transport. The degree of this increase directly relates to the renewable and carbon reduction appetite.
- Post-2035 demand increases in Slow Progression, Low Carbon Life and Gone Green due to electrification of heat and transport. The degree of this increase directly relates to the renewable and carbon reduction appetite.

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

- Continued improvement in energy efficiency
- Increased consumer engagement resulting in changing behaviours and the adoption of new technologies
- The development, support and uptake of electrified heating and transport in conjunction with the decarbonisation of generation.

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
Electricity Interconnection

Key statistics

Demand	Gone Green	Slow Progression	No Progression	Low Carbon Life
Annual 2020 (TWh)	338	337	345	353
Annual 2030 (TWh)	345	322	337	364
ACS* Peak 2020 (GW)	59	59	60	61
ACS Peak 2030 (GW)	62	57	59	63

* Average Cold Spell

4.1 continued
Power Demand

Further reading

- Policy landscape (section 3.1)
- Demographic background (section 3.2.1)
- Economic Background (GDP) (section 3.2.2)
- Heat (section 3.3)
- Energy Efficiency Improvements: Heat (section 3.3.1)
- Heat Pumps (section 3.3.2)
- Residential Resistive Electrical Heat Demand (section 3.3.2)
- Consumer (section 3.4)
- Transport (section 3.5)
- Interconnectors (section 4.2.1)
- Distributed Generation (section 4.3.5)
- Micro-generation (section 4.3.6)

4.1.1
Annual Demand

In our Future Energy Scenarios we consider demand as the total amount of generation required, whether this comes from micro, distributed or transmission connected generation. This allows us to then assess this demand against different generation backgrounds in order to understand the impact on the GB networks.

Annual power demand, as shown in Figure 54, is weather corrected and consists of total residential, commercial and industrial demand, as well as losses and exports to Ireland. Micro-generation and embedded generation (including CHP[30]) are considered as supply, and do not reduce the demands in the scenarios shown below. Station demand[31] and pumped storage demand[32] are not included but are included in net generation output in the Power Supply (section 4.3).

GB Residential Power Demand

The residential demand scenarios account for around a third of annual power demand. The 2014 scenarios are created using a disaggregated bottom-up approach, modelling demand for the following components described elsewhere in this document:

- Appliances (section 3.4.2)
- Heating including heat pumps and hot water (section 3.3)
- Lighting (section 3.4.1)
- Electric Vehicles (section 3.5.1)
- Smart-meter associated demand reduction (section 3.4.3)
- Economic background (section 3.2)

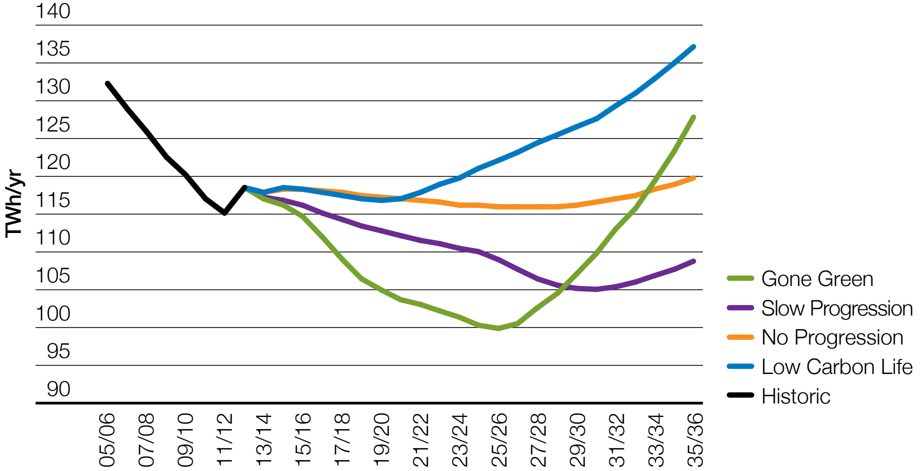
---

[30] The 2014 annual demand figures are higher than those published in 2013. This is due to different assumptions for CHP: Last year, it was assumed that all CHP power output was consumed on-site. This year we have taken this effect out of demand and considered it all as generation.

[31] Station demand is the onsite power station requirement for example for systems or start up.

[32] Pumping demand is the power required to fill hydro reservoirs.

Figure 54
Annual residential power demand



Demand fell steadily between 2005/06 and 2011/12 due to a variety of reasons including increasing energy prices, the 2008 recession, which tightened household budgets, and increasing energy efficiency. Demand increased by 3% in 2012/13, possibly due to improvements in economic conditions and consumer confidence.

The predominant difference between the residential demand scenarios in the first half of the scenario period is lighting demand. In the latter half of the scenario period, the largest distinguishing factor is the electrification of heating and transport.

Demand is highest in **Low Carbon Life**. This is due to increased affordability assumptions in this scenario which, with fewer efficiency offsets, causes higher appliance and lighting demand. In later years, the adoption of electric vehicles, which are affordable and are seen as a desirable purchase, further increases demand.

No Progression sees relatively static demand due to little change in consumer buying habits and less improvement in energy efficiency over time due to lower policy intervention and slower appliance replacement cycles.

Energy efficiency drives the initial decrease seen in **Gone Green** and **Slow Progression**. It is more pronounced in **Gone Green** due to stronger policy combined with increased appliance replacement cycles. This allows for more efficiency gains to be made (for example someone replaces their main television with a larger more efficient one sooner because they can afford to, rather than waiting until the current one breaks). Further decreases in **Slow Progression**, around 2025, are driven by improvements in lighting while the increases in **Gone Green** are caused by the electrification of heating and transport which can be afforded and are driven through policy and legislation.

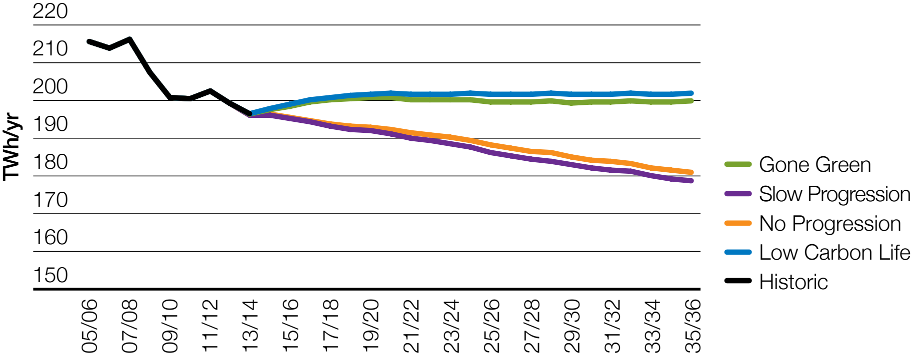
4.1 continued
Power Demand

GB industrial and commercial demand

The industrial and commercial demand scenarios account for around two-thirds of annual power demand. They are created using DECC historical demand figures by sector[33] and Experian's forecast sector outputs (see section 3.2). These are processed using an econometric regression analysis and an 11-year historic dataset. In addition to this we assess the impact of the Carbon Reduction Commitment (CRC) on industrial and commercial demand, commercial electric vehicles (e.g. taxis and small vans), and rail transport.

The scenarios are shown in Figure 55.

Figure 55
Industrial and commercial power demand



---

[33] https://www.gov.uk/government/publications/electricity-section-5-energy-trends

Demand has fallen since 2007/08 due to the 2008 recession and increased energy efficiency, particularly in the commercial sector.

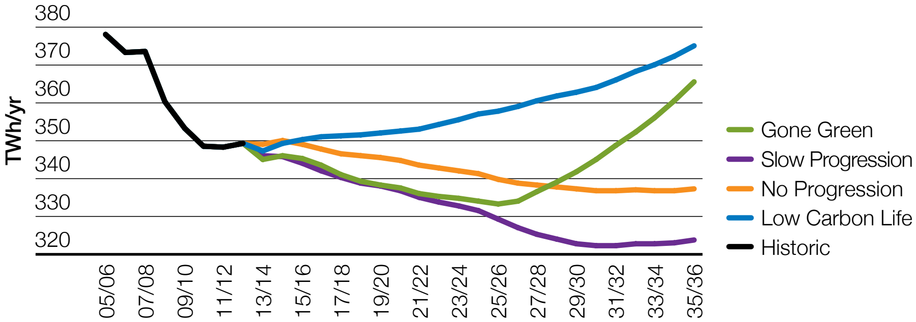
After 2014/15, demand increases in **Gone Green** and **Low Carbon Life** due to higher GDP growth assumptions of 2.5% per annum, which offsets the greater energy efficiency assumed in these scenarios.

No Progression and **Slow Progression** show lower demands due to a mix of lower GDP growth assumptions (2% per annum) and high levels of energy efficiency. The slight difference between the **Gone Green** and **Low Carbon Life** scenarios, and the **Slow Progression** and **No Progression** scenarios, is the efficiency assumptions due to the CRC analysis.

Annual GB demand

Figure 56 shows the total GB demand in the scenarios, aggregating residential, commercial and industrial demand, as well as losses and exports to Ireland.

Figure 56
GB annual power demand



Stakeholder feedback on our disaggregated bottom-up approach to residential power demand scenarios has been positive and we will continue to develop this area.

We have recognised the need to further develop our scenario creation tools for industrial and commercial demand. We are developing our understanding and modelling tools in conjunction with Arup in order to feed into the 2015 scenarios. This will allow us a greater depth of understanding and flexibility in modelling individual sectors from both a top-down (econometric) and bottom-up approach considering onsite generation and energy efficiency improvements.

4.1.2
Peak GB Power Demand

Peak demands are prepared on the same underlying basis as our annual demands (see section 4.1.1) and are weather corrected on an Average Cold Spell (ACS) basis.

Method

Peak demand is calculated by taking the underlying annual components of demand (residential, industrial, and commercial) and applying an historical assessment of how this relates to peak demand using historical outturn demands and consumption profiles. Where we are considering new technologies or behaviour changes that this historical assessment will not address we have analysed and applied this separately to create the peak demands. These include:

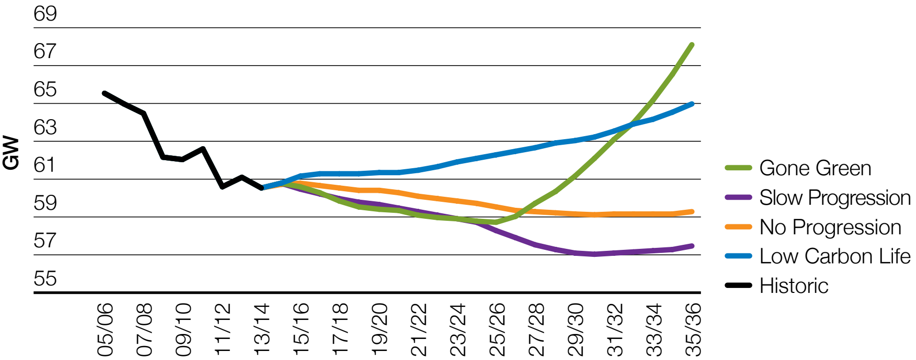
- The effects of smart metering and time-of-use tariffs
- Heat pumps
- Electric vehicles
- Interconnectors to be exporting to Ireland at peak rates

Peak demand is aligned with National Grid's February 2014 operational forecasts for Winter 2013/14 and Winter 2014/15.

Results

Annual demand trends drive the main trends in peak demand, see Figure 57. The individual peak components listed, drive changes in the longer term. This is most pronounced in **Gone Green** where the electrification of heat and transport increases peak demand at a faster rate than annual demand increases. Smart meters and TOUTs could have more than a 5% reduction on peak demand in the residential sector but the impact on national peak demand is limited in the near term by the speed of the smart meter roll-out and adoption of TOUTs.

Figure 57
Peak ACS demands



Industrial and Commercial Demand Side Response (DSR)

Demand Side Response (DSR) can be described as deliberate actions undertaken by customers to temporarily reduce their demand, in response to incentives or signals from the market, an energy supplier or a grid operator.

Residential DSR is covered in the Smart Meters and Time-of-Use Tariffs section (3.4.3). We refer here to Industrial and Commercial DSR as being the potential for this sector to reduce their demand on the grid (be it through demand reduction or on-site back up generation) at peak times. We have not prescribed or defined the market they are operating within. The peak demand scenarios shown in this document do not include any reduction for industrial and commercial DSR. However, DSR is considered for operational and planning purposes within National Grid.

Table 6
Industrial and Commercial Demand Side Response Scenarios at Peak (GW)

	2013	2020	2030
Gone Green	1.5	2.2	2.1
Slow Progression		2.8	2.3
No Progression		2.8	2.7
Low Carbon Life		3.0	3.0

The 2012 Element Energy study ‘Demand Side Response in the Non-Domestic Sector’ was used as the starting point for peak DSR analysis. This includes processes and building management systems (including lighting). The DSR potential increases to 2020 as customers increasingly engage with DSR in order to reduce costs. To 2030, the scenarios assume DSR falls or levels off as increasing energy efficiency reduces the amount of demand which may be temporarily reduced.

4.1.3
2035–2050

Electricity demand continues to grow in all scenarios from 2035 to 2050. The growth in demand varies between scenarios. The main growth from 2035 in the scenarios is in the heat, transport and exports sectors, which also show the greatest variation between scenarios. The higher demands beyond 2035 are in the scenarios with more renewable and carbon reduction achievement, as electrification of heat and transport using decarbonised and renewable electricity is where there is significant opportunity to meet UK environmental targets. As progress towards the environmental targets stalls in **No Progression**, there is no increase in these sectors post-2035. The increase in exports is to balance the system effectively as a result of spare generation at certain times, and these scenarios have some import requirement too to enable balancing, when there is a need. This is far more cost effective than building extra generation for this need. As **No Progression** has limited renewable or low carbon generation, it has low exports.

The demand for the four scenarios is shown in Figures 58 to 61. The 'Non-substitutable Demand[34]' represents the traditional underlying demand for historic electricity, such as lighting and appliances.

---

[34] 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

Figure 58
Gone Green electricity use to 2050

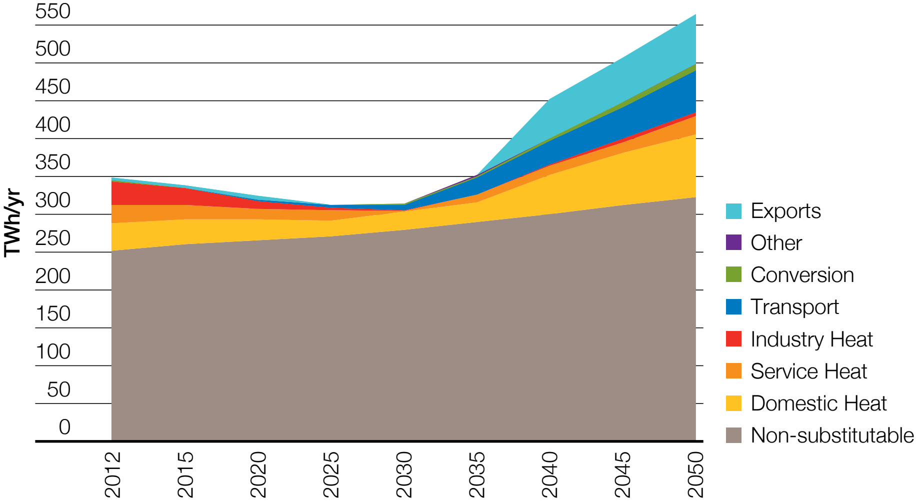
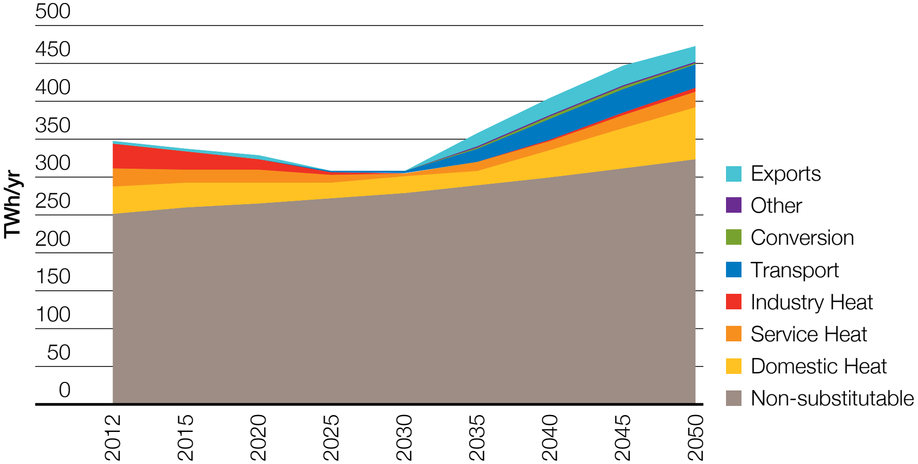


Figure 59
Slow Progression electricity use to 2050



4.1 continued
Power Demand

Figure 60
No Progression electricity use to 2050

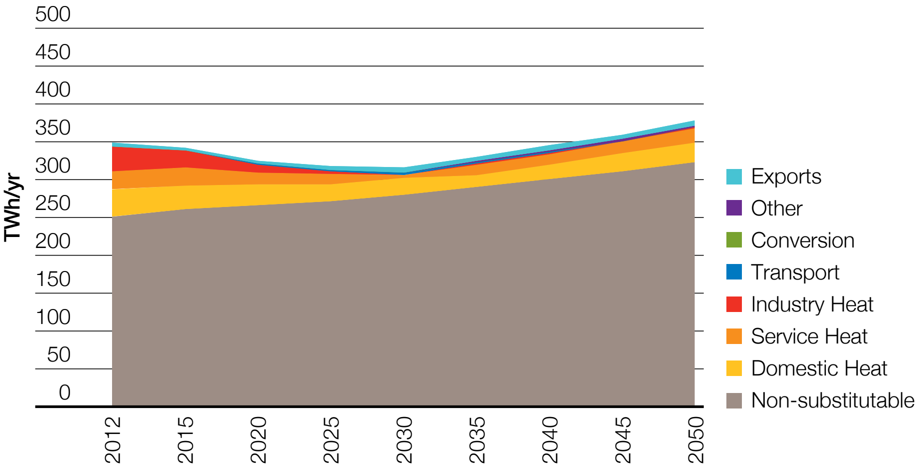
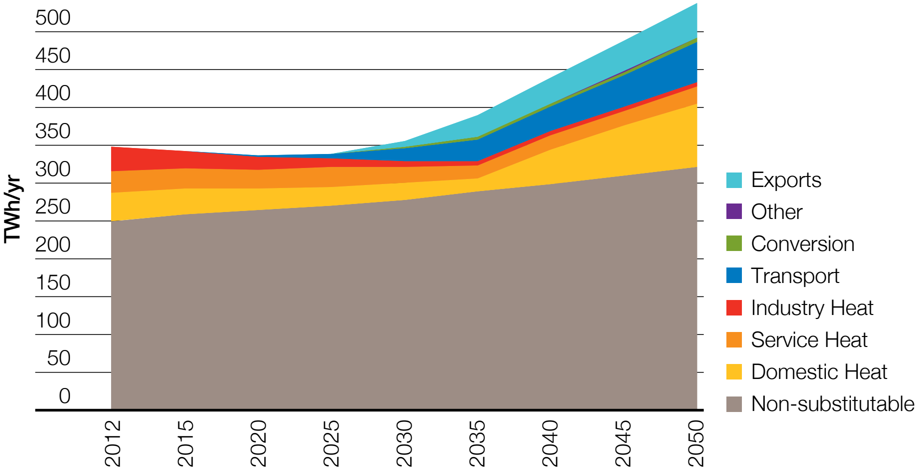


Figure 61
Low Carbon Life electricity use to 2050



Improving our within-day understanding of demand

In order to gain a better understanding of peak demand and within-day demand profiles we are developing a new modelling method.

The disaggregated, bottom-up approach we aim to develop will require a significant amount of research to establish which elements have an impact on the peak and the within-day load profiles and how they will evolve in the future. There will be many variables to consider for which there is only a small evidence base to draw on such as TOUT, energy efficiency, consumer behaviour etc.

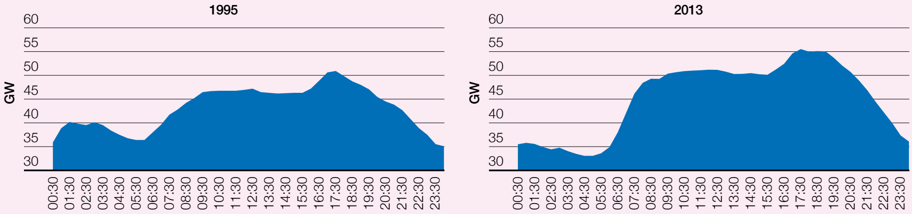
For the residential sector the individual profiles for consumer units such as washing machines, lighting, heating, ICT (information communication technologies) will be established. From these starting points the future changes to the individual profiles will be assessed by applying information drawn from numerous sources, such as trade bodies, research, government projections, new technologies, and stakeholder engagement.

Changes in consumer behaviour and technological advances will be central to this modelling. It will require an understanding of questions as diverse as:

- What will TOUTs look like in the future, and how will different tariffs affect behaviour and consumption of different electrical loads?
- How will technology advancements change demand with new technologies being developed and improvements in energy efficiency. For example will there be a continual advance in ICT and audiovisuals and how will this shift consumer behaviour; will TV be the dominant information portal into a household or will there be a shift to streaming via laptops and tablets or all of them? Will home working become more prevalent?

Having addressed such questions, these profiles will then be recombined to construct future projected profiles. But, as this is a large piece of work, there will be a prioritisation of the profiles investigated with wet goods, lighting, heating, ICT and audiovisual being the first for analysis as we believe these have the largest propensity for change which will vary across our scenarios.

Peak Demand Day Profiles for 1995 and 2013



The last 18 years has seen significant change in daily demand profiles. We aim to improve our analysis to thoroughly understand what will change over the next 20 years.

4.2
Flexible Power Sources

Axioms that influence this section

Government Policy

Electricity Interconnection

Summary

Interconnection

- The stronger regulatory and policy environment in **Gone Green** and **Slow Progression** drives higher levels of interconnection. Weaker policy and regulatory approach in **Low Carbon Life** and **No Progression** leads to lower levels of capacity.
- In **Gone Green** total annual flows across all interconnectors change from net import to export between 2020 and 2035, driven by levels of GB renewable generation.

Electricity storage case study

- Up-front cost reductions or a framework that facilitates access to multiple revenue streams are needed to make storage commercially competitive, but we recognise this 'revenue stacking' can be complex.
- Flexibility is a key benefit of storage. There is a need to understand how the value of flexibility changes over time and what the market is willing to pay to deliver it. In contrast the market recognises the value of capacity in financial mechanisms.

Key statistics

- Current installed interconnector capacity is **~4GW**
- Gone Green **~6GW** in 2020, **~11GW** in 2030
- Slow Progression **~6GW** in 2020, **~8GW** in 2030
- No Progression **~5GW** in 2020, **~7GW** in 2030
- Low Carbon Life **~5GW** in 2020, **~7GW** in 2030

Further reading

- Government Policy (appendix 1)
- Economic Background (section 3.2)
- Power Demand (section 4.1)
- Power Supply (section 4.3)

4.2.1
Interconnectors

Electricity interconnectors are transmission assets that connect the GB market to those of other European countries and allow market participants to trade electricity between countries. We model annual interconnector flows and make assumptions on the flows at peak times for each scenario to help our understanding of the ability of our scenario-based supply sources to meet demand.

For each scenario, the level of interconnection capacity, peak flows and annual flows feed into our demand and generation scenarios. Export flows (i.e. flows out of GB) and import flows (i.e. flows into GB) are treated as demand and generation respectively, feeding into the development of those parts of the scenarios.

Method

Total interconnector capacity in our scenarios is developed through a rule-based deterministic approach. The planned connection dates for interconnectors and other projects being discussed publicly are the starting point and this aspirational view is supplemented by assessing stakeholder feedback, market intelligence and ENTSO-E (European Network of Transmission System Operators for Electricity) data against our interconnector axiom and scenario assumptions. The stronger regulatory and policy environment in **Gone Green** and **Slow Progression** is anticipated to drive higher levels of interconnection.

There is currently major focus of European policy-makers on interconnectors, with an ongoing discussion on a potential interconnector target of 15% of installed generating capacity by 2030. In GB a new cap and floor regulatory regime is also in development for pre-2020 interconnector projects. These significant developments could bring existing and new interconnector projects to market earlier in the forthcoming years and this will be reflected in our 2015 analysis.

Peak flow assumptions are based on analysis of historic flows. Annual flows for Irish and continental interconnection are modelled separately. A separate continental dispatch model is used for electricity flows only.

Results

In **Gone Green** there is approximately 6GW of interconnection in 2020 and approximately 11GW in 2030, which is equivalent to 10.7% of installed generation capacity[35] in 2030. **Slow Progression** has similar capacities to **Gone Green** in 2020 but with a slower build rate resulting in approximately 8GW in 2030 or 6.5% of installed generation capacity.

The weaker policy and regulatory approach resulting from the interconnector axiom in **Low Carbon Life** and **No Progression** results in lower capacities, with approximately 7GW in both scenarios in 2035, which is 6.3% and 7.7% of installed generation capacity respectively.

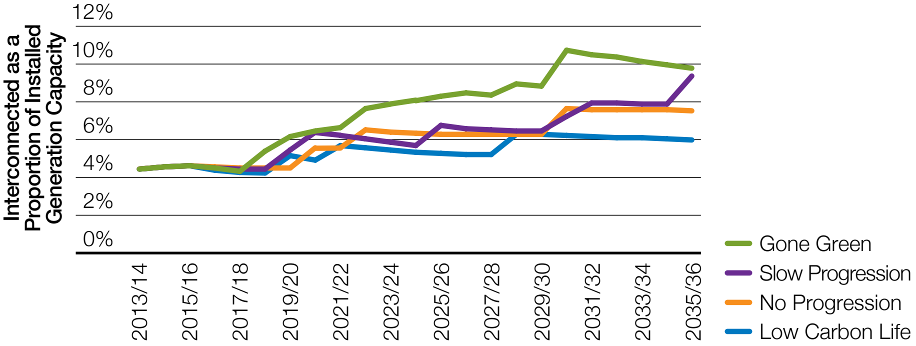
Interconnector capacities for each scenario are shown as a comparison with generation capacity, in Figure 62.

---

[35] Using the European Network of Transmission System Operators – Electricity (ENTSO-E) Ten Year Network Development Plan (TYNDP) definition of level of interconnection compared against capacity, where micro-generation is not included in installed generation capacity. We treat Irish wind projects as generation in our scenarios but they are included as interconnection for the purposes of this calculation, in line with ENTSO-E and European Commission classifications.

