nationalgrid

Future Energy Scenarios in five minutes

System Operator

JULY 2018

Welcome to our *Future Energy Scenarios*

These scenarios, which stimulate debate and help inform the decisions that will shape our energy future, have never been more important – especially when you consider the extent to which the energy landscape is being transformed.

Factors include ambitious environmental policy and legislation, a dramatic growth in local generation, and the development of technologies that are allowing consumers to break away from the more traditional models of energy supply.

The pace of change was starkly highlighted this year when Britain had three consecutive days free of coal-fired power generation. And solar generation continues to set new records.

Against this backdrop, it's impossible to accurately forecast a single energy future over the long term. However, creating a range of credible futures allows us to continue supporting the development of an energy system that's robust against different outcomes.

And it's not just based on our own input – we've gathered the views of 430 organisations through meetings, workshops, webinars and our conference, so we could learn more about what our stakeholders thought the future of energy could look like.

Our new scenarios highlight some important themes and future developments. For example, gas will remain crucial for both heating and electricity generation in all scenarios for the coming decades. There will be a significant increase in electricity infrastructure, from new renewable generation to electric vehicle charging networks. And the decarbonisation of heating will be challenging, with multiple ways to achieve it – requiring both electricity and different types of gas.

We've refreshed our scenario framework to reflect the increasing importance of decentralisation and decarbonisation in our industry. We've also included, for the first time, the early results from our project to cost the scenarios. Our key messages highlight the insights from the scenarios and act as a call to action. They will help the industry to focus on how we could efficiently transition to a low carbon economy.

Another development is happening within our own business. National Grid's Electricity System Operator (ESO) will separate from our electricity transmission business in April 2019. Although the ESO will soon start to look and feel different, our *Future Energy Scenarios* will remain a whole system publication. It will also play an important role for the RIIO-2 process, providing valuable analysis and insight.

Of course, this publication is only the start of our work. Our expert analysts will be working on what the scenarios mean for network development, system operability and security of supply. Their findings will appear in our other System Operator publications.

Thank you for your valuable insight over the past year. Please continue to share your views with us. Details about how to contact us are on our website: fes.nationalgrid.com.

Fintan Slye
Director, UK System Operator

What are the *Future Energy Scenarios (FES)*?

Our scenarios outline different credible pathways for the future of energy for the next 30 years and beyond. These consider how much energy we might need and where it could come from. They look at what the changes might mean for the industry, our customers and consumers.

Why do we create them?

We use the scenarios for planning how we develop and operate the gas and electricity systems and for other key activities like charging projections. Our scenarios are also used widely across the energy industry and beyond, driving debate and decision-making.

How do we create them?

FES is the product of in-depth analysis by our team of experienced analysts. Stakeholder feedback is fundamental to the development of these scenarios. Combining the expertise of industry specialists with our own insights gives us the depth of knowledge we need to produce scenarios that are independent, well informed and up-to-date.

***FES* is the product of in-depth analysis informed by industry experts and National Grid's own insights.**

Scenario overview

We have created a new framework for our 2018 scenarios. It retains a 2 x 2 matrix with four scenarios but these are now aligned to axes of 'speed of decarbonisation' and 'level of decentralisation'.

The speed of decarbonisation axis is driven by policy, economics and consumer attitudes. The level of decentralisation axis shows how close the production and management of energy is to the end consumer. Two scenarios, **Community Renewables** and **Two Degrees**, meet the UK's 2050 carbon reduction target. The table below shows some of the key characteristics of the four scenarios. It is a selective summary for illustrative purposes and the full details can be found in the main *FES* document.