4.2 Flexible Power Sources

Figure 62
Proportion of interconnection in comparison with installed capacity



We assume for all scenarios that at times of peak demand electricity will be exporting to Ireland and continental interconnection will be importing at a similar level. The result would be that GB as a whole would have a net position of zero MW being imported and exported. This assumption is based on analysis of historic flows.

Flows to and from Europe are highly sensitive to both GB demand and supply mix and also those of the country they are connected to. This means both the levels of imports and exports flowing through the interconnectors are subject to a great deal of uncertainty.

In **Gone Green**, total annual flows across all interconnectors change from net import to export between 2020 and 2035. This is as a result of the level of GB renewable generation compared to continental Europe. The same pattern of flows is seen in last year's scenarios but with a higher volume of exports in 2035. The increasing level of solar power in GB is a key driver in the rise in export flows. The flows in **Low Carbon Life** follow the same pattern over time, but at a lower level than **Gone Green**.

Slow Progression is similar to last year in that total annual flows remain at the net import position on a consistent basis throughout all years. Flows in **No Progression** follow the same behaviour as **Slow Progression**, but at a higher level.

4.2.2
Case Study: Storage

Opportunities and challenges for electricity storage

There is a widely held view that electricity storage has a role to play in the future of energy, helping to integrate increasing levels of renewable generation into the UK generation mix. The ability to store and release electricity at chosen periods provides flexibility and could help to mitigate the variability of renewable generation such as wind and solar. It would also have the advantage of enabling the capture of electricity when prices are low, or capturing electricity when supply exceeds demand. The ability to take electricity off the system when there is an oversupply of generation has the effect of flexing the generating capacity that is available.

There are a number of challenges associated with electricity storage. Regardless of the type and scale of electricity storage, there will be fixed costs attached. In order to cover these fixed costs and make it a viable business, the storage device will require a certain number of cycles per year. For technologies where the fixed costs are high, as is often the case for technologies in their infancy, a high payment per cycle or high number of cycles across the expected asset life will be required in order to recover the up-front costs. In addition, there is the challenge of round trip efficiency – the ratio of total electricity output (discharge) to the total energy input (charge); the lower the round trip efficiency, the greater the losses. Round trip efficiency varies between storage devices, ranging from ~50% for compressed air energy storage to in excess of 85% for a number of battery technologies.

National Grid procures Balancing Services in order to balance electricity demand and supply. These services are currently provided through a number of routes, which electricity storage would have to compete against. Current balancing solutions include demand side response (DSR), interconnectors, flexible generation, and existing pumped hydro energy storage.

Background

We conducted a case study to investigate the potential for electricity storage to become a viable, cost competitive tool. The case study provides a starting point for discussion as to whether it is reasonable to include increased levels of electricity storage, in addition to existing pumped hydro, within our scenarios. The findings have been considered alongside stakeholder feedback and market intelligence.

Scope

The case study investigated Sodium Sulphur (NaS) batteries, Lithium ion (Li-ion) batteries, pumped hydro energy storage (PHES) and compressed air (both below and above ground) energy storage (CAES). The scope was focused on these technologies due to their relative level of maturity and the technologies being deployed in UK trials. We recognise that there are large volumes of energy storage existing in the UK, for example in the form of hot water tanks and electricity storage heating. These are opportunities that could be and are readily utilised today. They have been kept outside of the scope of this case study.

Our analysis explored the number of years taken to recover the cost of these electricity storage technologies through revenue from individual reserve services alone (STOR and Fast Reserve) and the decrease in total plant costs that would be necessary in order to recover costs.

4.2
Flexible Power Sources

The following equation was used to estimate the years taken to recover the total cost of each storage device, with cost figures and asset characteristics obtained from the DOE/EPRI 2013 Electricity Storage Handbook[36]:

$$\frac{\text{(Total Plant Cost + O\&M costs)}}{\text{(annual revenue – annual electricity cost)}}$$

Total Plant Costs (TPC) were allocated to assets of specific sizes, with small and large capacity cases considered for each electricity storage technology. This led to a range in the number of years taken to recover costs for each technology.

The minimum technical requirements for Short Term Operating Reserve (STOR) and Fast Reserve were applied, including those relating to asset capacity, response time and duration. Assets under 3MW for STOR and 50MW for Fast Reserve were aggregated to meet the minimum capacity and TPC was adjusted accordingly. A weighted average cost of capital (WACC) of 15% was applied to reflect the relatively high investment risk and uncertainty surrounding electricity storage technologies.

Operating and Maintenance (O&M) costs were calculated based on fixed O&M costs (per MW capacity), periodic major maintenance (per MW capacity) and variable O&M costs (per MWh volume). As with TPC, minimum technical requirements for STOR and Fast Reserve were applied and O&M costs were adjusted accordingly.

Annual revenue was calculated using average availability and utilisation payments for STOR and Fast Reserve, based on data from National Grid's Monthly Balancing Services Statement (MBSS) and Procurement Guidelines report[37]. The hours available were based on the windows during which units are contracted for STOR and Fast Reserve each year, with the assumption that devices would cycle 365 times per year, and hence be utilised on a daily basis. For annual revenue, asset capacity was capped at the maximum requirement for Fast Reserve (c400MW); no assets exceeded the maximum requirement for STOR (c3000MW). It was assumed that all prices were flat and not indexed across the period investigated.

An offpeak power price of c£36/MWh from May 2014 was used to calculate the annual fuel costs, factoring in the round trip efficiency of each technology and the hours utilised for reserve services.

The following lifetimes were assumed for the technologies: 15 years for NaS and Li-ion batteries, 60 years for PHES, and 40 years for both above- and below-ground CAES.

---

[36] DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA: http://energy.gov/sites/prod/files/2013/08/f2/ElecStorageHndbk2013.pdf

[37] http://www2.nationalgrid.com/UK/Industry-information/Electricity-transmission-operational-data/Report-explorer/Services-Reports/

Findings

The following charts illustrate the gap between total cost and the revenue from both reserve services for each technology.

Figure 63
NaS battery: comparison of total costs against revenue over 15-year lifetime

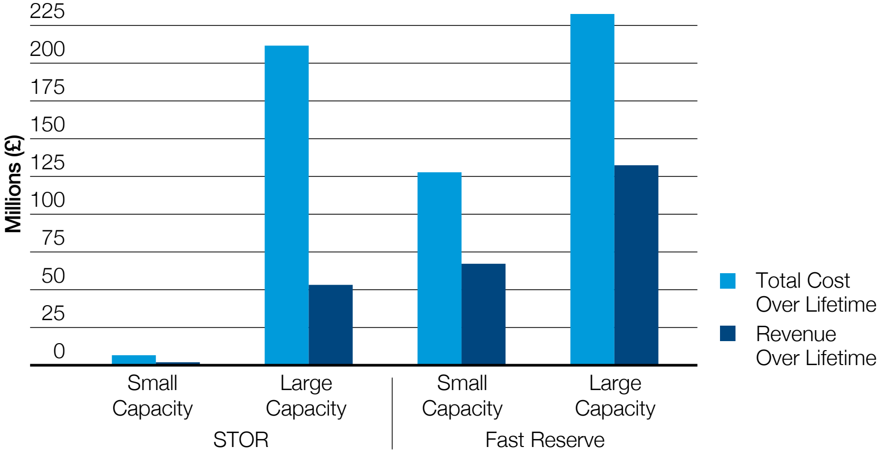


Figure 64
Li-ion battery: comparison of total costs against revenue over 15-year lifetime

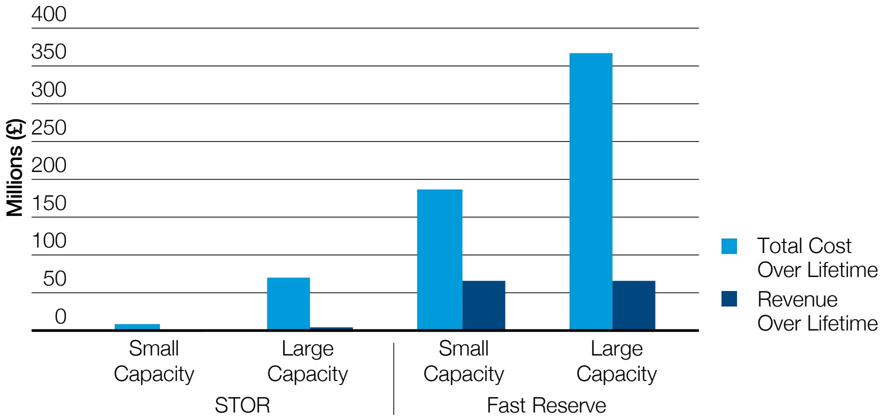


Figure 65
PHES: comparison of total costs against revenue over 60-year lifetime

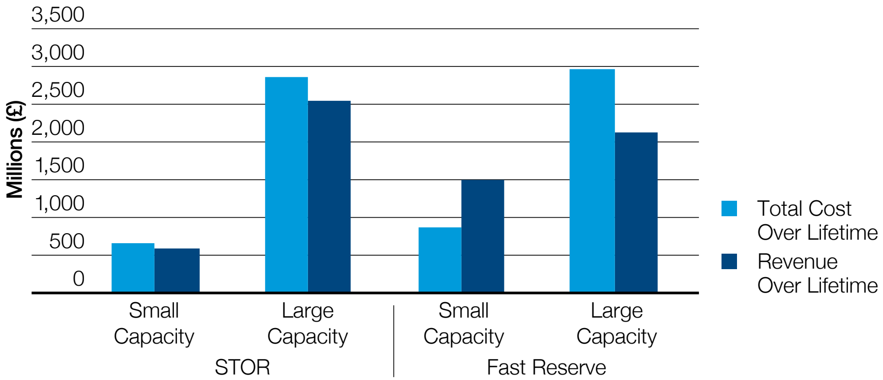


Figure 66
Below-ground CAES: comparison of total costs against revenue over 40-year lifetime

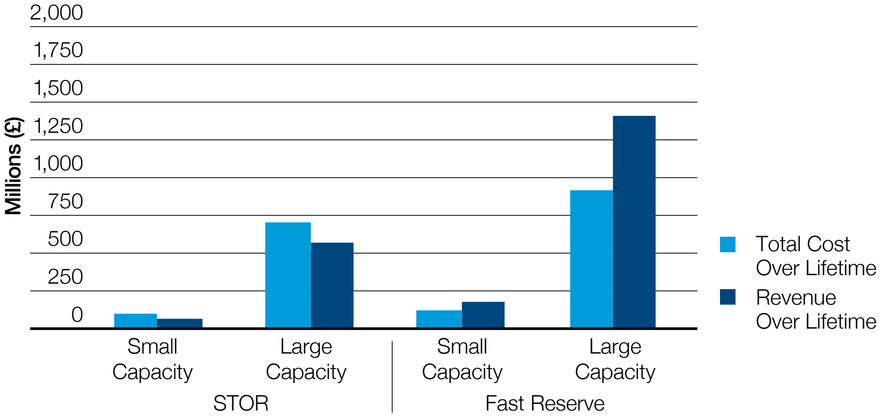
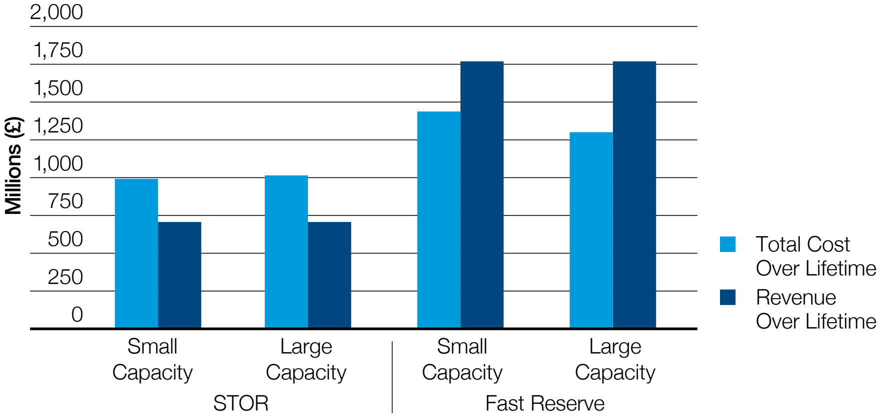


Figure 67
Above-ground CAES: comparison of total costs against revenue over 40-year lifetime



4.2
Flexible Power Sources

Under the assumption that storage providers receive revenue from providing STOR alone, we found that no storage technology considered within the case study recovers its costs within its lifetime. This is not the case for Fast Reserve, which emphasises the value of the fast response times of electricity storage.

Below-ground and above-ground CAES are the only technologies to recover their costs within their asset lifetime through providing Fast Reserve alone for both the small and large capacity cases. For PHES, only the small capacity asset recovers its cost within its lifetime. The large capacity PHES plant fails to recover its costs through providing Fast Reserve as it is not fully utilised; the costs are aligned to the actual asset capacity of 1200MW, whereas annual revenue is aligned to the capped capacity of 400MW. However the case study does not take into account the fact the spare capacity could be seeking revenue streams in other areas.

Both NaS and Li-ion batteries have a lifetime of 15 years; neither battery technology recovers its costs within this period from providing either reserve service. This is most likely the consequence of limited asset sizes for battery technologies. Although the battery devices were aggregated to meet the minimum capacities for STOR (3MW) and Fast Reserve (50MW), the asset sizes are still considerably smaller than those of CAES and PHES devices. Therefore, although TPC and O&M costs are generally lower for the battery technologies, availability and utilisation payments are also considerably smaller.

In order to recover costs during the lifespan of each technology, assuming revenue and cost of electricity remains fixed, the following table shows the required reductions in total plant costs:

Device	**Cost reduction required for STOR**	**Cost reduction required for Fast Reserve**
NaS	80–85%	52–58%
Li-ion	>99%	>99%
PHES	15–17%	0–41%
CAES below ground	67–71%	No reduction required
CAES above ground	51–53%	No reduction required

Market intelligence suggests specific components of each technology could be targeted to reduce the capital costs of energy storage. Battery cells account for almost 50% of the capital cost of a battery energy storage plant, therefore this is the component where reductions would be beneficial. The capital costs of PHES and CAES could be reduced by finding cheaper sites or excavation techniques. However, PHES is geographically constrained and there is limited potential for new sites within the UK. It is also a mature technology, accounting for 99% of the world's electricity storage, and therefore it is unlikely to see significant cost reductions in the future.

These findings emphasise the importance of either cost reductions in the manufacturing/build of storage assets or the ability for multiple revenue streams. It appears that in the majority of cases, providing a reserve service alone yields insufficient revenue to recover costs within a device's lifetime. Furthermore, our analysis assumes that the storage asset will cycle 365 times a year, is available for the full STOR or Fast Reserve windows and therefore receives the maximum availability payment. This may not be realistic. However, an average number of hours was used for utilisation payments, assuming utilisation is evenly spread across the portfolio.

In addition to participating in Balancing Services, storage providers may pursue price arbitrage opportunities in the wholesale market; buying (charging) when prices are low and selling (discharging) when prices are high. Depending on O&M costs, this will rely on sufficient price differentials between offpeak and peak prices. There may also be value in helping to improve transmission and distribution network capacities, potentially resulting in deferred or avoided investment, providing storage devices can offer a level of reliability that is similar to or better than that of traditional network assets. However, stacking revenue streams, so storage owners can access multiple simultaneous revenue streams, can be complex.

Questions for further investigation

As electricity storage must compete with balancing tools that are currently more economic such as DSR, interconnection and flexible generation, it is important to understand if and at what point storage may become essential to the efficient operation of the electricity system and market.

It will be important to monitor developments in the world of electricity storage over coming years and the impact of potential 'game changers' such as the launch of Tesla's Gigafactory to produce Li-ion batteries on an unprecedented scale by 2020. Anecdotal evidence suggests the cost of Li-ion batteries is falling, and Tesla anticipates the Gigafactory will drive down the per kWh cost of their battery packs by at least 30%. In addition, the findings of UK innovation projects will be valuable in enhancing the industry's understanding of the potential of electricity storage.

One of the key benefits electricity storage offers is flexibility. To achieve the UK's carbon reduction targets, the value of capacity is recognised, with associated financial mechanisms in place. It is crucial to understand how the value of flexibility changes over time and what the market will be willing to pay to deliver it. Only once these questions are answered will it become clear if or when the market needs to start turning to storage.

Cost reductions or access to multiple revenue streams is needed for electricity storage to be a commercially viable solution.

4.3 Power Supply

Axioms that influence this section

- Renewable Energy/ Carbon Targets
- Government Policy (UK & Europe)
- Fossil Fuel Prices
- Carbon Price
- Wind Generation
- Solar PV Generation
- Hydro Generation
- Wave and Tidal Generation
- Bio-energy Generation
- Nuclear Generation
- CCGT/OCGT
- Coal Generation
- Carbon Capture and Storage Generation
- Electricity Interconnection
- CHP

Summary

- Our **Gone Green** generation background has adequate installed capacity to generate enough renewable electricity by 2020 to meet the government renewable energy targets and sufficient low carbon generation to comply with the carbon budgets.
- The continued focus on environmental targets within our **Slow Progression** scenario ensures continued support for the deployment of renewable generation. However, the less favourable economic conditions compared to **Gone Green**, mean that low carbon and renewable technologies are deployed at a slower rate.
- The generation background in **No Progression** has adequate installed capacity to ensure security of supply with particular emphasis placed on cheaper forms of generation.
- In **Low Carbon Life**, investment in power generation is underpinned by growth in the economy. There is higher deployment of renewable generation at a local level compared to the other scenarios. The long-term decarbonisation strategy places increased emphasis on low carbon technologies, in particular, for nuclear and carbon capture and storage (CCS) generation.

Further reading

- Government Policy (appendix 1)
- Economic Background (section 3.2)
- Power Demand (section 4.1)
- Flexible Power Sources (section 4.2)
- Gas Demand (section 4.4)
- Gas Supply (section 4.5)

Key statistics

	2013/14	Gone Green 2020/21	Slow Progression 2020/21	No Progression 2020/21	Low Carbon Life 2020/21
Installed Capacity	91GW	106GW	97GW	93GW	105GW

		Gone Green 2015/16	Slow Progression 2015/16	No Progression 2015/16	Low Carbon Life 2015/16
Security of Supply: LOLE		3.75hrs	2.94hrs	3.82hrs	4.92hrs

What needs to happen for the targets to be met?

- Life extensions for existing nuclear power stations confirmed and new plant to obtain relevant consent and final investment decision approval.
- Sufficient consents, support and finance for offshore and onshore wind in order to meet the target level in 2020 and beyond.
- An effective supply chain in place to reduce barriers to delivery in the offshore industry.
- Commercial deployment of technologies such as CCS and marine energy.
- Successful implementation of Electricity Market Reform (EMR) to ensure support for low carbon technologies and a capacity market to maintain security of supply.
- Development of networks to allow increasing levels of variable and low carbon generation to connect.

Security of supply

One of the key proposals from the EMR is the establishment of a reliability standard for security of supply, as introduced by the Department of Energy and Climate Change (DECC) in the Delivery Plan[38]. The reliability standard has been set at 3 hours per year, based on the loss of load expectation (LOLE) metric[39].

The LOLE represents the number of hours per year in which supply is expected to be lower than demand under normal operation of the system. This does not however mean that customers will be disconnected or that there will be blackouts for that number of hours a year. In circumstances when available supply is not high enough to meet demand the National Electricity Transmission System Operator (NETSO) can call upon a range of tools to mitigate the effects of unmet demand, for instance reducing the voltage of electricity on the electricity system, calling upon generators to increase to their maximum possible output and/or accessing the new balancing tools[40].

Our power supply backgrounds have been developed as to not exceed the 3 hour LOLE threshold from 2018/19 onwards and so identifying the level of new build generation capacity required to meet this standard. Pre 2018/19 the LOLE is an output derived from our analysis modelling.

---

[38] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268221/181213_2013_EMR_Delivery_Plan_FINAL.pdf

[39] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/267613/Annex_C_-_reliability_standard_methodology.pdf

[40] https://www.ofgem.gov.uk/publications-and-updates/decision-funding-arrangements-new-balancing-services

4.3 continued
Power Supply

4.3.1
Method

Generation capacity

Our power supply backgrounds are developed using a rule-based deterministic approach. The scenario narrative and axioms provide the uncertainty envelope that determines the emphasis placed on the different types of generation technology within each scenario. The emphasis placed on a particular generation technology is determined by a number of factors such as market intelligence, historic and predicted growth rates, government policy and legislation, project status and economics applicable to that particular technology.

The generation backgrounds are then developed to meet the security of supply standard for each of our demand scenarios and stay within the allowed spend profile for each year as specified by the Levy Control Framework (LCF)[41].

Market intelligence

Our market intelligence focuses on three key areas:

- Developer Profile: information relating to the developer of a certain project or portfolio of projects, providing insight into how and when projects may develop.
- Technology: looking at developing technologies to gauge the impact they may have on the generation mix.
- Financial Markets: the financial markets are also considered in terms of how easy it will be for the developer to raise the capital to complete the project or where available capital may be deployed in a portfolio.

Government Policy and Legislation
Energy legislation enacted at European and national level will impact what sources of power generation are developed and connected to the electricity system (see appendix 1).

Project Status
The project status is a key indicator in determining when a power station may connect or decommission from the electricity system. For new power stations, the factors considered include: whether a generator has a signed connection agreement to the electricity grid (if applicable), has the project acquired the necessary planning consent and has a final investment decision been taken. For existing power generation, it is important to consider any decommissioning dates (e.g. nuclear), potential replanting of stations (e.g. wind, gas) and the lifecycle for particular technologies.

Plant Economics
This area explores the economic viability of the power generation fleet. It considers a number of factors to derive the revenue and associated costs which are used to determine the plant profitability for a number of case studies. Factors considered included fuel, carbon and power prices and fixed and variable costs associated to a particular power station and/or technology.

---

[41] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209276/EMR_Spending_Review_Announcement_-_FINAL_PDF.pdf

Generation supply

The generation supply for each source of power is determined from the respective installed capacities and the relative cost of generation. This is determined by the Short Run Margin Cost (SRMC) for each technology. For each half hour the stations which are available, with the lowest SRMC, operate until the projected demand in that half hour is met, the generation supply is then aggregated to annual levels, the results of which may be seen in section 4.3.3.

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

Zero short run marginal costs

The first tranche of technologies have zero SRMC; these are typically renewable technologies such as wind and marine. These are assumed to operate 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 7.

Table 7
Renewable technology average load factors

Technology	**Annual Average Load Factors**
Onshore Wind	28%
Offshore Wind	38%
Solar PV	11%
Hydro	33%

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 and combined heat and power (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 8. Again these availabilities are based on observed history and taking into account improvements in future technologies.

Table 8
Low carbon technology average availabilities (transmission connected)

Technology	**Average Availability**
Nuclear	75%
Biomass	65%
CHP	60%
CCS	85%

Fossil fuel plant
The final tranche of technologies are fossil fuel plant. These include coal, gas and oil fuelled plant. The SRMC of these plants is determined by the cost of fuel and of CO_2 (carbon dioxide) emissions (see section 3.2.5 for further detail).

The figures shown in section 4.3.3 provide the generation capacity and output for each scenarios at key spot years. Our capacity charts are split by technology while our output charts are categories by fuel used by that generation technology.

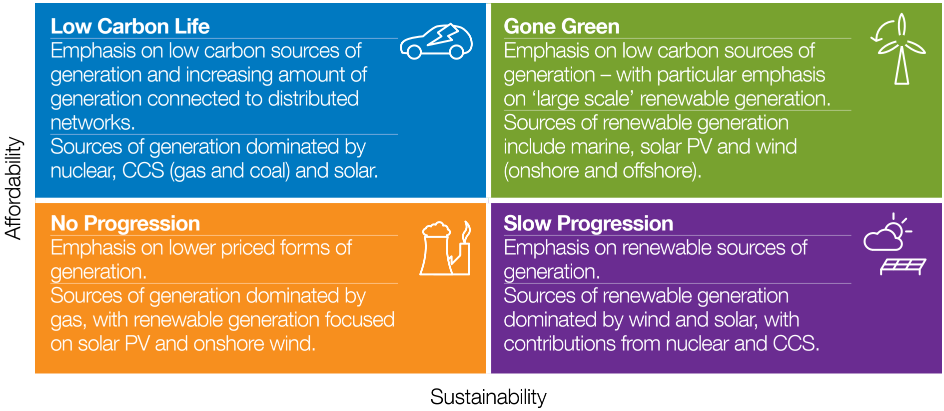
4.3.2
Overview

Our four power supply scenarios provide alternative outcomes for the future sources of electricity generation. The scenarios illustrate how the power supply mix is shaped by decisions taken on the three cornerstones of energy policy: sustainability, affordability and security of supply.

Our scenarios consider all sources of generation irrespective of where and how it is connected.

Our scenarios show the total Great Britain (GB) generating capacity connecting to the transmission and distribution networks, plus micro-generation. The sources of generation are dependent on the emphasis placed on sustainability and affordability within each scenario as illustrated by Figure 68. Security of supply, in the longer term, targets the 3-hour LOLE reliability standard which has been introduced as part of EMR (see section 4.3.4).

Figure 68
Power supply technology emphasis



Low Carbon Life
Emphasis on low carbon sources of generation and increasing amount of generation connected to distributed networks.
Sources of generation dominated by nuclear, CCS (gas and coal) and solar.

Gone Green
Emphasis on low carbon sources of generation – with particular emphasis on 'large scale' renewable generation.
Sources of renewable generation include marine, solar PV and wind (onshore and offshore).

No Progression
Emphasis on lower priced forms of generation.
Sources of generation dominated by gas, with renewable generation focused on solar PV and onshore wind.

Slow Progression
Emphasis on renewable sources of generation.
Sources of renewable generation dominated by wind and solar, with contributions from nuclear and CCS.

4.3.3
Power Supply Landscape

How and when the different sources of generation may influence the power supply landscape is illustrated by our scenario envelope. The outcomes of our analysis are generation mixes that show how we generate our electricity and how these sources may change in the future.

2013/14 to 2018/19
The sources of power generation continue to be largely centred on traditional technologies and their compliance with environmental legislation e.g. Large Combustion Plant Directive (LCPD) and Industrial Emissions Directive (IED). The influence of renewable generation on the power supply landscape increases over this period. All scenarios have similarities regarding the flavour of the generation mix with subtle changes due to slightly different technology emphasis.

2019/20 to 2025/26
This is the period which sees the impact of existing environmental legislation on the generation fleet, with the potential connection of substantial volumes of renewable generation and closure of fossil fuel plant as the affected power stations choose how they comply and subsequently operate within the provisions of the IED legislation. The impact of the IED legislation and the options available to the affected plant are illustrated in our scenarios with the greatest impact on coal-fired generation. All of our scenarios have the majority of coal power stations closing by 2023 as they select not to comply with the IED requirement.

2026/27 to 2035/36
This period considers the extent to which the generation fleet is decarbonised with the potential connection of substantial volumes of low carbon and renewable technologies and the commercialisation of the next generation of power station technologies.

Gone Green
Figures 69 and 70 show the power supply landscape in our **Gone Green** scenario which has been shaped by the switch from traditional (fossil fuel-based) generation technology to a supply mix with increased levels of renewable and low carbon generation to achieve the climate change targets.

Figure 69
Gone Green generation background

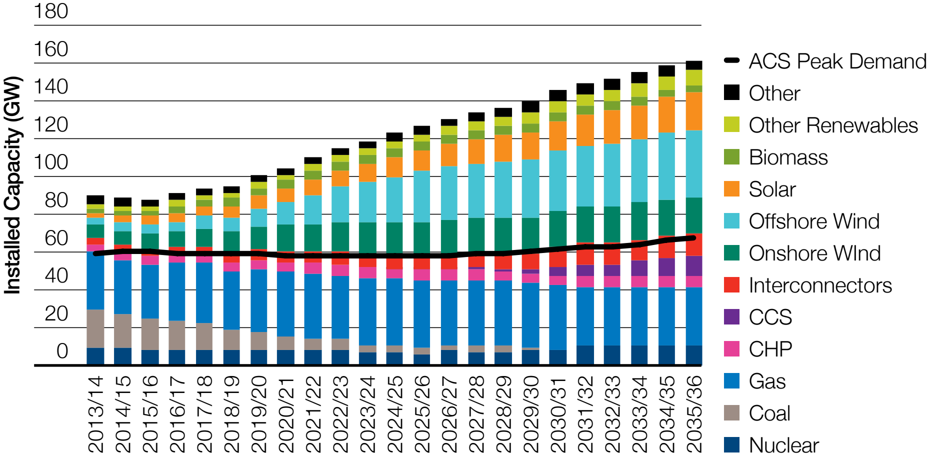
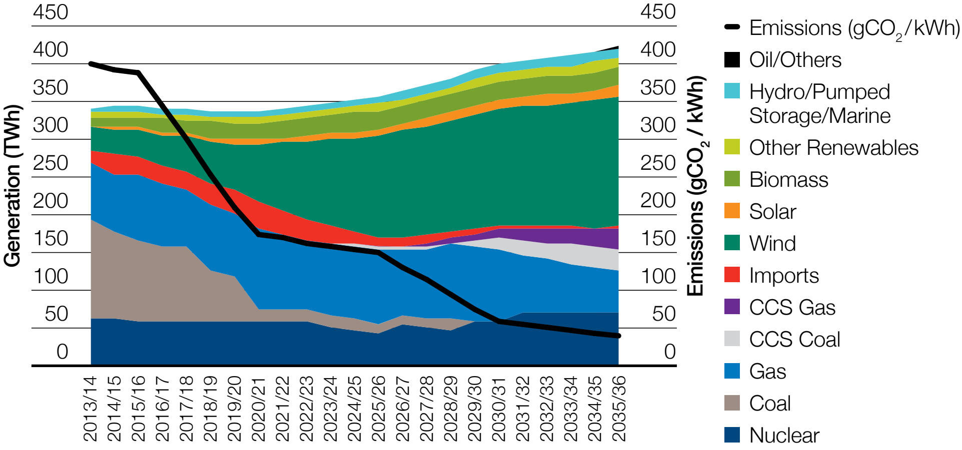


Figure 70
Gone Green generation output



4.3 continued
Power Supply

Given the maturity of the technology and the opportunity for large scale deployment, the growth in renewable generation is centred on wind and solar. The installed capacity levels for offshore wind triple by 2020 as the larger offshore wind projects become operational, with similar deployment rates occurring for solar photovoltaic (PV) and onshore wind over this period. By 2020/21, wind (onshore and offshore) and solar PV generation represents 31.9% of the supply mix and 24.2% of electricity output, with the first Round 3 offshore wind farm project connecting in 2017/18.

The deployment of renewable generation continues out to 2035/36, with renewable generation representing 53.8% of installed capacity and contributing over 50% of the electricity output. Wind and solar PV continue to provide the largest contribution of renewable energy, representing 46.0% of the supply mix and 43.5% of electricity output by 2035/36.

Figures 71 to 74 show snapshots of the generation background and associated output for our **Gone Green** scenario at 2020/21 and 2035/36.

Coal and oil generation declines as power stations which have opted-out from the LCPD close and the impact of the IED requirements influence how affected plant (particularly coal) operate under the new legislation on carbon emissions. The requirements of IED and the emphasis on decarbonising the energy sector, results in no transmission connected coal-fired power station operating post-2030. The closure of the coal power stations means that additional generation is required to connect in order to maintain the security of supply standard. **Gone Green** shows an increase in the installed capacity of gas-fired generation as new power stations become operational.

The lower deployment rate of new gas-fired generation post-2025 is counterbalanced by a significant increase in the connection of nuclear and CCS (coal and gas) power stations as the sources of electricity shift to lower carbon-based technologies to ensure the achievement of the climate change targets at 2050. By 2035/36, nuclear and CCS generation represents 13.3% of the supply mix and 30.3% of electricity output, with the first new nuclear and CCS power stations connecting in the mid-2020s. Table 9 shows the installed capacity level for our **Gone Green** scenario.

Table 9
Gone Green installed capacity levels

	Installed Capacity Levels				
	2013/14 MW	2020/21 MW	2025/26 MW	2030/31 MW	2035/36 MW
Nuclear	9,471	8,981	6,383	9,022	10,692
Coal	20,454	7,217	3,264	-	-
Gas	30,760	34,085	36,575	33,729	31,904
CCS	-	-	304	4,522	10,964
Onshore Wind	6,727	13,669	18,093	19,149	19,446
Offshore Wind	4,083	12,581	26,587	31,935	35,375
Solar	2,263	7,456	11,394	15,563	20,054

4.3 continued
Power Supply

Figure 71
Gone Green 2020/21 power generation capacity

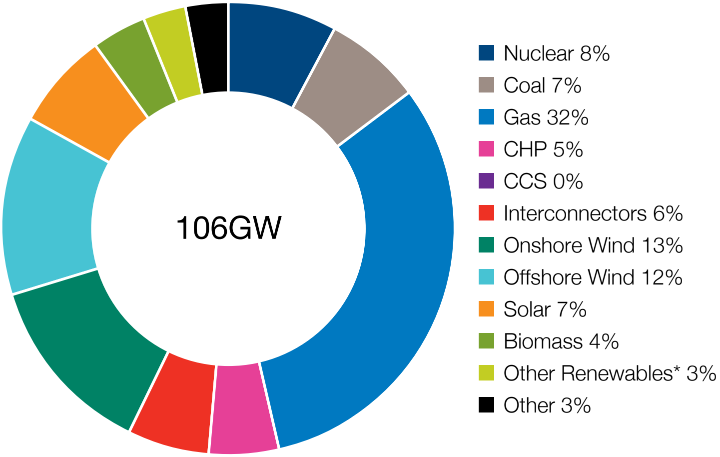


Figure 72
Gone Green 2020/21 power generation output

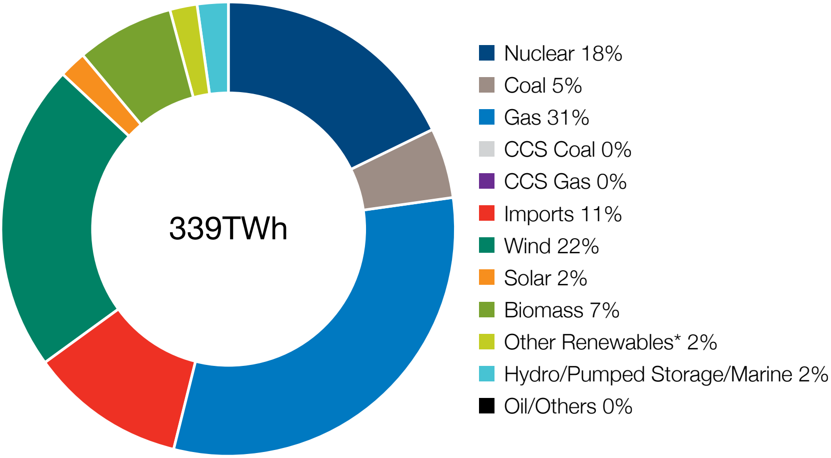


Figure 73
Gone Green 2035/36 power generation capacity

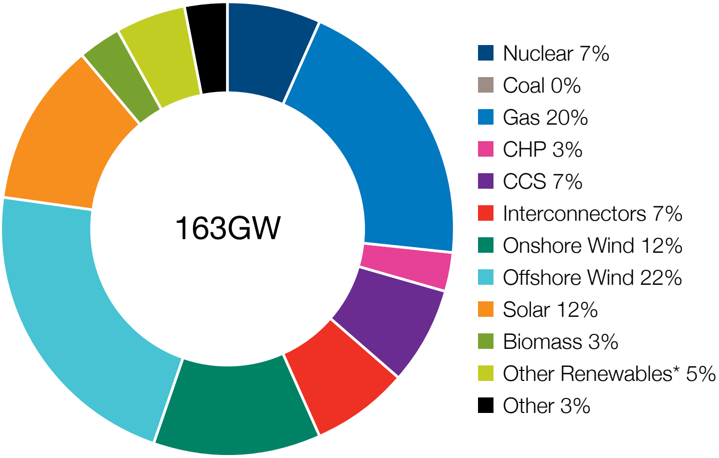
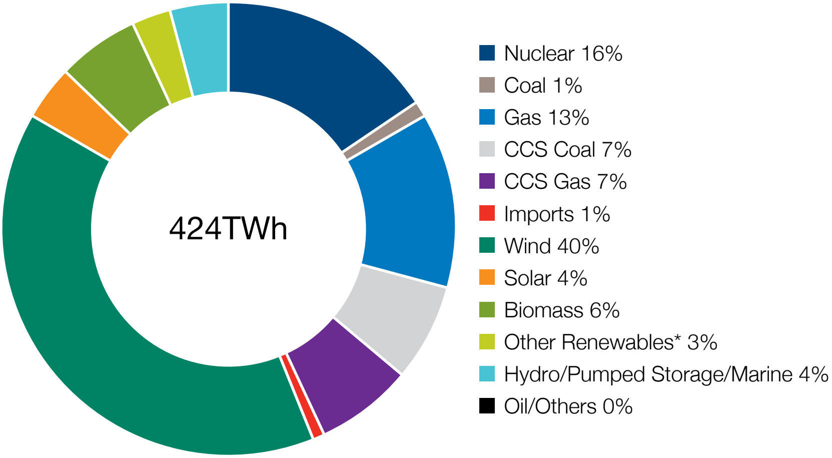


Figure 74
Gone Green 2035/36 power generation output



*Anaerobic digestion, landfill gas, sewage, waste and advanced conversion technology.

4.3 continued
Power Supply

Slow Progression

The future power supply landscape in **Slow Progression** is also shaped by the switch from traditional (fossil fuel based) generation technology to a supply mix with increased levels of renewable generation, as environmental legislation and the sustained focus on reducing greenhouse gas emissions has an impact, as illustrated in Figures 75 and 76.

Our **Slow Progression** scenario has an increasing volume of renewable generation being deployed, albeit at a slightly lower level than in **Gone Green** given the less favourable economic conditions. Renewable deployment remains focused on wind and solar PV technologies. The deployment of solar PV doubles out to 2020 as developers benefit from lower capital costs and continued financial support for this technology. There are similar deployment rates for wind (onshore and offshore) over this period, with an 80% increase in installed capacity by 2020/21. By 2020/21, wind (onshore and offshore) and solar PV generation represents 25.7% of the supply mix and 17.5% of electricity output.

Figures 77 to 80 show snapshots of the generation background and associated output for our **Slow Progression** scenario at 2020/21 and 2035/36.

Figure 75
Slow Progression generation background

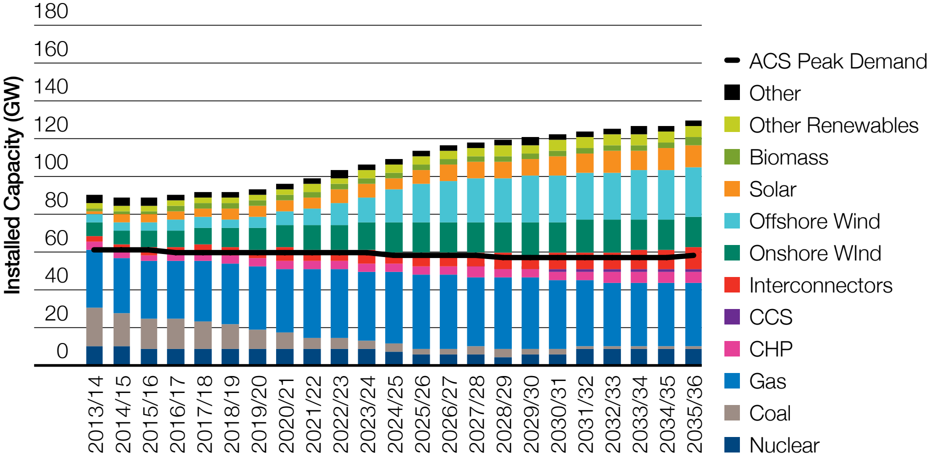
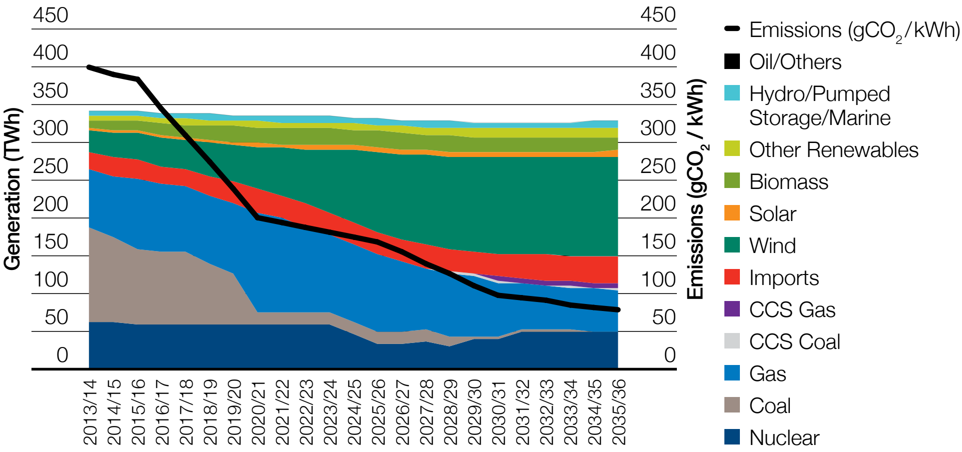


Figure 76
Slow Progression generation output



4.3 continued
Power Supply

Figure 77
Slow Progression 2020/21 power generation capacity

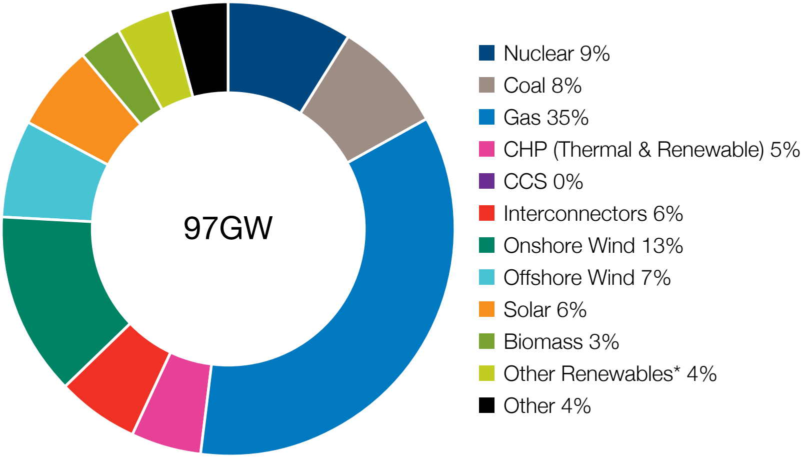


Figure 78
Slow Progression 2020/21 power generation output

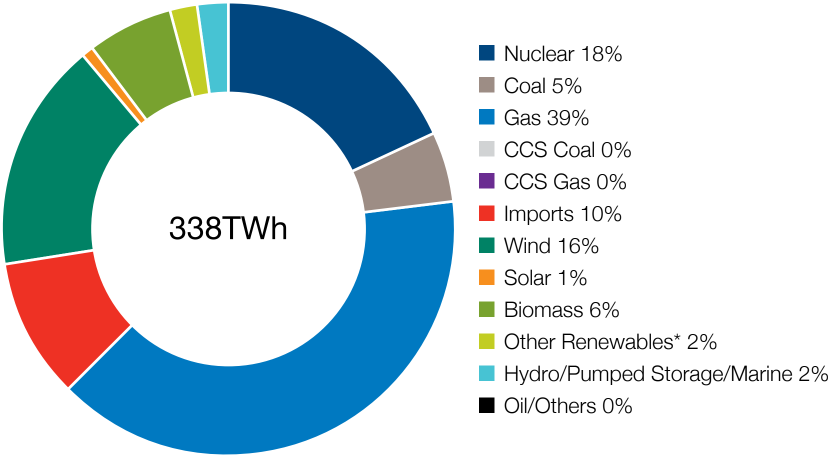


Figure 79
Slow Progression 2035/36 power generation capacity

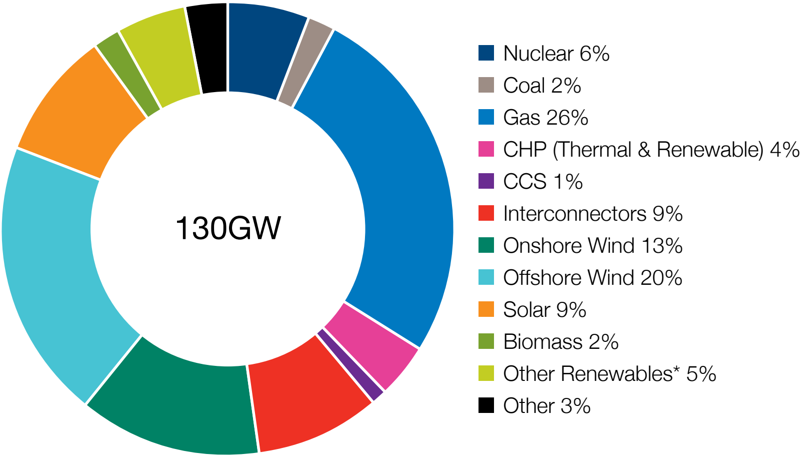
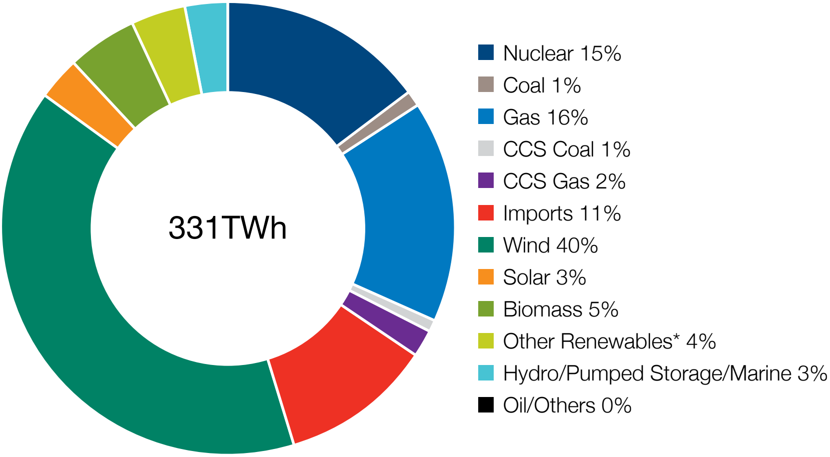


Figure 80
Slow Progression 2035/36 power generation output



*Anaerobic digestion, landfill gas, sewage, waste and advanced conversion technology.

4.3 continued
Power Supply

The deployment of renewable generation continues out to 2035/36, with renewable generation representing 49.9% of installed capacity and contributing over 50% of the electricity output, which is comparable with our **Gone Green** scenario. Wind and solar PV continue to provide the largest contribution of renewable energy, representing 42.1% of the supply mix and 42.5% of electricity output by 2035/36, with the first Round 3 offshore wind farm project connecting in 2021/22.

The reduction in traditional forms of generation remains focused on coal and oil, with a reduction in installed capacity and associated generation output of approximately 40% by 2018/19 from the coal fleet due to IED requirements effective from January 2016. **Slow Progression** shows an increase in the installed capacity of gas-fired generation, to maintain the security of supply standard due to the closure of the majority of coal fleet. New gas-fired generation offsets the closure of older plant which has been assumed not to comply with the IED out to 2025/26. There is a limited new build programme post-2025 as alternative low carbon technologies, in particular nuclear and CCS, begin to connect to the electricity transmission system.

The deployment of low carbon based technology strengthens from 2025 onwards albeit at a lower rate than that in our **Gone Green** and **Low Carbon Life** scenarios due to the less favourable economic background. In the last 10 years, our **Slow Progression** scenario sees the next generation of nuclear power stations becoming operational and the introduction of CCS technology. By 2035/36, nuclear and CCS generation represents 7.2% of the supply mix and 17.1% of electricity output. Table 10 shows the installed capacity level for our **Slow Progression** scenario.

Table 10
Slow Progression installed capacity levels

	Installed Capacity Levels				
	2013/14 MW	2020/21 MW	2025/26 MW	2030/31 MW	2035/36 MW
Nuclear	9,471	8,981	5,179	6,222	7,892
Coal	20,454	7,855	3,902	1,194	1,194
Gas	30,760	34,250	38,752	36,250	34,290
CCS	-	-	-	1,104	1,504
Onshore Wind	6,727	12,158	15,884	16,551	16,801
Offshore Wind	4,083	7,202	20,166	25,215	25,715
Solar	2,263	5,488	7,388	9,612	12,253

No Progression

Figures 81 and 82 show that the future power supply landscape in **No Progression** is dominated by cheaper forms of generation (traditional and renewable technologies). The impact of current environmental legislation has an impact on the sources of generation from the latter half of this decade.

Our **No Progression** scenario shows gas-fired generation as the dominant fuel source representing 37.1% of installed capacity by 2020/21. The installed capacity increases to maintain the security of supply standard due to the closure of the majority of the coal fleet and the lower deployment of renewable generation out to 2020/21.

Our **No Progression** scenario has an increase in the installed capacity levels for renewable technologies out to 2020/21, albeit at a reduced levels when compared with our other scenarios. The focus for renewable deployment is centred on wind and solar due to their relatively lower costs. By 2020/21, wind (onshore and offshore) and solar PV generation represents 22.1% of the supply mix and 13.6% of electricity output.

Figures 83 to 86 show snapshots of the generation background and associated output for our **No Progression** scenario at 2020/21 and 2035/36.

4.3 continued
Power Supply

Figure 81
No Progression generation background

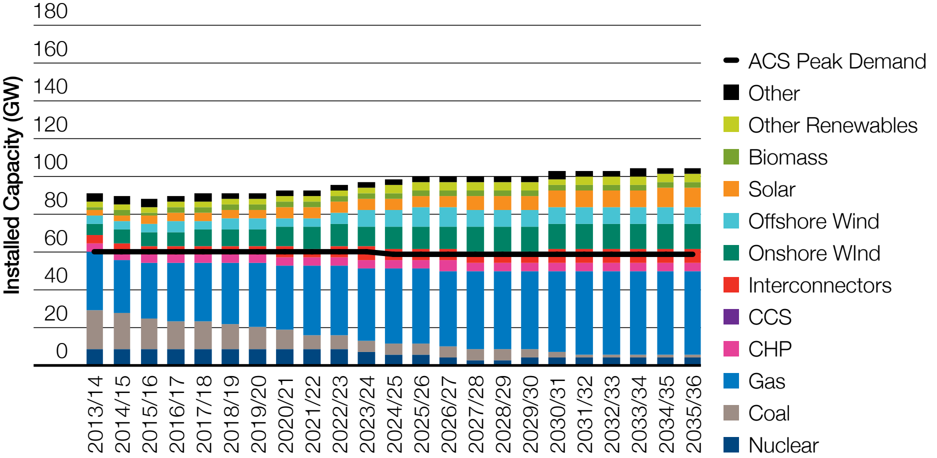
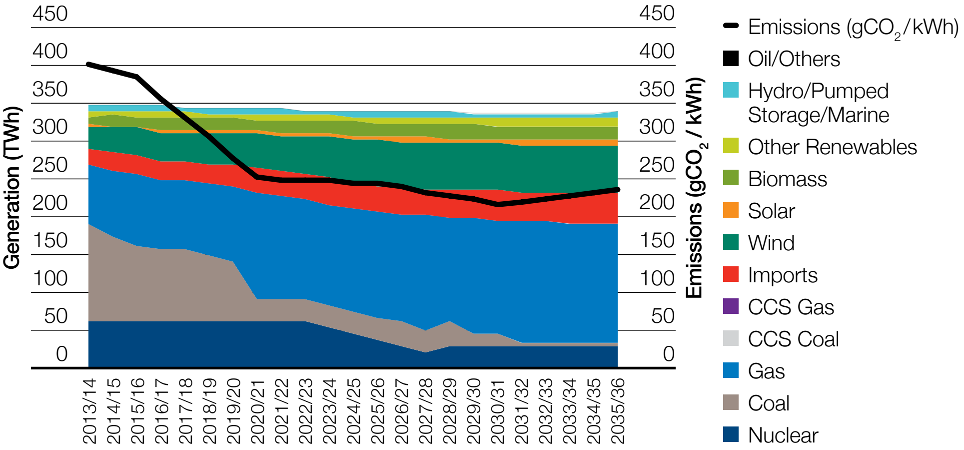


Figure 82
No Progression generation output



The deployment of gas-fired generation continues out to 2035/36 representing 41.2% of installed capacity and contributing over 40% of the electricity output. The connection of new gas-fired generation offsets the closure of older plant, which has been assumed not to comply with the IED requirements and cease operation.