Level of decentralisation ↑ / Speed of decarbonisation →

✗✗ 2050 carbon reduction target is not met

Consumer Evolution

Electricity demand	Moderate-high demand: high for electric vehicles (EVs) and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Small scale renewables and gas; small modular reactors from 2030s
Gas supply	Highest shale gas, developing strongly from 2020s

Steady Progression

Electricity demand	Moderate-high demand: high for EVs and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Offshore wind, nuclear and gas; carbon capture utilisation and storage (CCUS) gas generation from late 2030s
Gas supply	UK Continental Shelf still producing in 2050; some shale gas

✓✓ 2050 carbon reduction target is met

Community Renewables

Electricity demand	Highest demand: high for EVs, high for heating and good efficiency gains
Transport	Most cars are EVs by 2033; greatest use of gas in commercial vehicles but superseded from mid 2040s by hydrogen (from electrolysis)
Heat	Heat pumps dominate; high levels of thermal efficiency
Electricity supply	Highest solar and onshore wind
Gas supply	Highest green gas development from 2030s

Two Degrees

Electricity demand	Lowest demand: high for EVs, low for heating and good efficiency gains
Transport	Most cars are EVs by 2033; high level of gas used for commercial vehicles but superseded from mid 2040s by hydrogen
Heat	Hydrogen from steam methane reforming from 2030s, and some district heat; high levels of thermal efficiency
Electricity supply	Offshore wind, nuclear, large scale storage and interconnectors; CCUS gas generation from 2030
Gas supply	Some green gas, incl. biomethane and BioSNG; highest import dependency

Key messages

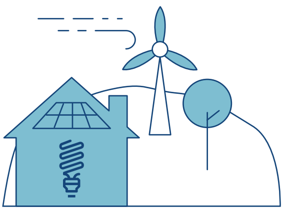
1. We are entering a new world of energy. The expected growth of low carbon and decentralised generation means the electricity system will need to change.

What this means

- The market will need to adapt to the changing plant mix. Key industry processes are likely to need reviewing, bringing with them opportunities for new services.
- Balancing security of supply, affordability and efficiency in a decarbonised world presents new challenges. We will work with industry, Ofgem and the Government to meet these challenges to deliver a reliable, efficient and operable low carbon system.

Increase in capacity from **103GW** today to between **189GW** and **268GW** by 2050.

Up to 65%
Percentage of generation capacity which could be local by 2050.



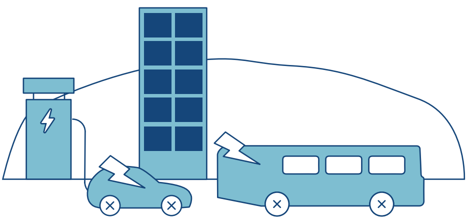
2. Electric vehicle growth goes hand in hand with electricity decarbonisation. Smart charging and vehicle-to-grid can actively support the decarbonisation of electricity.

What this means

- Balancing demand and supply and power flows will become increasingly complex and need a coordinated approach across the whole industry.
- This presents opportunities for developers and suppliers, but data and information flows will become increasingly critical.

Electricity demand is expected to grow significantly by **2050.**

36m
Potential number of electric vehicles (EVs) by 2040.



Key messages

3. Action on heat is essential and needs to gather pace in the 2020s to meet carbon reduction targets. A mix of low carbon heating solutions and better thermal efficiency of buildings is needed.

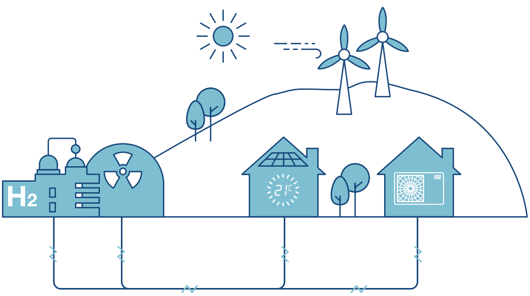
What this means

- Decarbonising heat is crucial but needs to address significant technical and commercial challenges. A balance of technologies is needed to meet the heat challenge.
- Development of hydrogen and the rollout of heat pumps need to be driven by clear policy and supportive market arrangements.

There are different ways to decarbonise heating.

Up to 60% of homes could be using heat pumps by 2050.

Or hydrogen could heat **one third** of homes by 2050.