The reduction in capacity is dominated by the decrease in coal-fired generation due to IED related closures and the decrease in nuclear as the existing nuclear fleet decommission. The reduction in nuclear capacity is slightly offset by the commissioning of a new nuclear power station in late 2020s. Our **No Progression** scenario has no CCS generation connecting due to the less favourable economic backgrounds and the subsequent focus on cheaper forms of generation.

The deployment of renewable generation continues out to 2035/36, with renewable generation representing 38.2% of installed capacity and contributes over 30% of the electricity output. Renewable deployment is focused on solar PV, due to its relatively low cost. There is limited wind deployment post 2020/21 with a 43% increase in installed capacity levels by 2035/36 as a handful of the larger Round 3 offshore wind farms connect from 2022/23 onwards. Table 11 shows the installed capacity level for our **No Progression** scenario.

Table 11
No Progression installed capacity levels

	Installed Capacity Levels				
	2013/14 MW	2020/21 MW	2025/26 MW	2030/31 MW	2035/36 MW
Nuclear	9,471	8,981	5,659	4,552	4,552
Coal	20,454	9,797	5,855	2,897	1,914
Gas	30,760	34,488	39,568	42,465	43,214
CCS	-	-	-	-	-
Onshore Wind	6,727	10,261	12,161	12,430	12,642
Offshore Wind	4,083	5,192	9,441	9,441	9,441
Solar	2,263	5,091	6,622	8,274	10,042

4.3 continued
Power Supply

Figure 83
No Progression 2020/21 power generation capacity

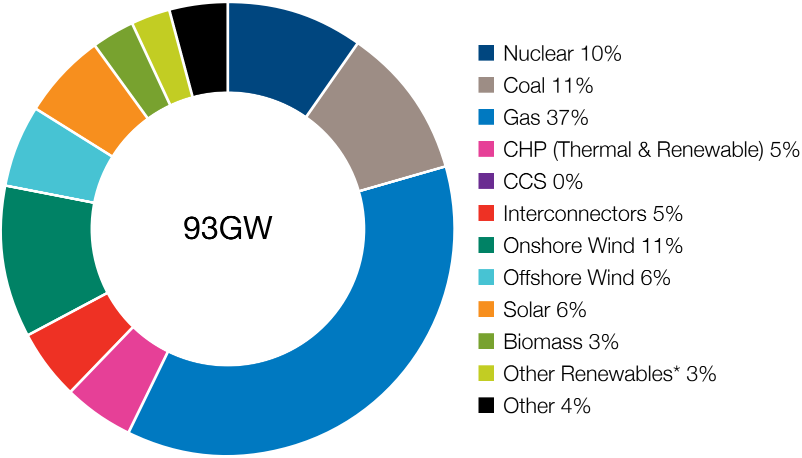


Figure 84
No Progression 2020/21 power generation output

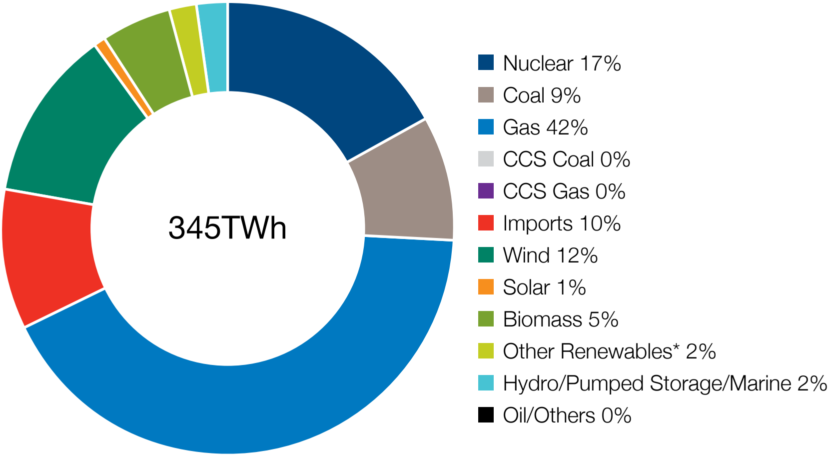


Figure 85
No Progression 2035/36 power generation capacity

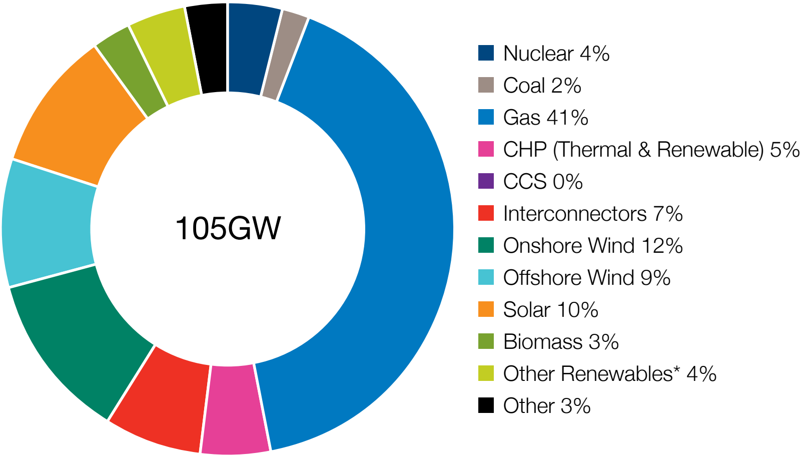
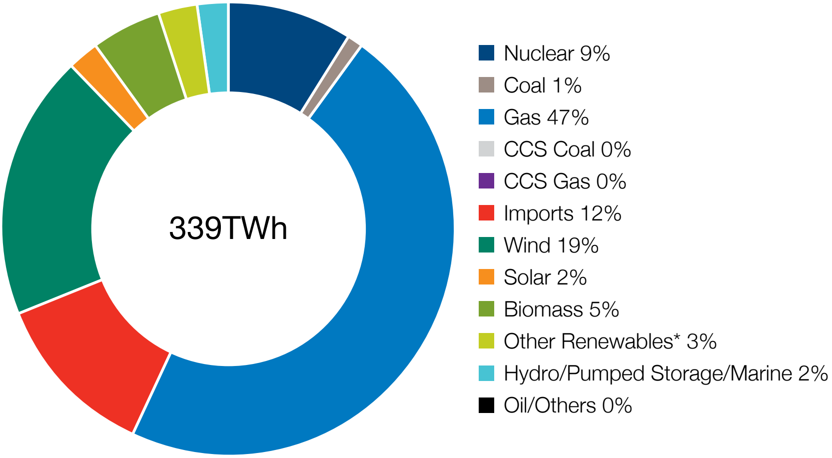


Figure 86
No Progression 2035/36 power generation output



*Anaerobic digestion, landfill gas, sewage, waste and advanced conversion technology.

4.3 continued
Power Supply

Low Carbon Life

The **Low Carbon Life** power supply landscape as shown in Figures 87 and 88 is characterised by the switch from traditional (fossil fuel based) technology to a supply mix dominated by low carbon forms of generation. This is as a result of the enduring focus on decarbonising energy which drives the types of technology connecting to the electricity system.

Figure 87
Low Carbon Life generation background

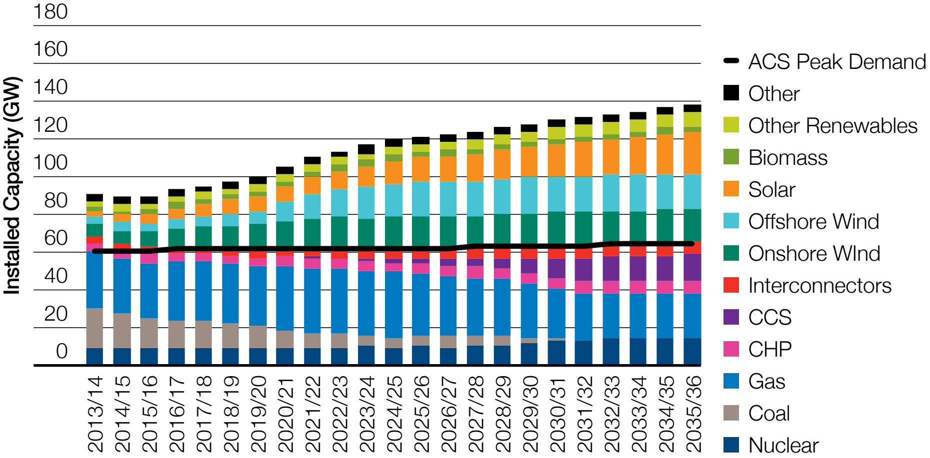
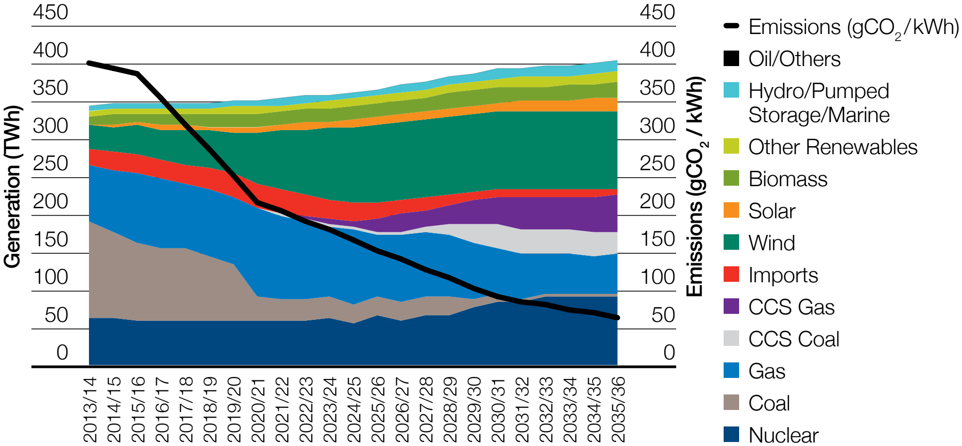


Figure 88
Low Carbon Life generation output



Our **Low Carbon Life** scenario is dominated by the significant increase in the deployment of distributed generation (particularly solar PV and onshore wind) as developers make the most of a more favourable economic background and the government incentive mechanisms.

There is a faster deployment of renewable generation compared to low carbon technologies, out to 2020/21, with the deployment of solar PV quadrupling out to 2020/21 and the installed capacity levels for wind (onshore and offshore) doubling over the same period. By 2020/21, wind (onshore and offshore) and solar PV generation represents 30.8% of the supply mix and 21.1% of electricity output, with the first Round 3 offshore wind farm project connecting towards the end of this decade.

Figures 89 to 92 show snapshots of the generation background and associated output for our **Low Carbon Life** scenario at 2020/21 and 2035/36.

4.3 continued
Power Supply

Figure 89
Low Carbon Life 2020/21 power generation capacity

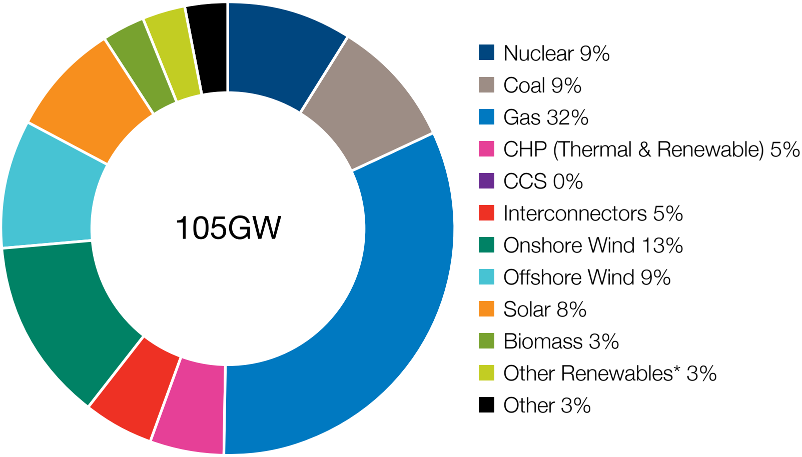


Figure 90
Low Carbon Life 2020/21 power generation output

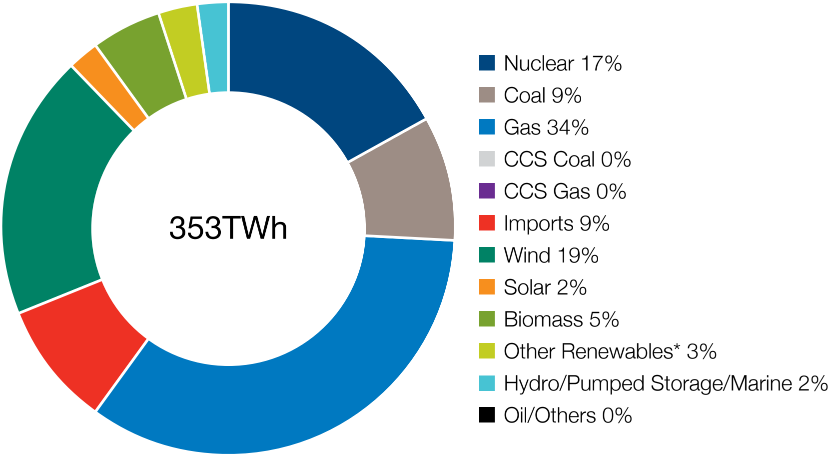


Figure 91
Low Carbon Life 2035/36 power generation capacity

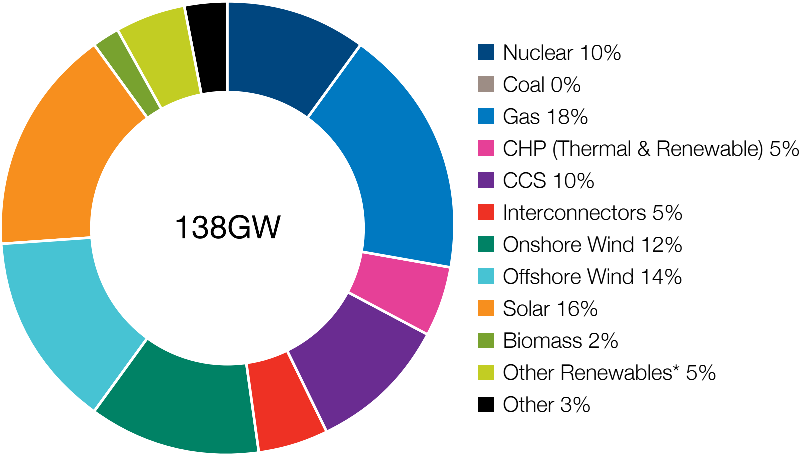
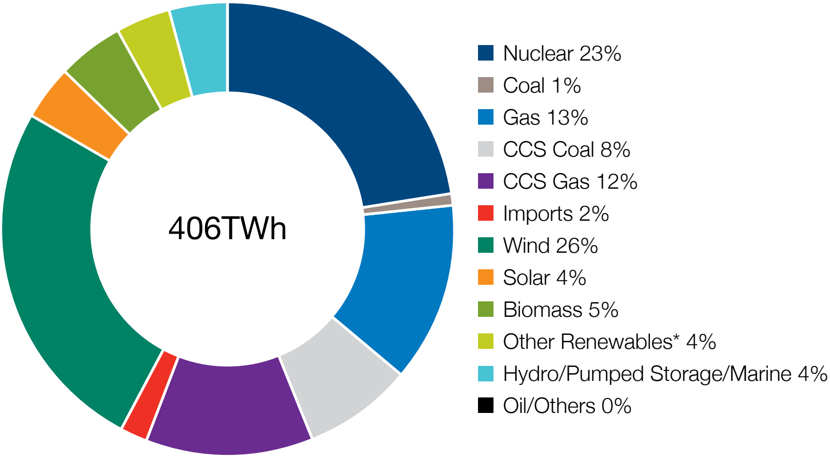


Figure 92
Low Carbon Life 2035/36 power generation output



*Anaerobic digestion, landfill gas, sewage, waste and advanced conversion technology.

4.3 continued
Power Supply

The deployment of renewable generation continues out to 2035/36 as a result of the focus and agreement on a long-term decarbonisation strategy for the electricity sector, with renewable generation representing 50% of installed capacity and contributing over 40% of the electricity output. Wind and solar PV continue to provide the largest contribution of renewable energy, representing 42.0% of the supply mix and 30.3% of electricity output, by 2035/36. Given the emphasis and accessibility to other alternative low carbon technologies during the 2020s, **Low Carbon Life** has a minimal amount of new wind generation being deployed post-2026/27.

Coal and oil generation decline as power stations which have opted out from the LCPD close and the impact of the IED influences how coal-fired and gas-fired generation operate under the new legislation on carbon emissions, with the last remaining transmission-connected coal stations closing in the early 2030s. The closure of coal power stations requires additional generation to connect in order to maintain the security of supply standard, resulting in new gas-fired generation commissioning particularly between 2018/19 to 2021/22. **Low Carbon Life** shows a decrease in the installed capacity of gas-fired generation by 2035/36, as the closure of older plant offsets the limited new build programme post 2025.

The emphasis on a long-term decarbonisation strategy for the electricity sector and a more favourable economic background, results in strong deployment of nuclear and CCS technologies. The first new nuclear and CCS connect during the early 2020s and by 2035/36, nuclear and CCS generation represent 20.1% of the supply mix and 42.0% of electricity output. Table 12 shows the installed capacity level for our **Low Carbon Life** scenario.

Table 12
Low Carbon Life installed capacity levels

	Installed Capacity Levels				
	2013/14 MW	2020/21 MW	2025/26 MW	2030/31 MW	2035/36 MW
Nuclear	9,471	8,981	10,399	12,958	14,091
Coal	20,454	9,797	5,855	1,953	-
Gas	30,760	33,643	32,252	25,659	24,589
CCS	-	-	2,826	10,624	13,624
Onshore Wind	6,727	14,059	16,206	16,610	16,953
Offshore Wind	4,083	9,837	18,697	18,922	18,922
Solar	2,263	8,461	12,520	17,069	22,069

Other technologies

All of our scenarios consider other forms of generation technology. Although an important part of the generation mix, the impact of other technologies is less significant than the technologies already discussed.

Biomass

All our scenarios consider both dedicated biomass projects and biomass conversions over this period; with **Gone Green** showing an increase in biomass generation, from 1.9GW in 2013/14 to 3.8GW in 2020/21, influenced by coal stations converting to biomass. Out to 2025/26, the increase is focused on the connection of dedicated biomass projects with installed capacity reaching 4.3GW by 2025/26. Our **Slow Progression**, **No Progression** and **Low Carbon Life** scenarios all have a slower growth in biomass generation which is reflective of recent project terminations and a reduction in the number of coal-fired power stations converting to biomass.

Marine

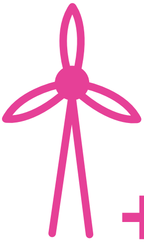
Marine is a technology which is still in its infancy and has yet to reach commercial scale although there remain significant developer aspirations within the sector. Our scenarios consider a wide range of deployment of tidal and wave technologies, from minimal uptake of the technologies in our **No Progression** scenario to our **Gone Green** scenario showing the highest growth rates.

Hydro and pumped storage

Installed hydro and pumped storage capacity shows an increase in capacity over the period. Hydro increases from 1.7GW in 2013/14 to 3.4GW in 2035/36 in **Gone Green** and **Slow Progression**, with the majority of the new projects at the micro-generation level. Both our **Gone Green** and **Low Carbon Life** scenarios show an increase in the installed capacity for pumped storage, from 2.7GW in 2013/14 to 4.9GW in **Gone Green** and 3.4GW in **Low Carbon Life** by 2035/36 as large scale projects connect.

CHP

Our scenarios consider CHP from multiple fuel sources, with all of the generation backgrounds showing a slight increase of capacity out to 2035/36, from 4.0GW in 2013/14 to 5.5GW in **Gone Green** and **Slow Progression**, 5.0GW in **No Progression** and 6.3GW in **Low Carbon Life** in 2035/36.



+15.4GW

All our scenarios consider onshore and offshore wind projects, with Gone Green showing an increase in installed capacity from 10.8GW in 2013/14 to 26.2GW in 2020/21.

4.3.4
Security of Supply

Security of supply is a key area of focus as the generation mix diversifies over time. We have used the LOLE metric – this calculation is different from the gross plant margin, spot de-rated and equivalent firm capacity (EFC) methods which have previously been used. This change in our approach follows the introduction of the reliability standard, set by the Secretary of State at 3 hours per year as part of the EMR.

Method

The calculation considers all power stations connected to the transmission system and all wind connected to the wider electricity system (including distributed and micro electricity generation). For all technologies other than wind, an availability assumption is made based on mean output at the period of highest transmission system demand, known as a static de-rating factor. Wind is treated on an EFC basis, which does not assume a static de-rating factor. Under EFC, the factor changes over time in relation to how much wind capacity is installed and the availability of the total generation mix. Rather than looking at the historic peak half hour of demand to derive a de-rating factor for wind, this method adopts a statistical risk-based view over the full winter period.

Why change?

The proportion of wind power connected to the GB electricity system has increased in recent years and is expected to continue. This, combined with other factors (such as the characteristics of demand, the potential expansion of interconnectors and a reduction in conventional generation), makes the use of a stochastic methodology (like LOLE) more preferable to calculating security of supply than the traditional plant margin method.

Our power supply backgrounds have been developed as to not exceed the 3-hour LOLE threshold from 2018/19 onwards and so identifying the level of new build generation capacity required to meet this standard. Pre-2018/19 the LOLE is an output derived from our analysis.

Figure 93
Security of supply

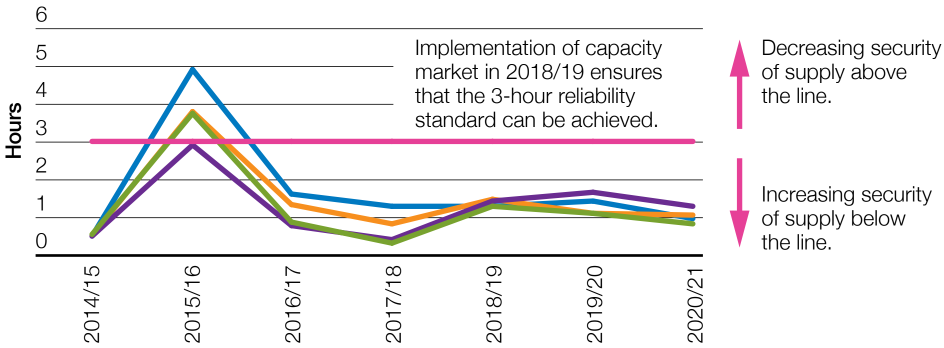


Figure 93 shows the LOLE for all four scenarios against the 3 hours per year reliability standard.

The LOLE in the four scenarios is similar out to 2014/15 before rising above the 3-hour reliability standard in 2015/16: 2.94 hours in **Slow Progression**, 3.75 hours in **Gone Green**, 3.82 hours in **No Progression** and 4.92 hours in **Low Carbon Life**.

The increase in the LOLE in this period is due to plant closures, Transmission Entry Capacity (TEC) reductions and the closure of the remaining LCPD plant, coupled with limited new capacity connecting to the electricity system and a slight change in power demand between the scenarios. After 2015/16, the LOLE starts to reduce assuming the return of mothballed plant and the connection of additional installed capacity in all scenarios.

4.3.5
Distributed Generation

Our distributed generation scenarios consider the potential for development of generation plant connected to or making use of the distribution network which are 1MW and above, up to large scale generation as defined by the transmission areas within GB[42]. This, along with micro-generation, is viewed as an area of potential significant increase, encouraged by government incentives for low carbon technologies. Our distributed generation scenarios consider a wider variety of technologies, which may be categorised into two groups: fossil and renewable as shown in Table 13.

Table 13
Distributed generation technologies

Fossil	**Renewable**		
CHP	Waste	Anaerobic Digestion	Landfill Gas
Coal	Sewage	Advanced Conversion Technologies	Tidal
Diesel	Wave	Solar PV	Wind Onshore
Gas	Wind Offshore	Biomass – Co Firing	Biomass Dedicated
Oil	CHP		

We have developed three data sets which have different deployment rates for the technologies considered and have been applied to our scenarios as shown in Table 14.

Table 14
Distributed generation scenarios

Low Case	No Progression Scenario
Medium Case	Slow Progression and Gone Green Scenarios
High Case	Low Carbon Life Scenario

---

[42] This is a change to the 2013 Future Energy Scenario where distributed generation covered installations of 5MW and above.

The deployment rates for distributed generation have been developed from a variety of different information sources, from Government data to information provided from trade associations and electricity distribution networks. Given the limited visibility of future distributed generation deployment at an individual plant level, the scenarios have focused on the potential take-up of particular technologies.

All of our scenarios consider a potential growth in distributed generation, starting from 9.8GW in 2013/14 increasing to 17.6GW in our **No Progression** scenario, to 21.8GW in **Gone Green** and **Slow Progression**, to 26.3GW (nearly 1/5 of all installed generation capacity) in **Low Carbon Life** by 2035/36 with particular emphasis on renewable generation: solar and wind.

The levels of installed capacity and associated output for distributed generation for our **No Progression** and **Low Carbon Life** scenarios are shown in Figures 94 to 97.

4.3 continued
Power Supply

Figure 94
Low Carbon Life distributed generation installed capacity

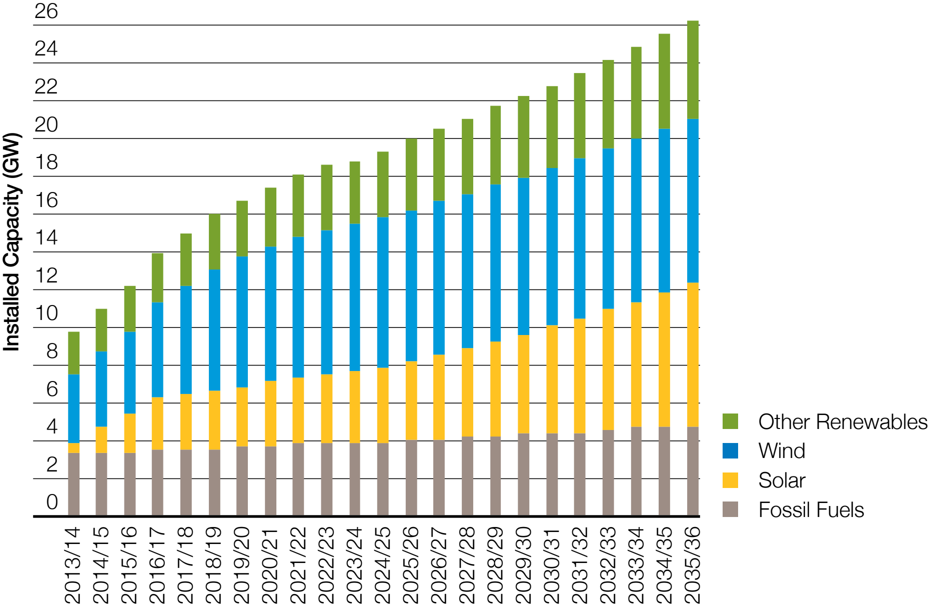


Figure 95
Low Carbon Life distributed generation output

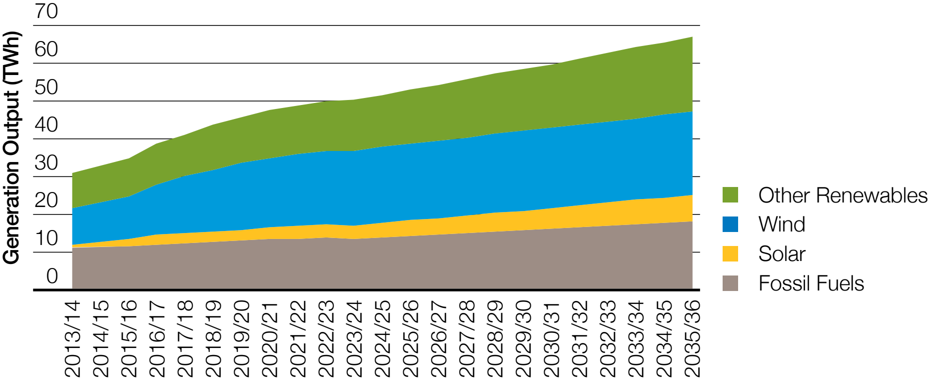


Figure 96
No Progression distributed generation installed capacity

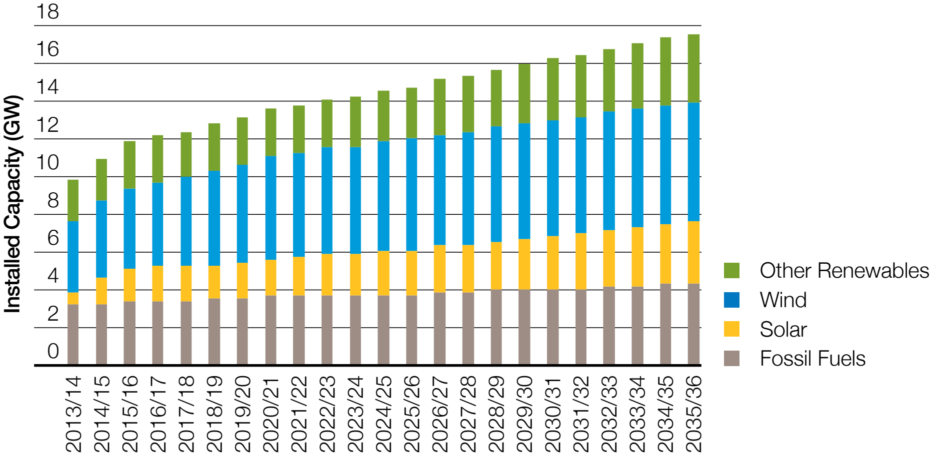
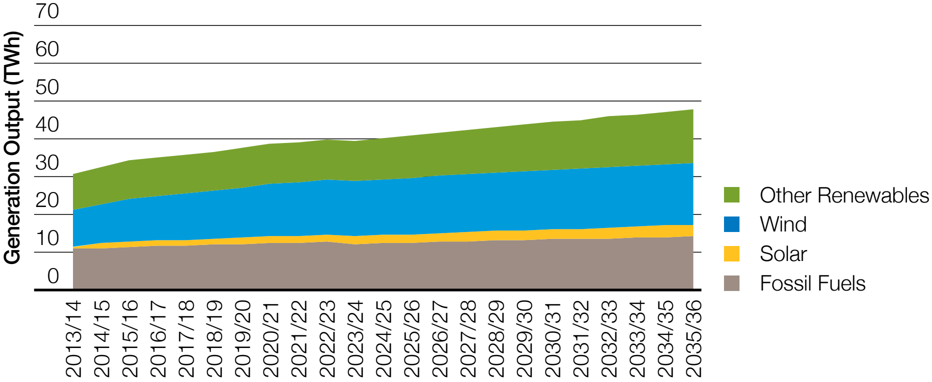


Figure 97
No Progression distributed generation output



4.3.6
Micro-generation

Our micro-generation scenarios consider the potential for development of sub-1MW wind, solar PV and hydro installations[43]. For solar PV, falling installation and unit costs have led to falls in subsidies, however growth has continued with market indicators suggesting that this trend will remain into the future. While similar effects have been experienced in the wind and hydro industries, they have not been as dramatic and as such slower growth is expected. Development of micro-generation is an important consideration for our future energy scenarios, as it reduces the transmission demand and can have localised impact on the wider electricity network. Recent evidence has also shown that homes with solar panels are changing their consumption behaviour, which may have further impacts in the future.

Our scenarios consider different deployment rates for the key technologies of wind, hydro and solar PV technologies, as shown in Table 15.

Table 15
Micro-generation scenarios

Gone Green	High wind, high solar, high hydro
Slow Progression	High wind, low solar, low hydro
No Progression	Low wind, low solar, low hydro
Low Carbon Life	Low wind, high solar, high hydro

The levels of installed capacity and associated output for micro-generation for our **Gone Green** and **No Progression** scenarios are shown in Figures 98 to 101.

---

[43] This is a change to the 2013 Future Energy Scenarios where micro-generation covered installations of less than 5MW.

Figure 98
Gone Green micro-generation installed capacity

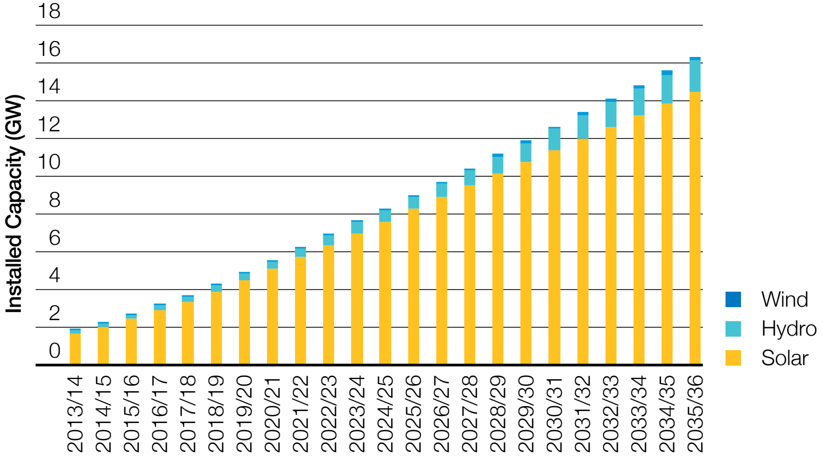
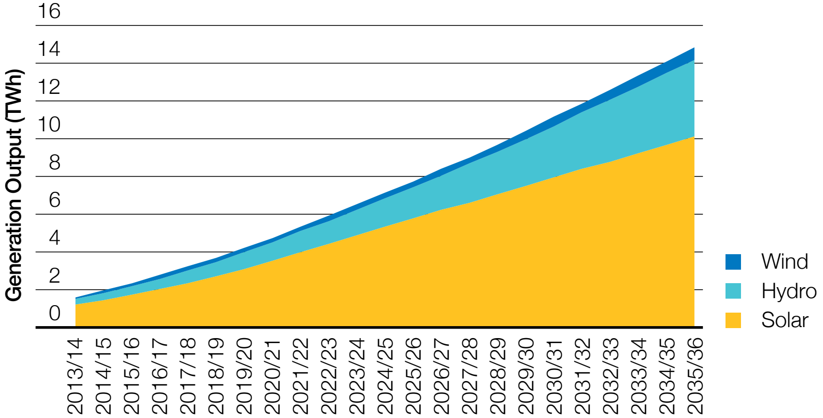


Figure 99
Gone Green micro-generation output



4.3 continued
Power Supply

Figure 100
No Progression micro-generation installed capacity

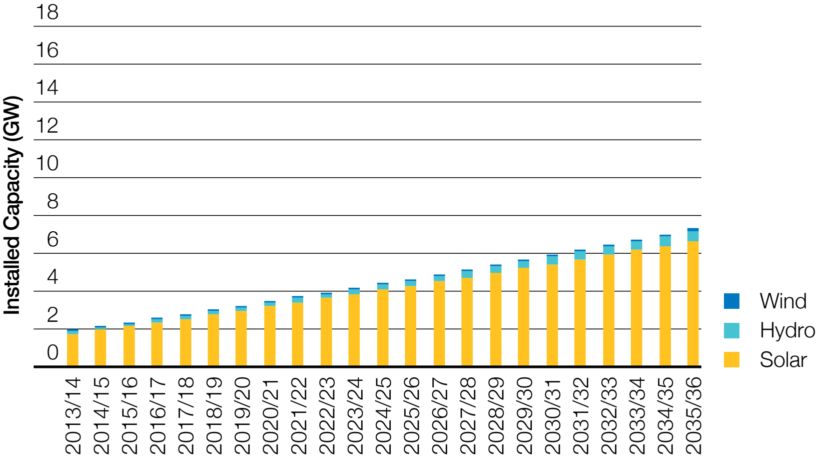
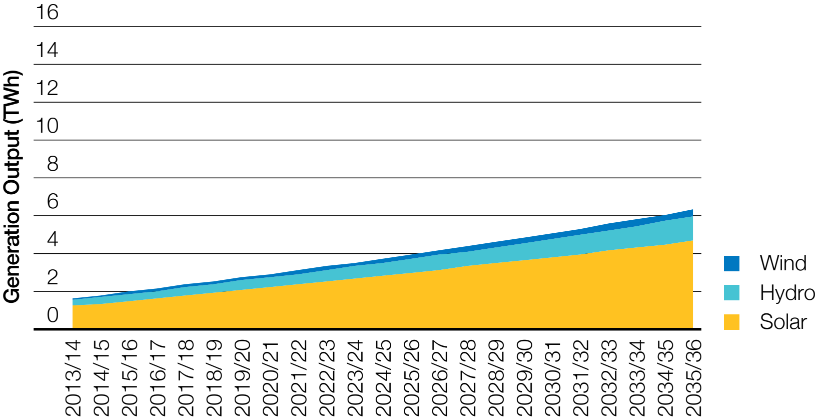


Figure 101
No Progression output



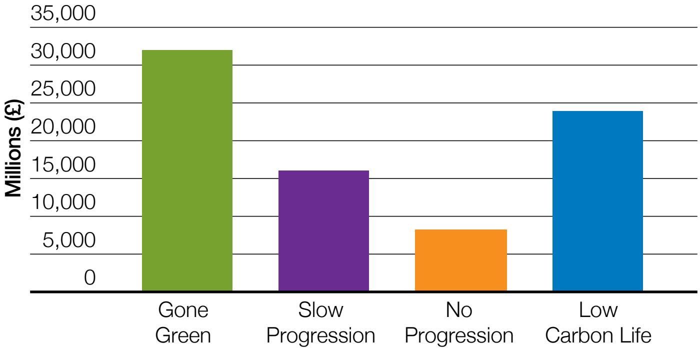
4.3.7

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 request, we derived a breakdown of the estimated capital costs associated with new generation connecting between now and 2020/21 (see Figure 102 and Table 16) for our scenarios (transmission generation only).

Please note that these costs do not include infrastructure, maintenance or any other operation costs and are derived from publicly available data referenced in DECC's Electricity Generation Costs report (December 2013)[44]. For the assumptions, definitions and detailed description of the unit costs used please refer to this report.

Figure 102
Cost of new (transmission) generation by scenario at 2020/21



---

[44] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/269888/131217_Electricity_Generation_costs_report_December_2013_Final.pdf

4.3 continued
Power Supply

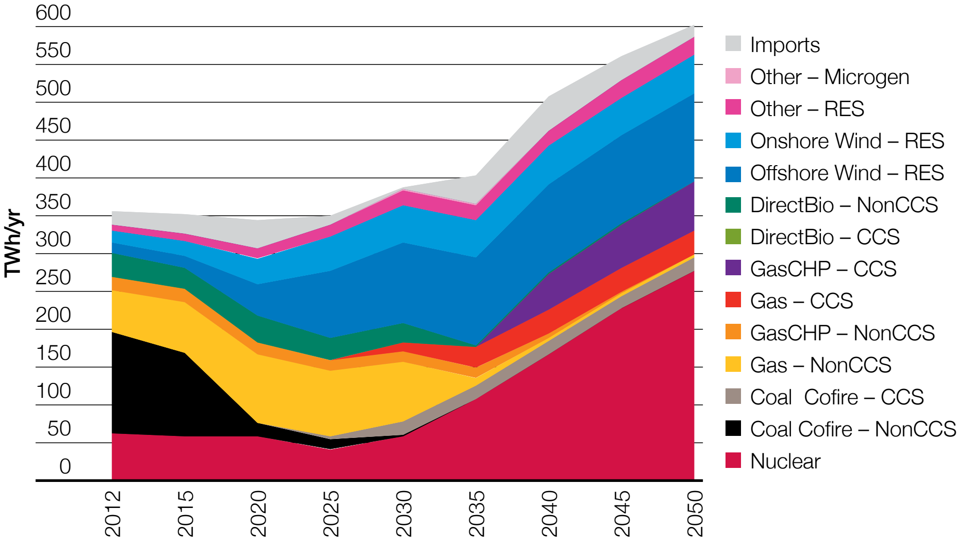
Table 16
Cost of new (transmission) generation at 2020/21

	Capital Costs (£/kW)	**Gone Green £m**	**Slow Progression £m**	**No Progression £m**	**Low Carbon Life £m**
CCGT	610	2,013	2,702	2,300	2,135
CHP	650	319	218	218	218
Nuclear	4,310	0	0	0	0
Biomass	2,496	948	699	0	998
Biomass Conversions	460	697	408	408	408
Offshore Wind (excluding Round 3)	2,470	11,145	7,316	2,351	8,477
Offshore Wind (Round 3 only)	2,605	9,975	0	0	5,640
Onshore Wind	1,566	6,962	4,615	3,105	6,114
CCS Coal	3,380	0	0	0	0
CCS Gas	1,330	0	0	0	0
Other (Hydro/ Marine)	2,700	54	54	27	54
		32,113	**16,012**	**8,409**	**24,043**

4.3.8
2035–2050

Our four scenarios illustrate how the power supply landscape may develop out to 2050. Beyond 2035 there is the potential for the further development of low carbon generation as the country's long-term aspirations for decarbonisation of the energy sector are potentially realised. The opportunities for the electrification of heat and transport become more apparent during this period, with the associated impact on the levels of electricity demand (see section 4.1) and supply. Figures 103 to 106 show the power supply landscape for all of our scenarios, illustrating the mix of generation technologies which could be contributing to meeting the country's electricity needs by 2050.

Figure 103
Gone Green electricity generation to 2050



4.3 continued
Power Supply

Figure 104
Slow Progression electricity generation to 2050

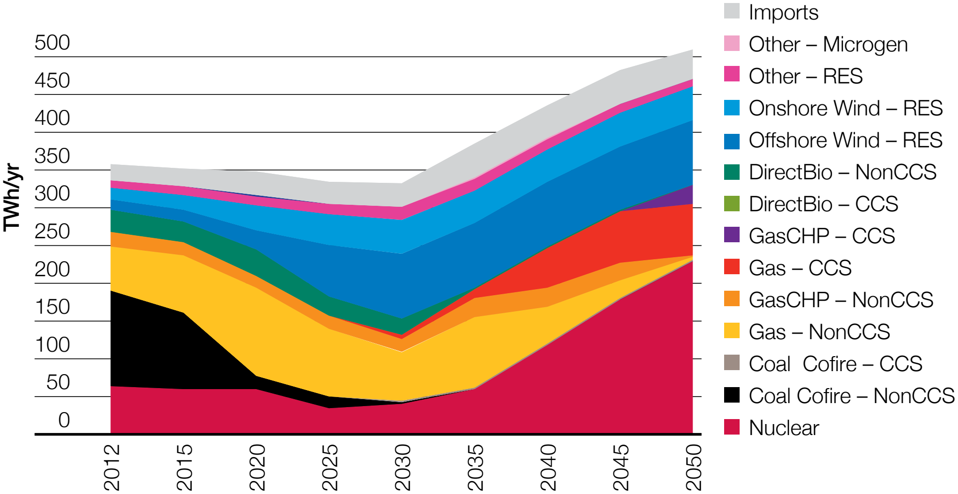
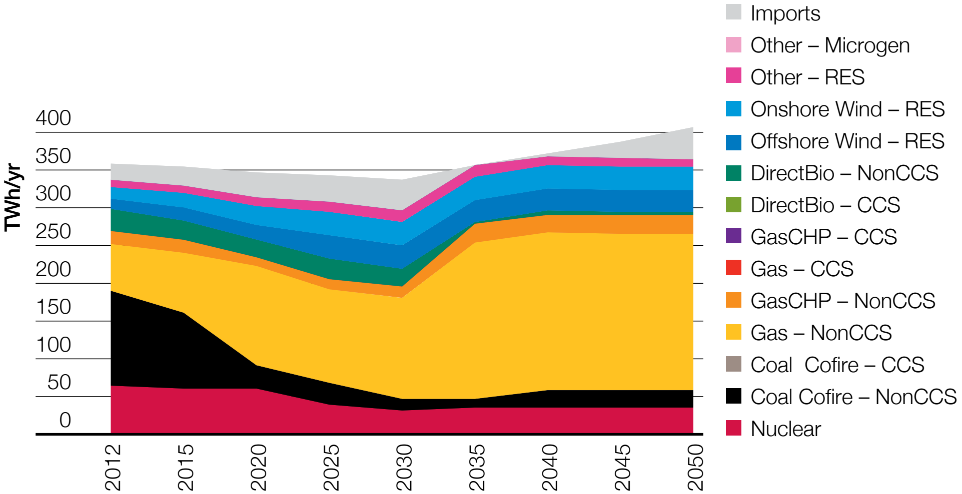
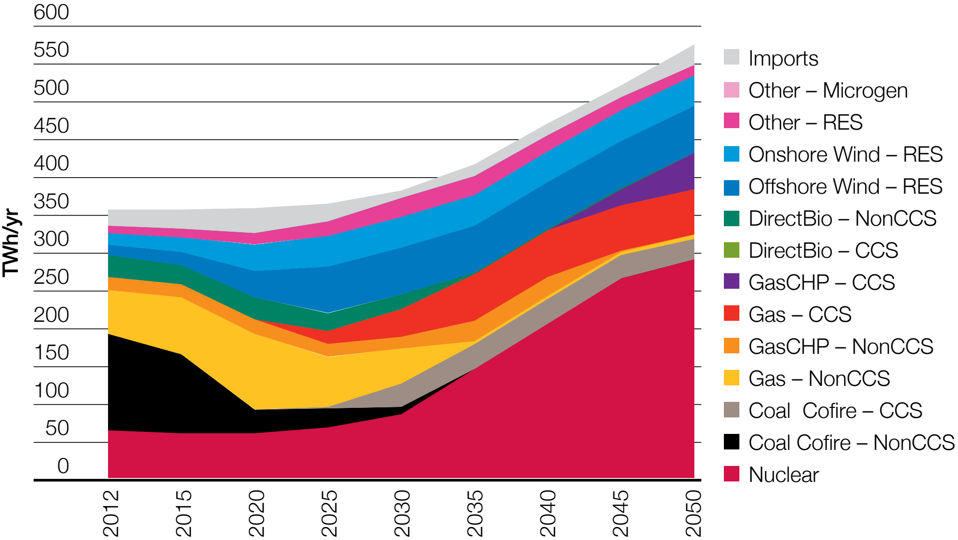


Figure 105
No Progression electricity generation to 2050



4.3 continued
Power Supply

Figure 106
Low Carbon Life electricity generation to 2050



Our **Gone Green** scenario with its emphasis on achieving the environmental targets by the designed date has the highest levels of heat and transport electrification as the country strives to achieve the greenhouse gas reduction target by 2050. The electrification of heat and transport increases the levels of electricity demand which is met by increasing amounts of low carbon generation, in particular nuclear (contributing near 50% of demand) and CCS (gas favoured over coal with greater prominence placed on gas CHP CCS). The contribution from wind generation remains constant out to 2050 as existing wind farms replant, extending their operational lifespan.

Our **Slow Progression** scenario maintains its focus on the reduction of greenhouse gas emissions with increasing levels of low carbon generation contributing to the electricity demand requirements of the country. The emphasis on low carbon generation remains centred on nuclear, CCS (with an emphasis on gas CCS) and wind, albeit all at lower levels than in **Gone Green** given the less favourable economic conditions and associated impact on demand requirements.

No Progression is dominated by cheaper forms of generation given the less favourable economic conditions and the lack of an enduring focus on decarbonising the country's energy requirements. Given the limited amount of heat and transport electrification in this scenario, demand levels remain relatively constant out to 2035. The generation mix is dominated by gas given its relative low cost base, counting for more than 50% of the total electricity supply by 2050. Our **No Progression** scenario has no CCS generation as the technology does not achieve commercial viability due to the focus on cheaper forms of generation.

Low Carbon Life has an emphasis on a long-term decarbonisation strategy for the country's energy requirements and a more favourable economic background ensures the electrification of heat and transport. The associated increased levels of electricity demand are met by a generation mix centred on low carbon technologies, namely nuclear and CCS (coal and gas). As with our **Gone Green** scenario, wind remains a key part of the technology mix with its contribution constant out to 2050 as existing wind farms extend their operational lifespan through replanting.

All of our scenarios have no hydrogen technology in the generation mix as the use of this technology is more likely to occur in the transport sector, as described in section 3.5.

What's changed since 2013?

- How power stations (above 50MW) may comply with the IED, with our assumptions being applied to both coal and gas power stations.
- Our definition of distributed and micro-generation has changed. Distributed generation includes installed capacity of 1MW and above (up to large scale generation as defined by the three transmission areas within GB) and micro-generation includes installed capacity of sub-1MW.
- Our security of supply assessment is based on the 3-hour LOLE reliability standard as introduced by the EMR.
- Development of a power economic model to analyse how particular plant may operate in the future.

Key uncertainties and areas for development

- Clarity on IED compliance decisions for the affected power stations.
- Certainty that new gas-fired generation can connect in the latter part of this decade to counteract the potential closure of coal-fired generation and maintain security of supply.
- Clarity on potential growth rates for new technologies, particular those connected to the distribution network.

4.4
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
- CCGT/OCGT
- Irish Gas

Summary

- There are four main drivers for changes in demand in the residential sector: behaviour change, energy efficiency, extra demand from new houses and change of heating fuel.
- Our other scenarios show similar trends in residential gas demand, with an overall modest reduction as efficiency improvements from new gas boilers and increasing insulation offset growth in new connections, mainly from new housing demands.
- **Low Carbon Life** has the highest residential demand as it suggests internal residential temperatures increase up to a capped level (in all other scenarios internal temperatures are held constant at today's level).
- **Gone Green** suggests that the heat pump market will increase as will solid wall insulation installations (low heat pump and solid wall insulation uptake is assumed in the other three scenarios) thus suggesting the lowest residential gas demand of all four scenarios.
- Demand in our commercial sector is variable between our scenarios reflecting the potential for efficiency saving, new developments associated with economic growth, and power and gas prices. **Gone Green** and **Low Carbon Life** show increasing demand from economic growth, **Slow Progression** also includes new demand as power prices become prohibitive for heating with **No Progression** continuing the long term decline.
- All our scenarios reflect the underlying demand reductions across the industrial sectors and provisions have been made for potential differing adaptation to the Industrial Emissions Directive.
- We have introduced a level of fuel switching in our **Gone Green** scenario that reduces gas demand from the middle of the next decade.
- Our gas demand associated with power generation is dependent upon our generation scenarios. There is low demand across the scenarios until successive coal plant closures from 2018/19 onwards. There is an increasing requirement for gas fired power generation to act as a backup for renewable generation in **Slow Progression**, **Gone Green** and **Low Carbon Life** alongside demand from CCS sites in **Gone Green** and **Low Carbon Life**. **No Progression** continues with further gas generation over the scenario.
- There is an increasing requirement for gas-fired power generation to act as a backup for renewable generation.
- **No Progression** has the highest total NTS gas demand of the four scenarios.

Further reading

- Government Policy (Appendix 1)
- Economic Background (section 3.2)
- Heat (section 3.3)
- Consumer (section 3.4)
- Transport (section 3.5)
- Power Demand (section 4.1)
- Power Supply (section 4.3)
- Gas Supply (section 4.5)

Key statistics

Total Gas Demand TWh	**2013**	**2020**
Gone Green	835	812
Slow Progression	835	819
No Progression	835	826
Low Carbon Life	835	828

Gas Demand Breakdown	**2013**
Residential	40%
Industrial and Commercial	29%
Exports: Ireland	8%
Exports: IUK	4%
Power Generation	19%

Gas Demand Changes by 2020	**Residential**	**Industrial and Commercial**	**Exports**	**Power Generation**
Gone Green	-6%	-3%	+7%	+34%
Slow Progression	-5%	-9%	-21%	+51%
No Progression	-4%	-12%	-30%	+57%
Low Carbon Life	-5%	-5%	-16%	+38%

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

- Continued replacement of older gas boilers with A-rated condensing boilers.
- 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.

4.4 continued
Gas Demand

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 0–73MWh 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 73MWh 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 from four main categories:

- Residential demand – accounts for around a third of UK gas demand
- Industrial and commercial demand – accounts for around a quarter of UK gas demand
- Power generation demand – accounts for nearly a quarter of UK gas demand
- Exports – account for around a sixth of UK gas demand

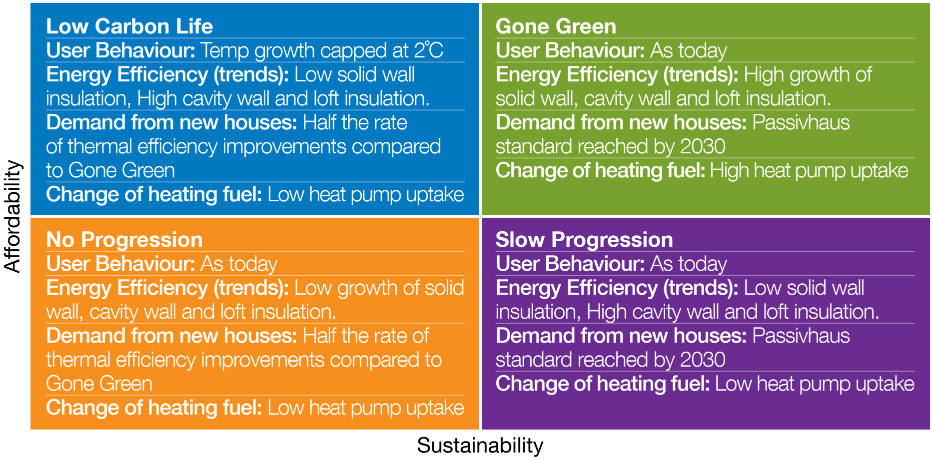
4.4.1
Residential Gas Demand

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.

Figure 107
Axioms' impact



Low Carbon Life
User Behaviour: Temp growth capped at 2°C
Energy Efficiency (trends): Low solid wall insulation, High cavity wall and loft insulation.
Demand from new houses: Half the rate of thermal efficiency improvements compared to Gone Green
Change of heating fuel: Low heat pump uptake

Gone Green
User Behaviour: As today
Energy Efficiency (trends): High growth of solid wall, cavity wall and loft insulation.
Demand from new houses: Passivhaus standard reached by 2030
Change of heating fuel: High heat pump uptake

No Progression
User Behaviour: As today
Energy Efficiency (trends): Low growth of solid wall, cavity wall and loft insulation.
Demand from new houses: Half the rate of thermal efficiency improvements compared to Gone Green
Change of heating fuel: Low heat pump uptake

Slow Progression
User Behaviour: As today
Energy Efficiency (trends): Low solid wall insulation, High cavity wall and loft insulation.
Demand from new houses: Passivhaus standard reached by 2030
Change of heating fuel: Low heat pump uptake

4.4 continued
Gas Demand

Energy efficiency

This has been covered in detail in section 3.4.

Extra demand from new houses

The extra heat demand for new houses is covered in detail in section 3.3.1.

In **Gone Green** the majority of heating in new houses is delivered by heat pumps, with only a small increase in gas demand. In all our other scenarios the majority of new houses are heated by gas boilers leading to more demand growth from new houses. In **Low Carbon Life** the majority of new houses continue to be heated by gas boilers, which combined with the rise in internal temperatures causes this scenario to have the highest residential gas demand.

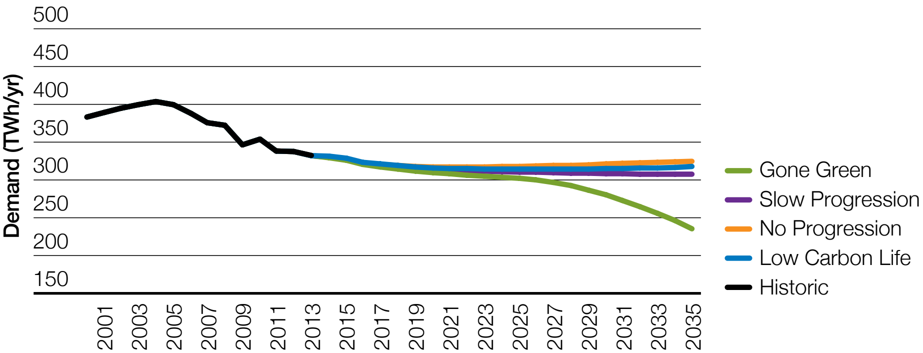
Change of heating fuel

Heat pumps have been discussed in section 3.3.2. 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.

In **Gone Green** it is assumed that heat pump uptake is high leading to gas-heated houses switching to heat pumps from the mid-2020s and causing a significant drop in gas demand. In each of the other three scenarios it is assumed that the heat pump market is not large enough for heat pumps to be a cost effective solution used in existing gas-heated houses.

Residential gas demand is shown in Figure 108.

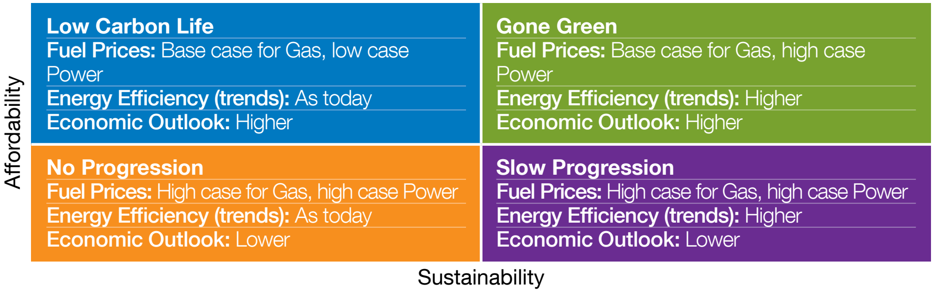
Figure 108
Residential gas demand in each scenario



4.4.2
Industrial & Commercial Demand

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

Figure 109
Axioms' impact



Low Carbon Life
Fuel Prices: Base case for Gas, low case Power
Energy Efficiency (trends): As today
Economic Outlook: Higher

Gone Green
Fuel Prices: Base case for Gas, high case Power
Energy Efficiency (trends): Higher
Economic Outlook: Higher

No Progression
Fuel Prices: High case for Gas, high case Power
Energy Efficiency (trends): As today
Economic Outlook: Lower

Slow Progression
Fuel Prices: High case for Gas, high case Power
Energy Efficiency (trends): Higher
Economic Outlook: Lower

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

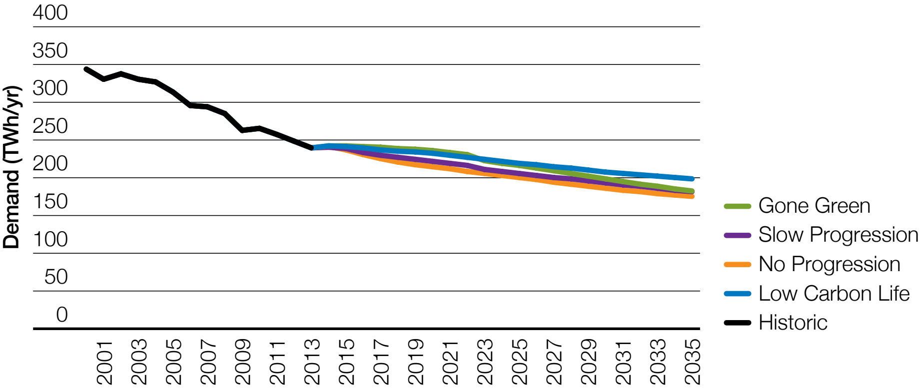
Our projections for the 73–732MWh load band are produced through our econometric modelling. The higher economic growth assumed in **Gone Green** and **Low Carbon Life** causes the commercial gas demand to increase, as does the higher power prices relative to gas. **No Progression** has the lowest commercial gas demand. In addition to the economic relationships, in **Gone Green** we have assumed similar growth in heat pumps consistent with the residential market penetration.

Our projections for the >732MWh 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 analysed via a site by site process, as there are relatively few of them and they tend to have fairly consistent demands.

4.4 continued
Gas Demand

Figure 110
Total industrial and commercial demand



4.4.3
Exports: Ireland and Europe

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 from 2015 and no further indigenous production developments over the scenario period.

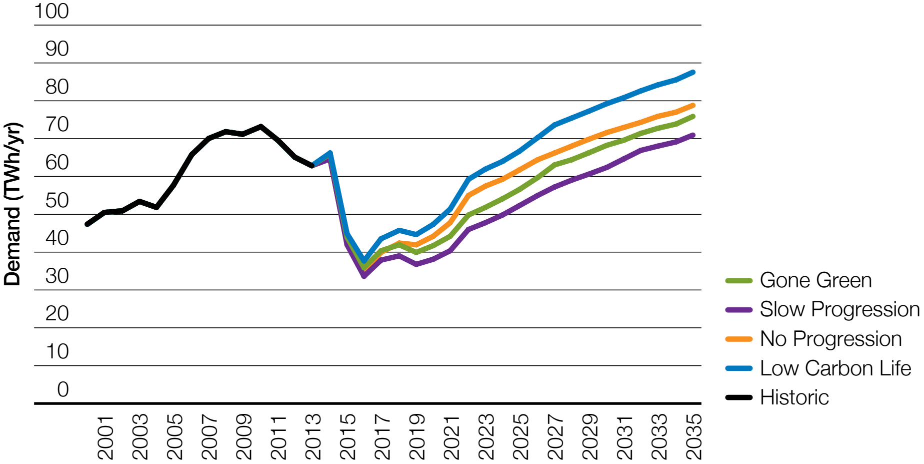
We assume similar energy trends in Ireland to that in the UK; hence Irish demand is essentially flat until the early 2020s when demand increases from power generation.

Gas demand in Ireland is broadly split into industrial, residential and power generation, with the generation dominating the sectors. We have taken underlying growth in industrial and residential demands from Bord Gais Network Development Plan, however; we have aligned our power demands to published ENTSOE Vision statements for the Republic of Ireland and Northern Ireland. Accordingly, we see higher economic growth in **Low Carbon Life** and **Gone Green** compared to **No Progression** and **Slow Progression**. We have aligned future generation assumptions to our UK scenario assumptions with **Gone Green** and

Slow Progression trending towards increasing renewable generation and a greater preference for gas generation in **Low Carbon Life** and **No Progression**. Our **Low Carbon Life** scenario shows the highest demand through Moffat and **Slow Progression** the lowest.

Gas flows to Ireland have become a significant part of NTS demands and we have a long-term demand range spreading due to power generation differences and economic developments. However, flows through Moffat are expected to be influenced by indigenous production and we see a sharp reduction in the near term as the Corrib gas field commences in 2015. Over the longer term Moffat demand recovers as underlying Irish gas demand increases and indigenous production levels fall.

Figure 111
Demand from the national transmission system to Ireland



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 4.5 the level of imports from the Continent and LNG are interrelated and subject to uncertainty in both scenarios.

For both **Gone Green** and **Low Carbon Life** the level of exports gradually increases towards historic levels as the UK is well supplied with indigenous production. In **Slow Progression** and **No Progression** the level of exports decreases as indigenous production declines and the requirement for imports increases.

4.4 continued
Gas Demand

4.4.4
Power

Power generation gas demand

Power generation gas demand is derived directly from our generation supply modelling (see section 4.3).

4.4.5
Total

Total gas demand

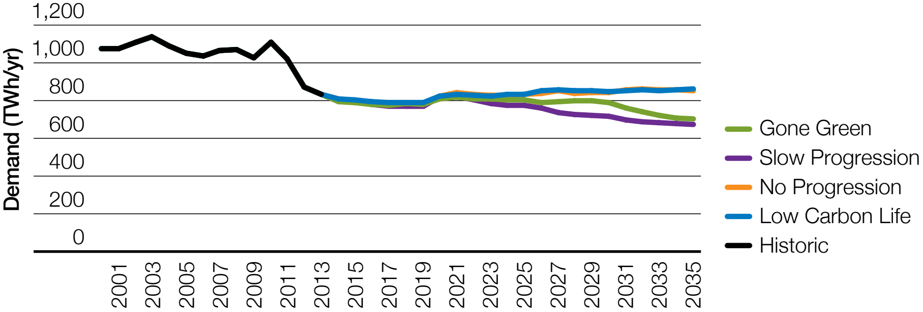
Total gas demand in each scenario is shown in Figure 112. **Gone Green** and **Slow Progression** are broadly similar for much of the period, as are **No Progression** and **Low Carbon Life**, due to differences between each pair of scenarios largely offsetting each other.

In **Gone Green**, gas demand declines post-2030 due to increased uptake of low carbon generation and continued uptake of heat pumps.

Slow Progression follows a similar trajectory but is instead due to lower economic growth and the increase in wind powered electricity generation (offsetting gas demand in the power sector) from the mid-2020s.

In **No Progression** and **Low Carbon Life** overall gas demand increases due to higher demand from power generation and increased exports to Ireland.

Figure 112
Total gas demand



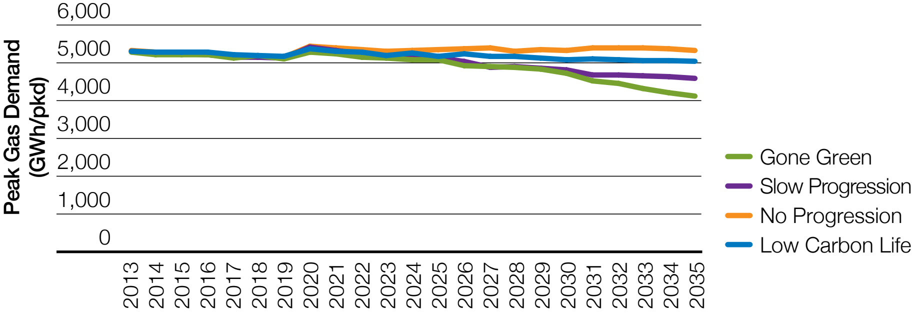
4.4.6
Peak

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 backup 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 113 shows the peak demand for all four 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 domestic demand and gas demand for power generation.

Figure 113
Peak gas demand

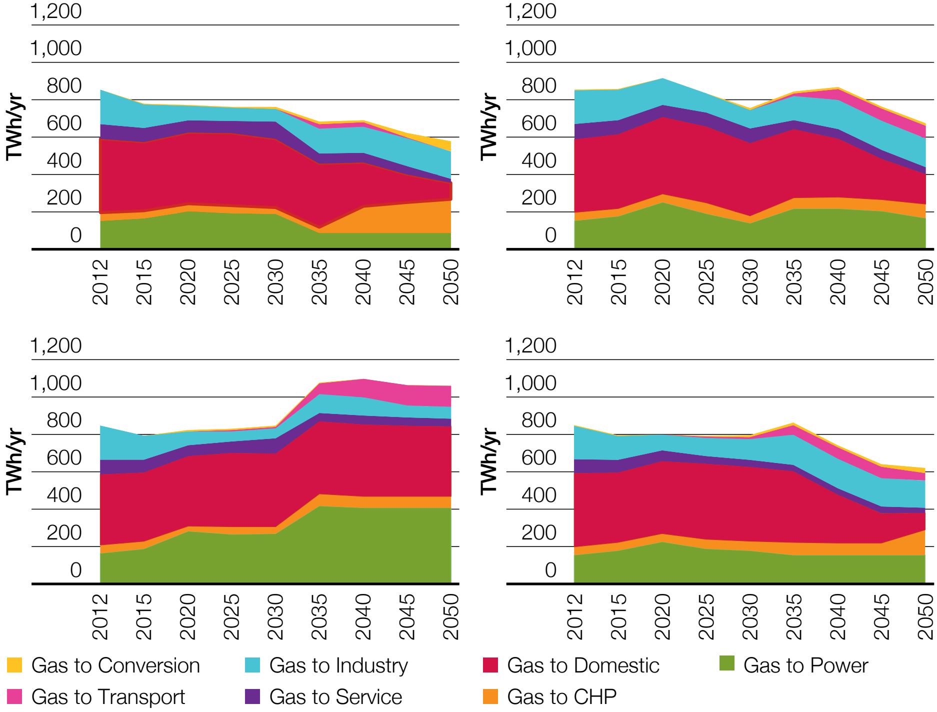


4.4 continued
Gas Demand

4.4.7
2035–2050

Changes in gas demand from 2035 are largely due to changes in domestic use for heating and power generation demand. **Gone Green**, **Slow Progression**, and **Low Carbon Life** show considerable gas demand reduction towards 2050, whereas **No Progression** shows an increase. Gas demand in the four scenarios is shown in Figure 114.

Figure 114
Gas use to 2050



In **Gone Green** from 2035 gas demand for power generation increases in the CHP sector. In 2050, almost all the gas demand for power generation is used in CCS power generation. Domestic gas demand reduces considerably from 2035, due to the shift away from conventional gas boilers, to electric heat pumps, gas heat pumps and hybrid systems. Gas to industry remains largely unchanged from 2035, as it is generally used for high temperature processes, the element that is hardest to electrify.

As with **Gone Green**, **Slow Progression** sees gas-fired generation increasing, with increases in gas CCS both (CHP and non), however this scenario still has some unabated gas generation beyond 2035, and most CCS is non CHP CCS. Domestic demand falls more slowly than in **Gone Green**, due to slower rate of change in the electrification of domestic heating.

No Progression sees post-2035 gas demand for power generation increase significantly, as this is the most cost effective type of power generation and **No Progression** is not constrained by the 2050 greenhouse gas reduction target. Domestic gas demand is almost unchanged, as domestic heating continues to be mainly gas fuelled. Gas to transport increases in this scenario, as it is thought to be more cost effective than traditional fossil fuels, for a limited proportion of the market, mainly for some large goods vehicles. This amount of gas used in this way in the other scenarios is limited as environmental targets mean they utilise some hydrogen instead of this gas.

In **Low Carbon Life**, from 2035 the gas used for power generation remains relatively constant as non-CCS gas-fired generation is replaced at a commensurate level with CCS, until 2050, when some extra CCS results in a slight increase. Domestic demand decreases in line with **Gone Green** for the same reasons.

What's changed since 2013?

Gas demand in 2050 is higher in the 2014 Gone Green Scenario than 2013 Gone Green due to more gas being used for CCS power generation in this year's scenario. As a result a lot of the gas demand in 2050 has very little carbon emissions associated with it.

4.5
Gas Supply

Axioms that influence this section

Global Gas Markets

Gas Supply (UK Continental Shelf (UKCS))

Gas Supply (Norway)

Gas Supply (Continent including Russian gas)

UK Shale Gas, Coal Bed Methane (CBM) and Biomethane

Summary

- There is a temporary respite in the long-term trend of decline in UKCS production.
- Our shale gas projections cover a wide range, reflecting Government support and interest from producers, but also the currently unproven nature of the UK reserves.
- We see continuing moderate support for biomethane in **Gone Green**.
- Norwegian gas continues to make up a significant part of the total supply.
- Uncertainties in the global gas market make it difficult to predict whether the requirement for imported gas will be met by LNG or continental gas.
- High level of UKCS and shale gas production in **Low Carbon Life** mean that imported gas makes up a lower fraction of the total supply in 2035 than it does today. On the other hand, lower indigenous production and high demand in **No Progression** lead to an import dependency of over 90%.

Key statistics

- UKCS future production peaks in 2017 in all scenarios, making up between **38%** of total supply, in No Progression, and **46%**, in Gone Green and Low Carbon Life. By 2035 the UKCS share of total supply falls to between **8%** and **16%**.
- Shale gas production ranges from **zero** in No Progression to **32bcm/year** by 2030 in Low Carbon Life. By 2035 Shale gas makes up **41%** of total gas supply in Low Carbon Life.
- By 2035 imported gas reaches a total of **71bcm/year** in No Progression, with **43bcm** of this made up of either continental gas or LNG. Import dependency in 2035 ranges from **40%** in Low Carbon Life, lower than today, to **91%** in No Progression.

Further reading

- Government Policy (appendix 1)
- Economic background (section 3.2)
- Gas Demand – (section 4.4)

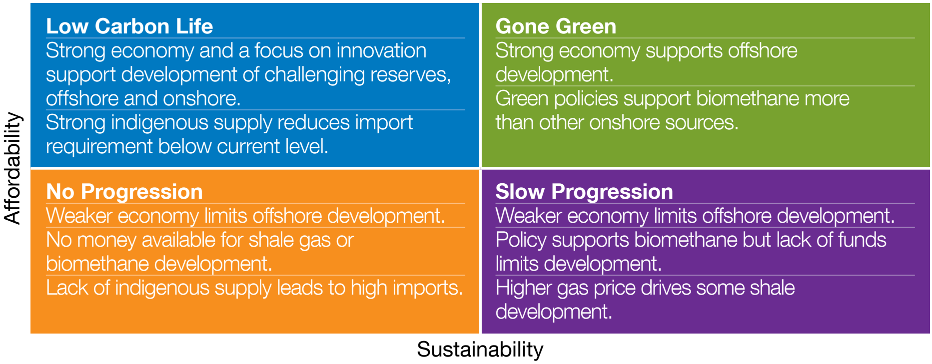
Method

To create the annual gas supply scenarios we first consider a possible range of production or availability from each of the supply components individually;

- UK Continental Shelf (UKCS)
- Onshore gas (Shale gas, biomethane and coal bed methane (CBM)
- Norwegian imports
- Liquefied Natural gas (LNG) imports
- Continental imports

For UKCS and onshore gas the treatment in each of the scenarios is matched to the scenario narrative as shown in Figure 115. For example in **No Progression**, the slow economic recovery and the inconsistent political climate and consequent lack of investor confidence mean that investment in shale gas is limited, with development money being spent in more favourable regimes instead of the UK.

Figure 115
Axioms' impact



Low Carbon Life
Strong economy and a focus on innovation support development of challenging reserves, offshore and onshore.
Strong indigenous supply reduces import requirement below current level.

Gone Green
Strong economy supports offshore development.
Green policies support biomethane more than other onshore sources.

No Progression
Weaker economy limits offshore development.
No money available for shale gas or biomethane development.
Lack of indigenous supply leads to high imports.

Slow Progression
Weaker economy limits offshore development.
Policy supports biomethane but lack of funds limits development.
Higher gas price drives some shale development.

Once the supply ranges have been established the annual supply for each scenario is determined by matching the availability of the components to annual gas demand.

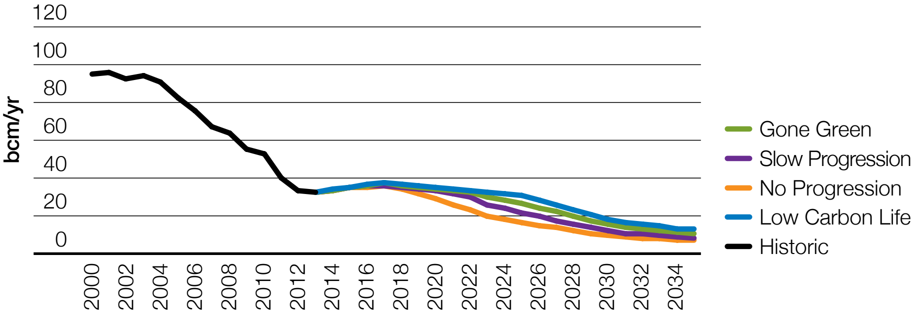
For peak supply scenarios the process is similar, with gas storage added to the list of supply components.

4.5 continued
Gas Supply

4.5.1
UKCS

Our UKCS projections are based on information provided by producers combined with market intelligence and our own analysis. Following many years of decline, production in 2013/14 showed a slight increase over the previous year, and this trend is expected to continue for the next few years in all scenarios. UKCS supply in the early years is inevitably very similar in all four scenarios as it depends on fields that are already in production or under development and close to production. In later years the UKCS sees greater expansion in **Low Carbon Life** and **Gone Green**, where the growing economy and a high level of technical innovation supports development of fields that are too difficult or too expensive for the poorer economic conditions of **Slow Progression** and **No Progression**. Projections for UKCS supply in the four scenarios are shown in Figure 116.

Figure 116
UKCS supply projections



4.5.2

Onshore Gas

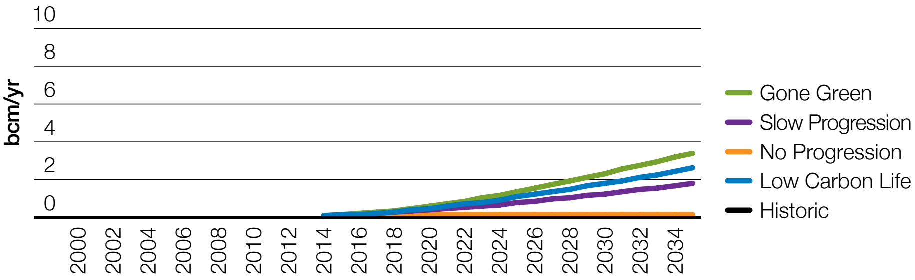
Coal Bed Methane (CBM)

There has been continuing, though fairly limited interest in Coal Bed Methane over the last year, and the technology is expected to make a small contribution in all four scenarios. The volume of gas is small, around 1bcm/year, and we do not differentiate between the scenarios; we expect limited new development but continued production from existing projects.

Biomethane

Injection of biomethane into the network is supported under the renewable heat incentive (RHI) and it contributes to meeting renewable energy targets. There is continuing interest in the field, with a number of projects under consideration. In our projection for **Gone Green** most of the projects come to fruition, with political and regulatory support and an economy that can deliver a sufficient level of funding. In **Slow Progression** development is slower as there is less money to support development, despite the political will. In **Low Carbon Life** there is reasonable development, driven by the favourable economy, though without the political support of **Gone Green**. In **No Progression** the lack of confidence in the subsidy regime leads to very little investment. Our biomethane projections are shown in Figure 117.

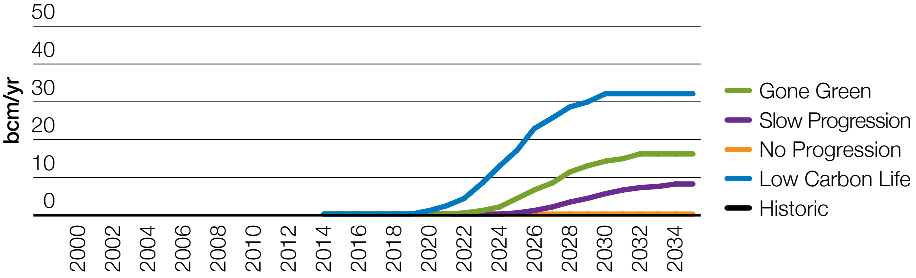
Figure 117
Biomethane projections



Shale gas

There has been a considerable increase in interest in shale gas development since the publication of our 2013 UK Future Energy Scenarios. There has been investment from a number of large gas industry companies and many expressions of government support, with a new onshore licensing round expected in 2014. However, no wells have currently been drilled beyond the exploration and testing stage so, following discussion with our stakeholders, we have based our projections on information published in a report by the Institute of Directors in 2013[45]. In the absence of real UK production data we have created a very wide spread of shale projections in our scenarios, ranging from no successful development in **No Progression** to a peak of around 32bcm/year in the early 2030s in **Low Carbon Life**. Production in **Gone Green** and **Slow Progression** is lower than in **Low Carbon Life** and also starts slightly later. Our shale gas projections are shown in Figure 118.

Figure 118
Shale gas projections



---

[45] http://www.iod.com/influencing/policy-papers/infrastructure/infrastructure-for-business-getting-shale-gas-working

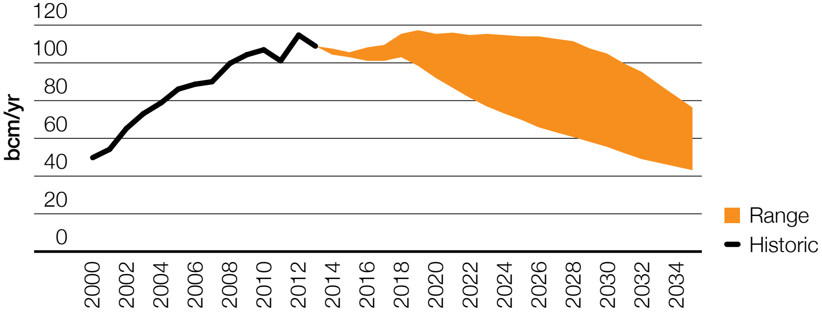
4.5.3
Norway

In making our projections of supplies of Norwegian gas to the UK we consider two different aspects: total production of Norwegian gas, and the proportion of the total that comes to the UK.

Our projections of production are based on data on reserves for the North Sea, Norwegian Sea and Barents Sea, held by the Norwegian Petroleum Directorate, together with external forecasts for some key individual fields. A range of possible production is created by assuming different success rates for developing new fields.

Our projection for the range of Norwegian production is shown in Figure 119.

Figure 119
Range of Norwegian production

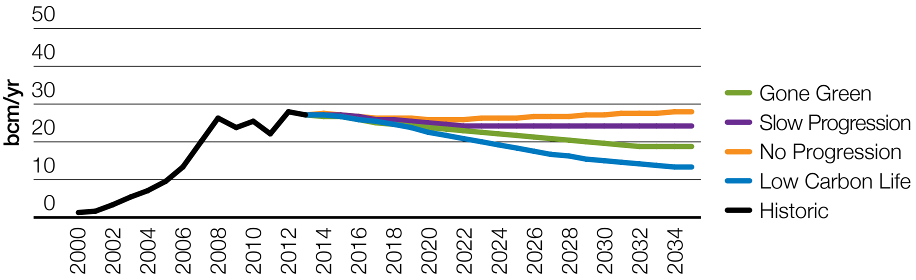


4.5 continued
Gas Supply

The amount of Norwegian gas available to flow to the UK is derived from the total production and from assumptions on the amount of gas that flows to the other major customers for Norwegian gas. In 2013, the UK took around 27% of all Norwegian exports, making us the second biggest customer after Germany with around 40%.

Supplies of Norwegian gas to the UK in our scenarios are not pre-determined, but are derived as part of the process of matching supplies to demand, so will be highest when demand is high and indigenous UK supply is low. The difference in Norwegian flows between scenarios is not as great as for other imported gas however, reflecting the fact that opportunities for Norwegian gas to find other markets are more limited than for other import supplies. Figure 120 shows the flows of Norwegian gas to the UK.

Figure 120
Range of possible supplies of Norwegian gas to UK



4.5.4

Imported Gas: Liquefied Natural Gas (LNG) and Continental Gas

In the process of matching supplies to demand, the indigenous UK components are allocated first, followed by Norwegian gas. There is then a deficit to be made up by other imported gas, either LNG or continental gas. The balance of LNG and continental gas in the supply match depends on a number of factors, including the availability and price of LNG on the world market and the supply and demand situation in Europe. In our 2013 UK Future Energy Scenarios we did not attempt to define the balance of LNG and continental gas but referred instead to a generic import which could be any mixture of the two, ranging from all LNG to all continental gas. In discussion with stakeholders this approach was well received so we have done the same this year. In all scenarios we assume that there will be at least a minimum flow from both LNG and continental gas, representing physical factors, such as boil off from LNG terminals and commercial factors such as contractual requirements for continental gas.

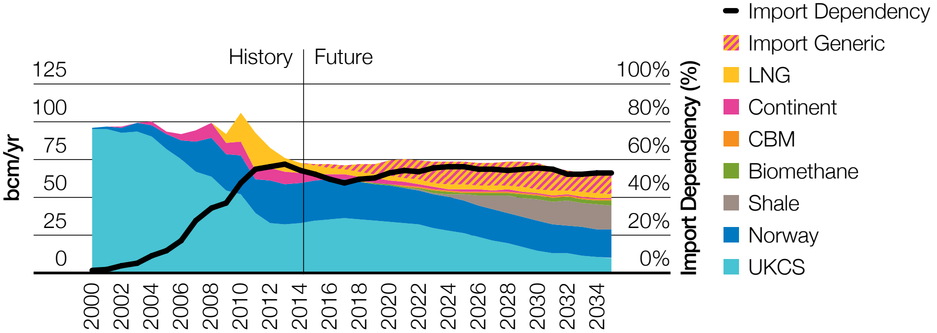
4.5.5
Annual Gas Supply

The previous sections have described the projections for each of the gas supply components. We now turn to the allocation of the supply components to meet the projected demand.

Gone Green

In **Gone Green** annual gas demand is quite low. There is reasonable development of UKCS and shale gas, and biomethane production is highest in this scenario, though as can be seen in Figure 121, the total is quite small when compared with the other components. The overall requirement for imported gas is moderate, and supplies from Norway are in the lower part of their potential range, leaving quite a small market for further imports which peak at 21bcm/year in 2030, similar to values seen in 2012.

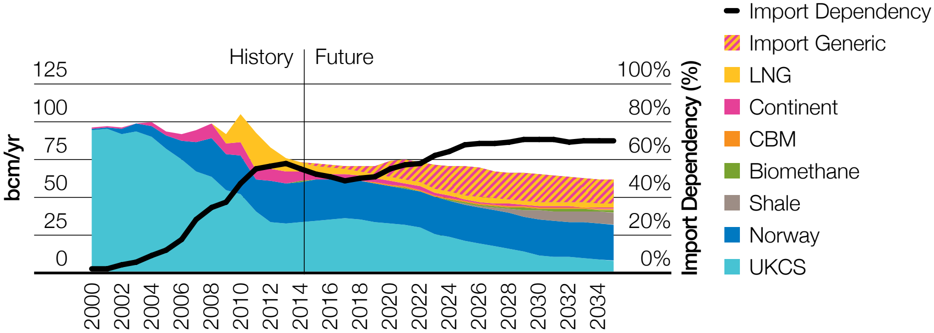
Figure 121
Annual supply pattern in Gone Green



Slow Progression

In **Slow Progression** gas demand is also low, but the lower production from the UKCS, shale and biomethane leaves a larger market for imports, which meet around 70% of demand by the mid-2020s as shown in Figure 122. Norwegian supplies are higher than in **Gone Green** and the combined LNG and continental import peaks at 24bcm/year in 2025.

Figure 122
Annual supply pattern in Slow Progression



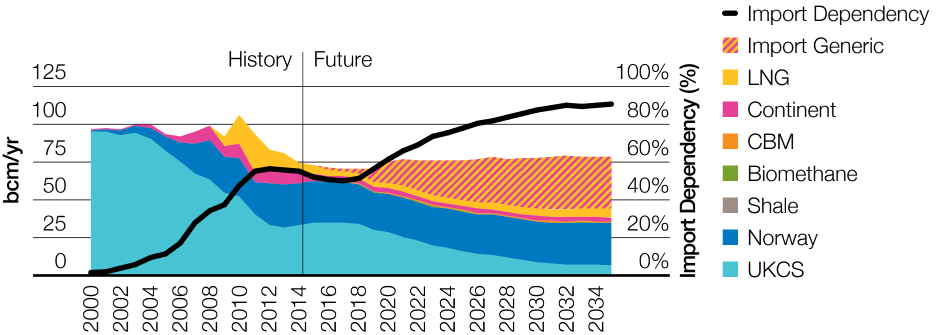
4.5 continued
Gas Supply

No Progression

No Progression has very high gas demand as there is no money to spend on developing lower carbon options. The lack of money means that there is limited development of the UKCS, no shale gas and very little biomethane. This leaves the largest market of all the four scenarios for imported gas, with imports meeting over 90% of demand by 2035, as shown in Figure 123, a level far in excess of anything seen in the recent past.

Norwegian supply is at the top end of our projected possible supply, but this still leaves room for a maximum of 35bcm/year of generic import in 2032, when the total of continental gas and LNG reaches 43bcm. It is worth noting that this could all be handled with the UK's existing LNG and pipeline infrastructure, though the amount of gas required may attract development of new import capacity.

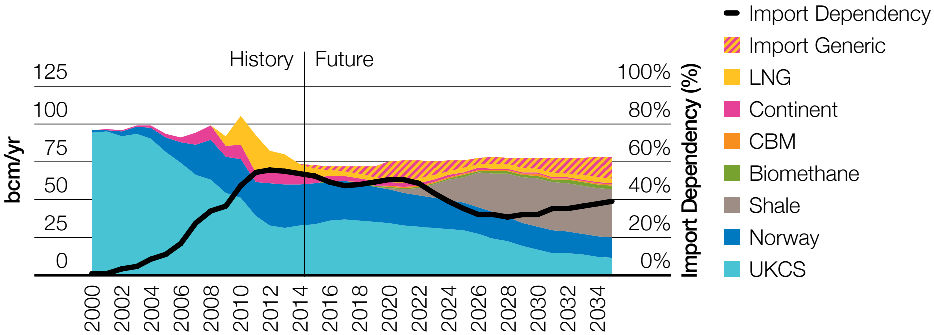
Figure 123
Annual supply pattern in No Progression



Low Carbon Life

In the affluent world of **Low Carbon Life** gas demand is also very high and there is money available for the development of gas supplies that would otherwise not come to fruition. In this scenario both the UKCS and shale gas are at their highest, which leaves much less room for imported gas as shown in Figure 124. This scenario has the lowest import dependency, with total LNG and continental imports falling to a minimum of around 8bcm/year in 2026, though this rises again to around 18bcm/year by 2035, similar to the total in 2013. Total imports, including Norwegian gas, meet around 40% of demand in 2035, compared with 56% in 2013.

Figure 124
Annual supply pattern in Low Carbon Life



4.5.6
Gas Storage

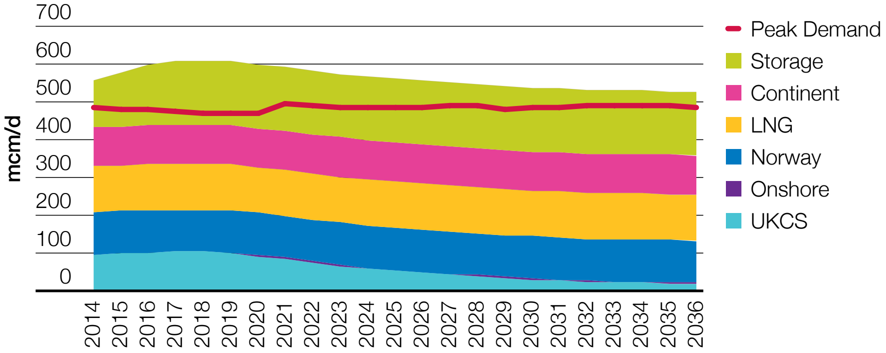
Gas storage plays a useful role in supporting security of supply and providing flexibility in the operation of the gas network. Many new storage sites have been proposed in recent years, both for medium range fast-cycle facilities and for long range seasonal storage. Two new medium range sites are expected to start operation in 2014, but the economics, in particular the price spread between winter and summer, have limited activity in new seasonal storage. This is especially true given the Government's decision in September 2013 not to offer subsidies to new storage development. As there is sufficient existing capacity to meet peak demands we have not added any new storage in any of the scenarios. However, there may be a case for operators to develop storage to support their operations, for example to make best use of shale gas, which is expected to be produced at a constant rate through the year, or to support the power generation market in scenarios dominated by intermittent low carbon generation.

4.5.7
Peak Gas Supply

In the assessment of peak gas supply we compare peak demand with the maximum capability from all supply components. The maximum possible supply from the UKCS and from the onshore sources varies between scenarios in line with assumptions about production as defined in the axioms. For the remaining sources the maximum capability is governed by existing infrastructure rather than production, and so does not change between scenarios.

Figure 125 shows the peak demand together with gas supplies for **No Progression**. This scenario has the highest peak demand but the lowest supply from the UK indigenous sources, and so represents the most extreme case for analysis of peak supply. The chart shows that in all years the peak demand can be met by the existing supply infrastructure.

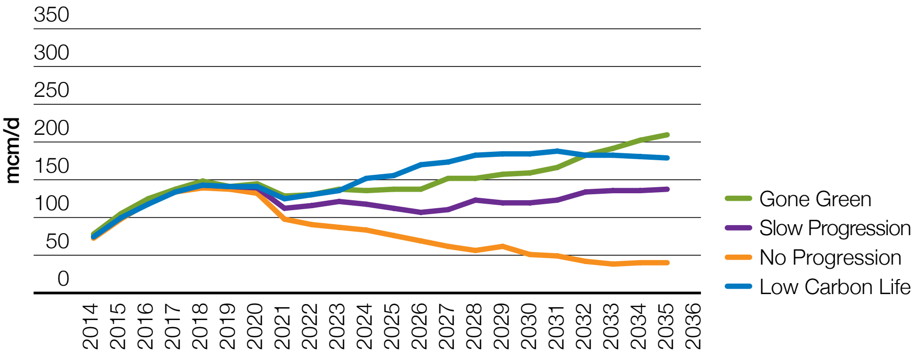
Figure 125
Peak demand and supply for No Progression



Rather than show similar charts for all four scenarios we have shown, in Figure 126, the margin of supply capability over peak demand for all scenarios in a single chart. The chart shows that for **No Progression** the available supply exceeds peak demand by 40mcm/day in 2035, while for **Gone Green** the margin exceeds 200mcm/day by 2035.

4.5 continued
Gas Supply

Figure 126
Margin of supply over peak demand for all scenarios



Global gas markets

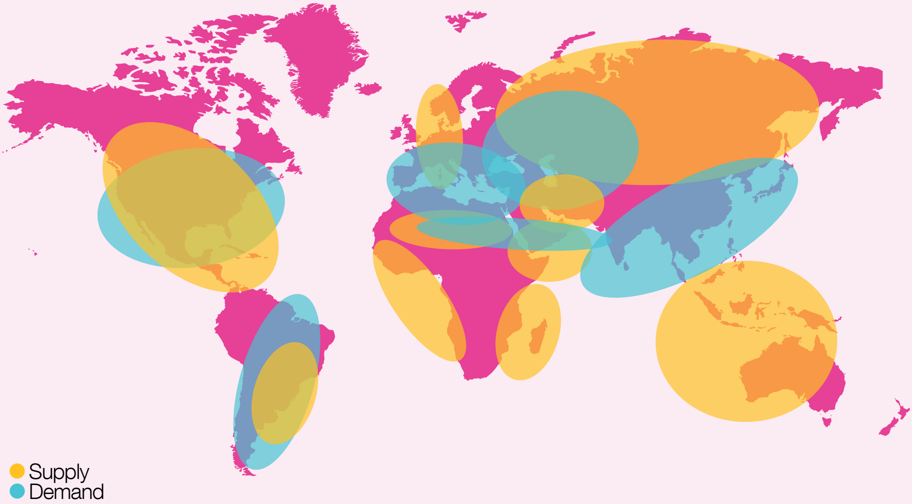
Whether the UK's import requirements are met by LNG or gas from Continental Europe will be driven by the dynamics of the global gas market. In this section we will explore some of the key factors that are likely to impact these markets over the next two decades.

Global demand[46]

Economic growth is expected to drive significant demand increases both in terms of overall energy and gas demand among non-OECD[47] countries over the period. Of particular significance will be the development of Chinese and Indian gas markets, Chinese gas demand is projected to grow to 529bcm by 2035 while Indian demand expected to reach 172bcm. By 2035 total non-OECD Asian demand is expected to reach 1088bcm, overtaking North America as the largest market for gas. Another significant growth area is Middle Eastern demand showing significant growth to 2035 reaching 700bcm.

While overall energy use is not expected to show significant growth within the OECD demand for gas is expected to increase, with the level of the increase driven by international, regional and national energy policies. For the power generation sector, as in the UK, the development of renewables, competing fuel and carbon pricing and nuclear policy will have a significant impact on the level of gas demand for power.

Figure 127
Key areas of global supply and demand 2035



---

[46] Statistics from IEA World Energy Outlook 2013

[47] OECD – Organisation for Economic Co-operation and Development

4.5 continued
Gas Supply

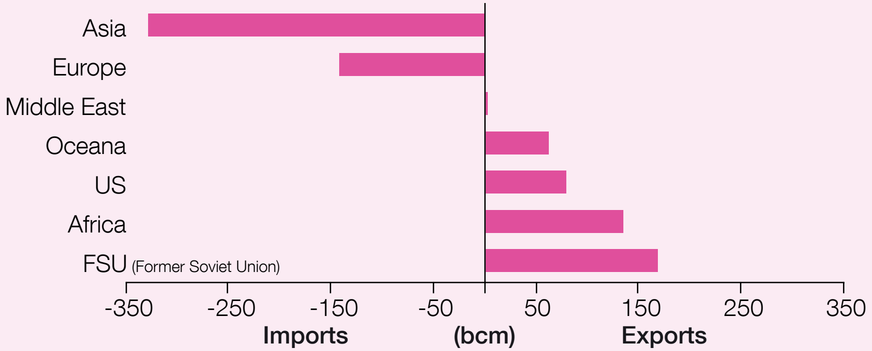
Global gas markets (continued)

Global supply

The growth of LNG supply, which is not physically restricted to any single destination, has significantly increased the level of interconnection between gas markets across the world. Qatar is currently the largest exporter of LNG and while it continues to be a significant exporter throughout the period new supplies from the US, Australia and Africa are expected to increase the competition between LNG exporters.

While pipeline supplies are limited to fixed routes there is still competition between markets, with pipeline flows impacting both LNG demand in importing countries and LNG supply in producing countries. In addition to this, access to alternative markets can also create competition for investment in upstream production, such as for Russian developments with pipeline exports to both Europe and China expected to be operational within the next decade.

Figure 128
Net Changes to Imports/Exports 2015–2035



European interactions

As global gas markets become more interconnected a similar trend is expected within Europe, with increases in both the physical and commercial interconnection between European nations. This interconnection should see increased competition for the gas delivered into Europe with countries able to access a wider range of supplies to meet demand. This could be further enhanced as more supply routes are opened both in terms of new LNG terminals and pipeline connections.

For the UK these interactions will be a key factor in the overall gas supply mix, with the wider European market impacting both the flow on the IUK and BBL interconnectors but also the LNG deliveries to the UK market.

What’s changed since 2013?

- Enhanced treatment of shale gas, in line with stakeholder feedback.
- There is no axiom for gas storage. Supplies are adequate to meet peak demand in all scenarios without building any new storage, though this does not preclude the development of new projects for operational reasons.

Key uncertainties and areas for development

- Development of new fields in the UKCS and Norway.
- The very wide range in shale gas projections reflects the lack of hard evidence that can only be provided by experience in drilling and developing wells.
- The balance between LNG and continental gas is subject to developments in the world gas market.

4.6
Progress Towards Targets

This section shows what environmental targets we have applied to each of the four scenarios and what progress is made towards them.

Environmental targets

There are currently two relevant environmental targets that we consider for our scenarios.

2050 Greenhouse Gas Target – This is a target to reduce annual UK emissions of carbon dioxide and carbon dioxide equivalent gases by 80% from 1990 levels in 2050. We have assumed progress towards this is in line with UK Carbon budgets.[48]

2020 Renewables Target – The 2009 Renewable Energy Directive (RED) set a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020.

There is currently no renewables target beyond 2020 but the EU is currently working towards reaching agreement on new targets for 2030. Therefore we have extended the renewables target out to 2030 based on the Green Alliance analysis[49] of a potential UK 2030 renewable energy target. A linear extrapolation of this target from 2020 beyond 2030 has been used to generate a 2050 renewables target. The renewables target for the UK in the relevant years is:

2020 – 15%
2030 – 23%
2050 – 39%

Figure 129 summarises which targets have been applied to the scenarios, and what progress is made against them.

Figure 129
Environmental Targets used in Scenarios

Low Carbon Life

Greenhouse gas targets are hit, and renewable targets are missed.

2050 greenhouse gas reduction target: hit
2020 renewables target: missed
No new renewables targets for 2030 and 2050 are introduced

Gone Green

All environmental targets are hit, including assumed new European targets post-2020.

2050 greenhouse gas reduction target: hit
2020 renewables target: hit
Assumed 2030 renewables target: hit
Assumed 2050 renewables target: hit

No Progression

Environmental targets are missed, and no new environmental targets introduced.

2050 greenhouse gas reduction target: missed and progress stalls
2020 renewables target: missed
No new renewables targets for 2030 and 2050 are introduced

Slow Progression

All environmental targets missed but achieved later. New European targets post-2020 introduced.

2050 greenhouse gas reduction target: missed but achieved later
2020 renewables target: missed but achieved later
Assumed 2030 renewables target: missed but achieved later
Assumed 2050 renewables target: missed but achieved later

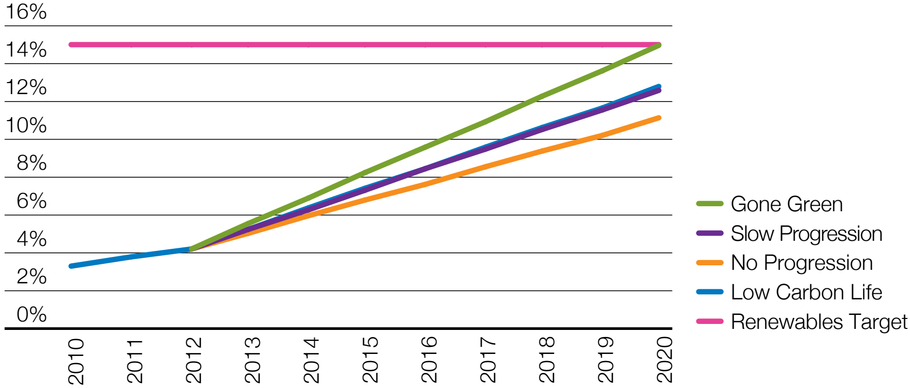
---

[48] https://www.gov.uk/government/policies/reducing-the-uk-s-greenhouse-gas-emissions-by-80-by-2050/supporting-pages/carbon-budgets

[49] http://www.green-alliance.org.uk/resources/The%20implications%20of%20a%20European%202030%20RE%20target%20for%20the%20UK.pdf

Figure 130 shows the proportion of total energy met by renewable sources. Data from 2010 to 2012 are from DUKES.[50] **Gone Green** meets the 15% target by 2020, as required; **Slow Progression** and **Low Carbon Life** only achieve levels just above 12.5% and **No Progression** reaches 11%.

Figure 130
Progress towards renewable energy targets



---

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

4.6 continued
Progress Towards 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 2020. Figure 131 summaries this contribution:

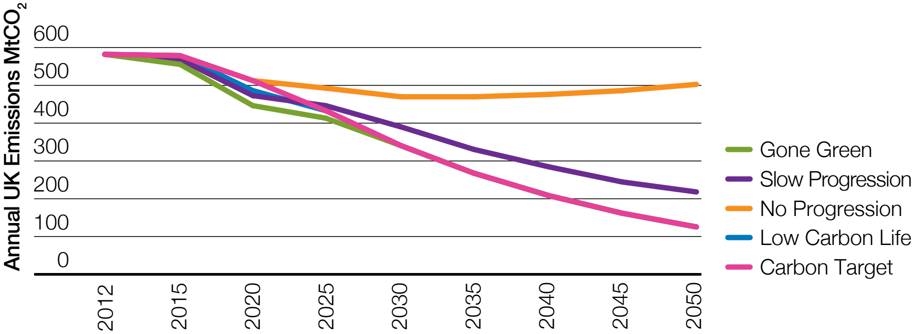
Figure 131
Percentage of power generation, transport and heat from renewable sources in 2020

	Low Carbon Life	Gone Green	No Progression	Slow Progression
Power Generation	– 30%	– 34%	– 22%	– 28%
Transport	– 7%	– 8%	– 7%	– 8%
Heat	– 9%	– 11%	– 7%	– 8%

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 160Mt 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 55Mt has been removed for non-CO_2 greenhouse gases.

Figure 132 shows a pathway to the 2050 greenhouse gas target and the emissions for all four scenarios on the same basis. Both **Gone Green** and **Low Carbon Life** initially have emissions below the indicative pathway, and then follow the pathway to 2050. **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 2025, suggesting that the emissions allowed under the fourth carbon budget will be exceeded in this scenario. **No Progression**'s emissions are above the pathway, suggesting the carbon budgets are unlikely to be met. Beyond 2030 progress towards the 2050 target has stalled and emissions begin to rise.

Figure 132
Carbon emissions and progress towards targets



4.6 continued
Progress Towards Targets

Figures 133 to 136 show the carbon emissions by sector to 2050, and shows that power generation, road transport and heat all make significant contributions to the reduction. The impact that each sector has varies quite considerably between scenarios.

Figure 133
Gone Green emissions by sector

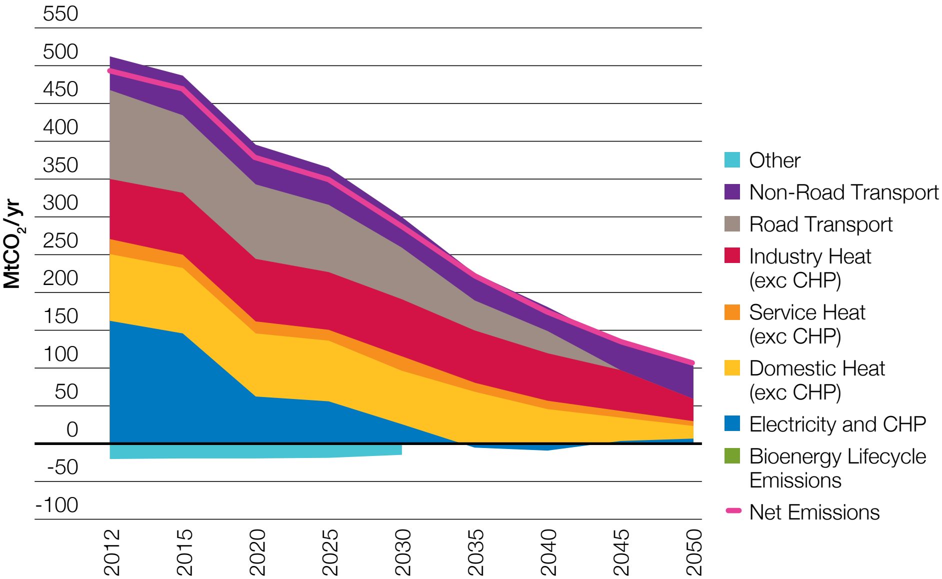
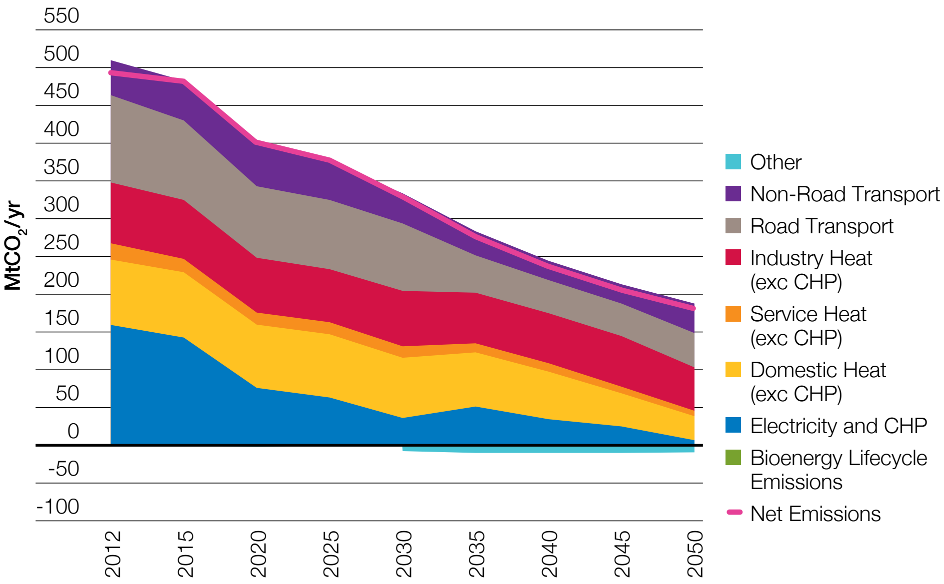


Figure 134
Slow Progression emissions by sector



4.6 continued
Progress Towards Targets

Figure 135
No Progression emissions by sector

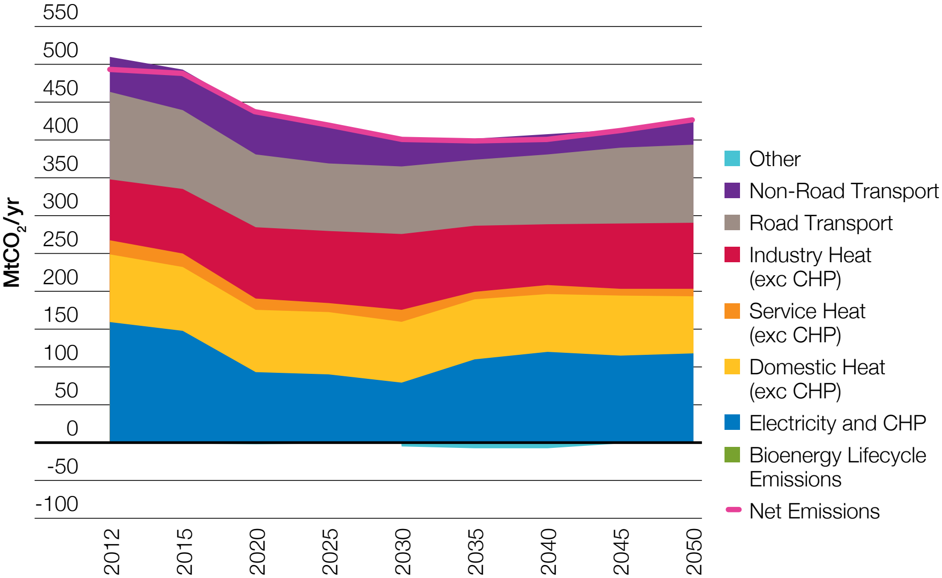
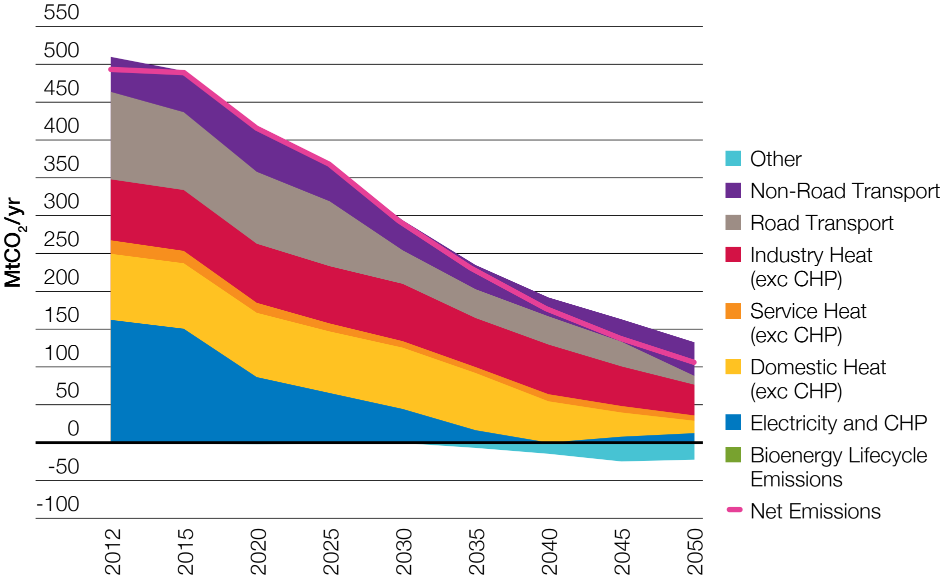


Figure 136
Low Carbon Life emissions by sector



The differences between scenarios represent the progress towards achieving the 2050 greenhouse gas reduction target. **Low Carbon Life** and **Gone Green** both hit the target, but the make up of the emissions between them is slightly different due to **Gone Green** also hitting the 2020 renewables target, whereas **Low Carbon Life** misses the target.

4.6 continued

Progress Towards Targets

Figure 137
Gone Green contributions to RED targets

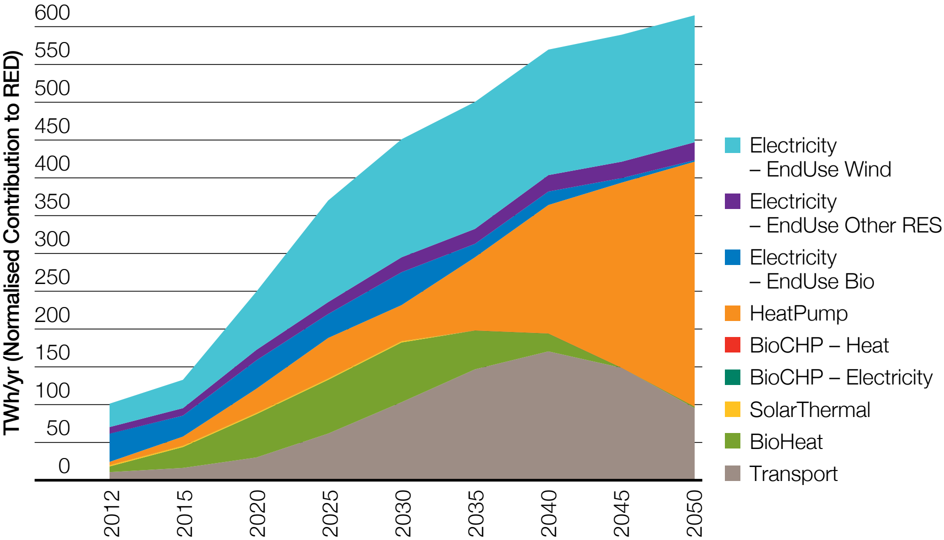
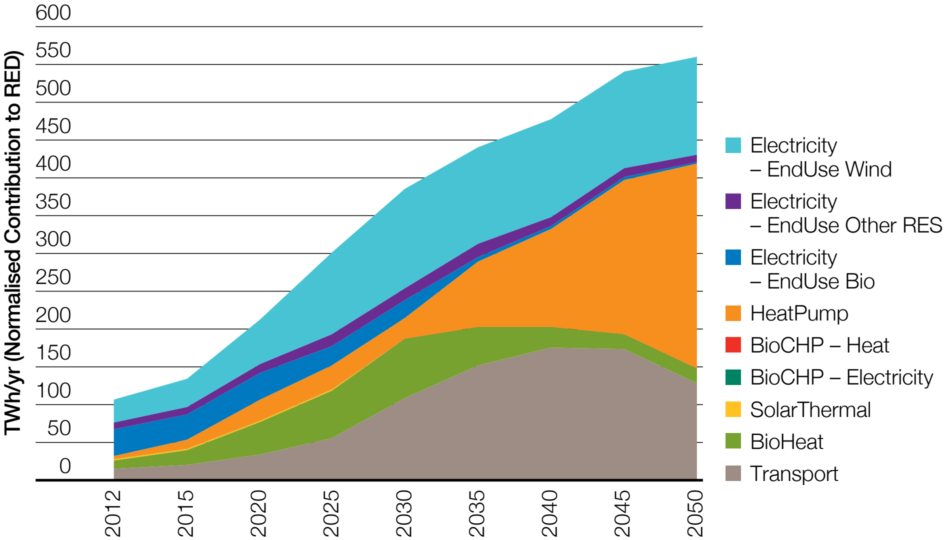


Figure 138
Slow Progression contributions to RED targets



4.6 continued
Progress Towards Targets

Figure 139
No Progression contributions to RED targets

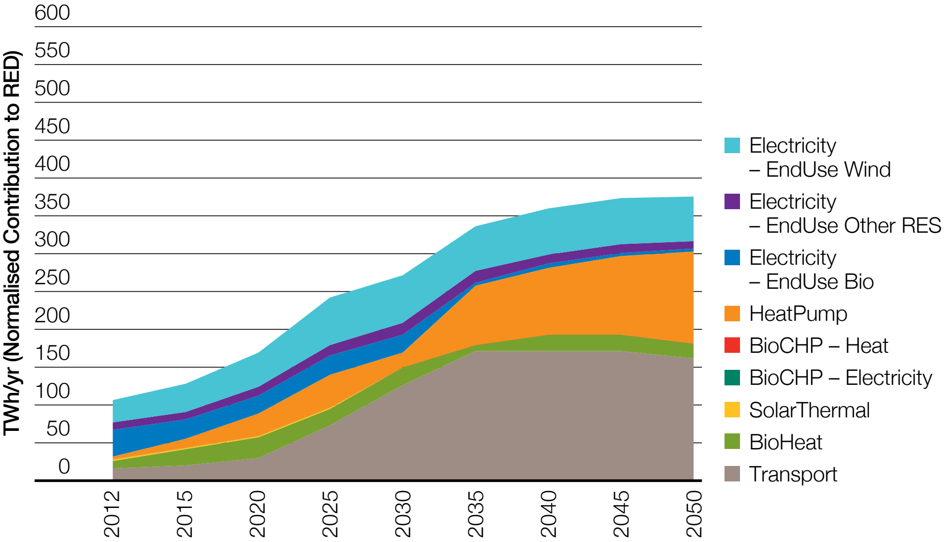
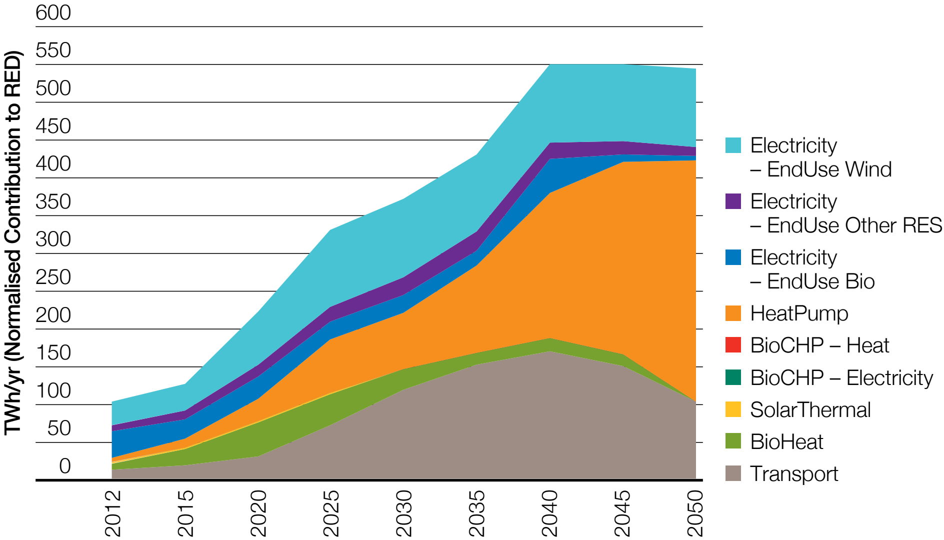


Figure 140
Low Carbon Life contributions to RED targets



Gone Green and **Slow Progression** show greater contribution to RED, due to the axioms being based on this.

In the earlier years, bioenergy contributes to a significant proportion of RED, mainly from burning of biomass for heat and electricity generation. In all scenarios, this contribution drops away as other renewable sources of energy become prevalent, and the supply of sustainable biomass becomes harder.

Heat and transport contribute to RED considerably especially in the latter years. The impact of heat pumps increases significantly from 2040 in all scenarios except **No Progression**, due to the increase in numbers.

Appendix 1
Government Policy

CRC Energy Efficiency Scheme (CRC)

The CRC Energy Efficiency Scheme[51] 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[52] includes the introduction of new long-term contracts – Contracts for Difference (CfDs) for new low carbon generation projects, a Carbon Price Floor[53] (in place since April 2013), a Capacity Market, to include demand response as well as generation, and an Emissions Performance Standard (EPS) set at 450g CO_2/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. The Energy Act of 2013 gave the Secretary of State for Energy and Climate Change the power to introduce these elements of EMR (besides the Carbon Price Floor). National Grid as the National Electricity Transmission System Operator (NETSO) has been appointed as the Delivery Body for EMR. This involves administering the Capacity Market and Contracts for Difference on behalf of DECC, as well as providing key analysis to inform decision making.

Our analysis of EMR is ongoing. We have taken account of the main themes in deriving our power supply backgrounds, shown in section 4.3. 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 (FITs)

The Feed-In Tariffs scheme[54] 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[55] replaces the Carbon Emissions Reduction Target (CERT)[56] 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 GfK NOP showed that in November 2013, 23% of consumers were aware of the Green Deal[57]. It is estimated that 26,000,000 homes could be eligible for Green Deal financing. By the end of March 2014, over 210,000 Green Deal assessments had been carried out, 143 authorised Green Deal providers had been registered and 2,575 organisations were signed up to carry out installations[58].

The Energy Company Obligation (ECO) commenced in 2013 and will operate until March 2015. It places 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

---

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

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

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

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

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

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

[57] https://www.gov.uk/government/publications/green-deal-household-tracker-wave-3

[58] https://www.gov.uk/government/collections/green-deal-and-energy-company-obligation-eco-statistics

in harder to treat properties, such as solid walled properties.

Industrial Emissions Directive (IED)

The Industrial Emissions Directive[59] 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 Large Combustion Plant Directive (LCPD) expires.

Under the terms of the IED, affected plant can:
- Opt out and continue running under previous (LCPD) emission limits.
- Opt in under the Transitional National Plan (TNP), which will impose a cap on annual mass nitrogen oxide emissions and a decreasing cap on annual mass sulphur dioxide emissions on all plants operating under a country's TNP until mid-2020. At that point they will have to decide whether to fit appropriate emission-reducing equipment to comply with the Directive, be limited to run a maximum of 1,500 hours a year or close.
- Opt in and comply fully from 1 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[60] 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[61] caps the annual amount of money that can be levied on bills to support UK low carbon generation at £2.35bn in 2012/13, rising to £7.6bn in 2020/21.This covers Feed-in Tariffs (FITS), Renewables Obligation (RO) and Contracts for Difference (CfDs).

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive[62] 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.

---

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

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

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

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

Appendix 2
Axioms

The axioms listed below will underpin our 2014 UK Future Energy Scenarios. An axiom is a premise or starting point of reasoning. It is a logical statement assumed to be true. Our 2014 axioms have been developed through stakeholder workshops and bilateral meetings, specifically influenced by the voting results and axioms abacus, which can be seen in Appendix 1 and Appendix 2 of our Stakeholder Feedback document[63].

Rules	
Levy Control Framework	Spend capped at £7.6 billion as agreed within LCF Trajectory out to 2021
Security of Supply	Abide by security standard as prescribed by Secretary of State (currently three hours loss of load expectation)

2014 Axioms			
Number	Title	Low Extreme	High Extreme
1	Renewable Energy/Carbon Targets	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.	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.
2	Government Policy (UK & Europe)	EMR mechanisms delivered late and are ineffective. Policy will hinder investment decisions. Policy fails and is weak and ineffective.	EMR mechanisms in place. Policy will drive investment decisions. No mass government intervention in markets. Policy is strong and effective.
3	Economic Outlook	Low economic growth. Benchmarked against external forecasts.	Moderate economic growth. Benchmarked against external forecasts.
4	Energy Efficiency incl. commercial	Lower drive for energy efficiency.	Higher drive for energy efficiency.
5	Fuel Prices	Low fuel prices. Benchmarked against external forecasts.	High fuel prices. Benchmarked against external forecasts.
6	Carbon Price	Low carbon price.	High carbon price.
7	Wind Generation	Limited deployment.	High deployment in line with targets for 2020. Primary renewable source for meeting the renewable targets.
8	Solar Generation	Low solar PV growth as incentives (hence returns) are reduced.	Continued growth in solar PV driven by falling installation costs.

---

[63] http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=31269

2014 Axioms			
Number	Title	Low Extreme	High Extreme
9	Hydro Generation	Hydro deployment broadly static.	Hydro deployment minimal growth.
10	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.
11	Bio-energy 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.	Pre-2020 there is stronger development; conversions are favoured over co-firing and dedicated plants. Post-2020, there is modest build of new dedicated plants. Modest deployment of distributed biomass.
12	Nuclear Generation	Further additional Advanced Gas-cooled Reactor (AGR) life extensions. First new nuclear plant delayed to late 2020s with limited deployment thereafter.	Limited additional 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.
13	CCGT/OCGT (unabated)	Existing fleet close early. Limited new build for gas plant in the near term.	Limited new build in near term. Existing fleet remains on longer than currently anticipated. More aggressive build programme for new fleet.
14	Coal Generation	Advanced closures based on Industrial Emissions Directive (IED) decisions. No new build.	Prolonged operation based on IED decisions. No new build.
15	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.
16	Electricity Interconnection (imports/exports)	Low interconnection capacity driven by market forces.	High interconnection capacity driven by market forces and government policy.

Appendix 2 continued
Axioms

2014 Axioms			
Number	Title	Low Extreme	High Extreme
17	CHP	Limited growth in CHP and district heating schemes.	Continued moderate growth in on-site industrial/commercial CHP deployment. Some district heating projects pre-2020, moderate growth post-2020.
18	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.
19	Heat	Some conversion of on gas grid properties. Incremental off gas grid deployment of technology at current rates.	Incentives promote wider uptake of low carbon heating technologies in both on gas and off gas grid properties.
20	Energy User Behaviour	The lack of capability or economic incentive at point of use results in high behavioural inertia and little change to energy usage patterns.	Over time, the increasing capability and economic incentives reduce behavioural inertia and drive demand reduction/shifting.
21	Global Gas Markets	Gas increasingly marginalised in global markets, leading to a weak investment climate for global gas supply projects.	Gas increasingly important in global markets, leading to a strong investment climate for global gas supply projects.
22	Gas Supply (UKCS)	Discoveries are less than initially expected. Technical challenges are high increasing the costs of bringing fields to market. Negative investment climate that limits exploration.	Discoveries are greater than expected. Less technical challenges in recovering reserves. Positive climate for investment driving increased exploration activity.
23	Gas Supply (Norway)	Low Norwegian volumes to the UK due to a combination of lower Norwegian production and/or higher flows to the Continent.	High Norwegian volumes to the UK due to a combination of higher Norwegian production and/or lower flows to the Continent.

2014 Axioms			
Number	Title	Low Extreme	High Extreme
24	Gas Supply (Liquefied Natural Gas – LNG)	Low LNG imports to the UK due to a combination of low global LNG production and/or high demand in global markets.	High LNG imports to the UK due to a combination of high global LNG production and/or low demand in global markets.
25	Gas Supply (Continent incl. Russian Gas)	Low Continental imports to the UK due to limited access to continental markets and/or limited investment in European Supply projects.	High Continental imports to the UK due to increased access to continental markets and/or significant investment in European Supply projects.
26	UK Shale Gas, Coal Bed Methane (CBM) & Biomethane	Limited development of UK onshore resources as investment is targeted elsewhere.	High development of UK onshore resources due to a positive investment climate.

Appendix 3
Key Data

This table shows selected key facts from each of the four scenarios. Greater detail is available on the National Grid website at www.nationalgrid.com/fes

	Gone Green		Slow Progression	
	2020	2030	2020	2030
Electricity				
GB Peak demand (GW)	59.3	62.1	59.5	57
GB Annual demand (TWh)	338	345	337	322
Capacity (GW)	**105.8**	**146.5**	**97**	**122.4**
Offshore wind (GW)	12.6	31.9	7.2	25.2
Onshore wind (GW)	13.7	19.1	12.2	16.6
Biomass (GW)	3.8	4.3	3.1	3.1
Solar PV (GW)	7.5	15.6	5.5	9.6
Other renewables (hydro/marine/other/CHP) (GW)	3.9	6.9	3.9	5.9
Renewable (GW)	**41.5**	**77.8**	**31.9**	**60.4**
Nuclear (GW)	9	9	9	6.2
CCS capacity (GW)	0	4.5	0	1.1
Low carbon (GW)	**50.5**	**91.3**	**40.9**	**67.7**
Interconnector (GW)	6	11.4	6	8.4
Unabated coal (GW)	7.2	0	7.9	1.9
Unabated gas (GW)	34.1	33.7	34.3	36.3
Other (oil/diesel/pumped storage/CHP) (GW)	8	10.1	7.9	8.1
Heat				
Residential heat pumps (millions)	1.2	5.6	0.3	0.6
Residential heat pumps electricity demand (TWh)	0.3	12.7	0.8	1.3
Transport				
EV number (millions)	0.6	3.2	0.2	1
EV electricity demand (TWh)	1.5	8.2	0.4	2.4
Rail transport (TWh)	5	6.9	5	6.4
Gas				
Residential gas demand (TWh)	309	279	313	308
Annual demand (TWh)	812	793	819	720
Renewable energy %	**15**	**28**	**13**	**23**
GHG reduction* %	**>34%**	**~60%**	**>34%**	**<60**

*Based on a 1990 baseline

No Progression		Low Carbon Life		
2020	2030	2020	2030	
				Electricity
60.3	59.1	61.4	63.2	GB Peak demand (GW)
345	337	353	364	GB Annual demand (TWh)
93	**102.7**	**105.1**	**130**	**Capacity (GW)**
5.2	9.4	9.8	18.9	Offshore wind (GW)
10.3	12.4	14.1	16.6	Onshore wind (GW)
2.8	3.1	3.2	3.2	Biomass (GW)
5.1	8.3	8.5	17.1	Solar PV (GW)
3.5	4.3	4	6.4	Other renewables (hydro/marine/other/CHP) (GW)
26.9	**37.5**	**39.6**	**62.2**	**Renewable (GW)**
9	4.6	9	13	Nuclear (GW)
0	0	0	10.6	CCS capacity (GW)
35.9	**42.1**	**48.6**	**86.4**	**Low carbon (GW)**
5	7.4	5	7.4	Interconnector (GW)
9.8	2.9	9.8	2	Unabated coal (GW)
34.5	42.5	33.6	25.7	Unabated gas (GW)
7.8	7.8	8.1	9.1	Other (oil/diesel/pumped storage/CHP) (GW)
				Heat
0.3	0 .6	0.3	0.6	Residential heat pumps (millions)
0.9	1.5	1	1.5	Residential heat pumps electricity demand (TWh)
				Transport
0.2	1	0.6	3.2	EV number (millions)
0.4	2.4	1.5	8.2	EV electricity demand (TWh)
5	6.4	5	6.4	Rail transport (TWh)
				Gas
317	320	315	314	Residential gas demand (TWh)
826	846	828	851	Annual demand (TWh)
11	**16**	**13**	**23**	**Renewable energy %**
~34	**<60**	**>34**	**~60**	**GHG reduction* %**

Meet the Energy Strategy & Policy Management Team…

Richard Smith
Head of Energy Strategy & Policy
Richard.Smith@nationalgrid.com

Marcus Stewart
Energy Supply Manager
Marcus.Stewart@nationalgrid.com

Lilian Macleod
Power Supply Manager
Lilian.Macleod@nationalgrid.com

Simon Durk
Gas Supply Manager
Simon.Durk@nationalgrid.com

Nigel Fox
Energy Demand Manager
Nigel.Fox@nationalgrid.com

Lauren Moody
Power Demand Manager
Lauren.Moody@nationalgrid.com

Russell Fowler
Power Demand Manager (from 1st July 2014)
Russell.Fowler@nationalgrid.com

Stephen Marland
Gas Demand Manager
Stephen.A.Marland@nationalgrid.com

Alice Etheridge
Strategy Development Manager
Alice.Etheridge@nationalgrid.com

Gary Dolphin
Market Outlook Manager
Gary.Dolphin@nationalgrid.com

Disclaimer

For the purpose of this statement, National Grid Gas plc and National Grid Electricity Transmission PLC will together be referred to as National Grid. The information contained within the UK Future Energy Scenarios document ("the Document") is disclosed voluntarily and without charge to you in order to facilitate and encourage discussion of the scenarios used by National Grid in its electricity and gas planning processes.

The Document does not replace the Gas Ten Year Statement (GTYS) or the Electricity Ten Year Statement (ETYS) (or any other document published by National Grid containing substantially the same information as those documents) published in accordance with the relevant licence conditions.

While National Grid have not sought to mislead any party as to the content of the Document and, whilst such content represents National Grid's best views as at the time of publication, readers should not place any reliance on the content of the Document. The Document (including, without limitation, information as regards capacity planning, future investment and the resulting capacity) must be considered as illustrative only and no warranty can be or is made as to the accuracy and completeness of such Document, nor shall anything within the Document constitute an offer capable of acceptance or form the basis of any contract. Other than in the event of fraudulent misstatement or fraudulent misrepresentation, National Grid does not accept any responsibility for any use which is made of the information contained within this Document.

Copyright National Grid 2014, all rights reserved. No part of the Document may be reproduced in any material form (including photocopying and storing in any medium or electronic means and whether or not transiently or incidentally) without the written permission of National Grid except in accordance with the provisions of the Copyright, Designs and Patents Act 1988.

Notes

Notes

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom
Registered in England and Wales
No. 4031152

www.nationalgrid.com