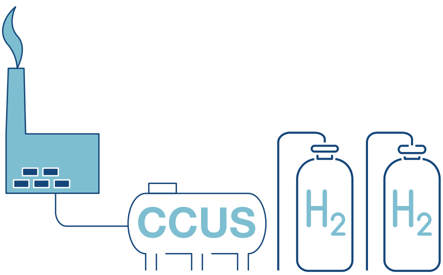
4. Gas will play a role in providing reliable, flexible energy supplies for the foreseeable future. New technologies and sources of low carbon gas can decarbonise the whole energy sector.

What this means

- Gas networks and markets will need to adapt to accommodate changing gas flows and reduced annual demand with more pronounced winter peaks.
- The development of hydrogen and carbon capture utilisation and storage (CCUS) needs innovation and demonstration projects to help overcome the technical, commercial and implementation challenges and to enable commercial rollout of CCUS and hydrogen in the 2030s.

Gas continues to provide **more energy than electricity** by 2050 in three of our four scenarios.

Gas usage patterns are changing, **providing flexibility** for heat and generation.



Key comparison chart

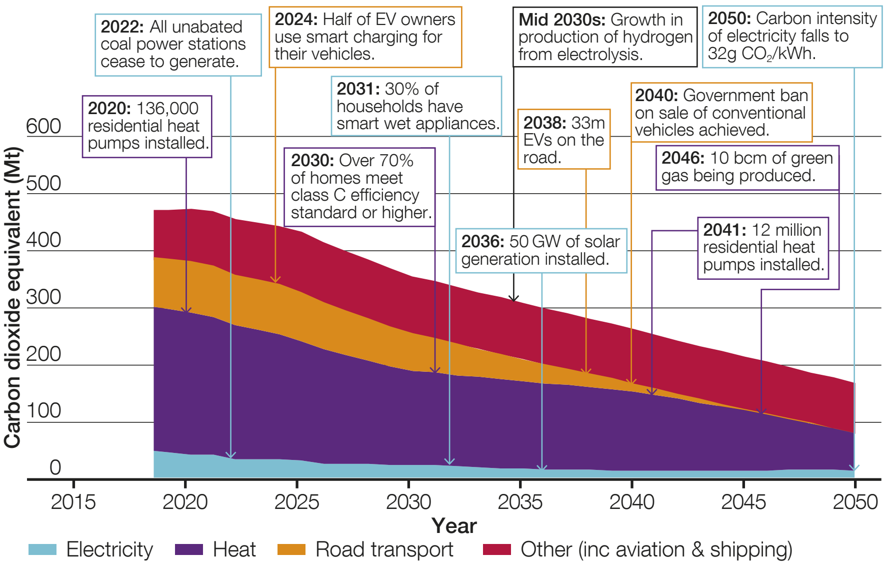
CR Community Renewables · TD Two Degrees · SP Steady Progression · CE Consumer Evolution

		2017	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	>2040	Maximum potential by 2050
Transport	Exceeds 2 million electric vehicles	95k					CR, TD					SP, CE													CR 38.5m
Transport	Exceeds 1 GW of vehicle-to-grid capacity	N/A											CR	TD			SP, CE								CR 20.6 GW
Transport	Reaches 50,000 natural gas vehicles	3k						CR, TD						SP, CE											CR 243k
Heating	10% of homes using low carbon heating	2%								CR, TD								CE					SP		TD 84%
Electricity generation	25% electricity output from distributed sources	17%			CR		TD		CE															SP	CR 43%
Electricity generation	Hits 60% renewable generation output	26%					TD	CR					SP	CE											CR 76%
Electricity generation	Carbon intensity of electricity generation below 100g CO_2/kWh	266g CO_2 kWh						TD	CR						SP			CE							TD 20g CO_2/kWh
Electricity storage	Exceeds 6 GW electricity storage technologies	2.9 GW						TD	CR			CE		SP											CR 28.8 GW
Electricity interconnection	10 GW of electricity import capacity	4 GW			TD	CR	SP	CE																	TD 19.8 GW
Gas supplies	10% of supplies from onshore production (shale and green gas)	0.3%						CE			SP							CR						TD	CE 54%

Decarbonisation

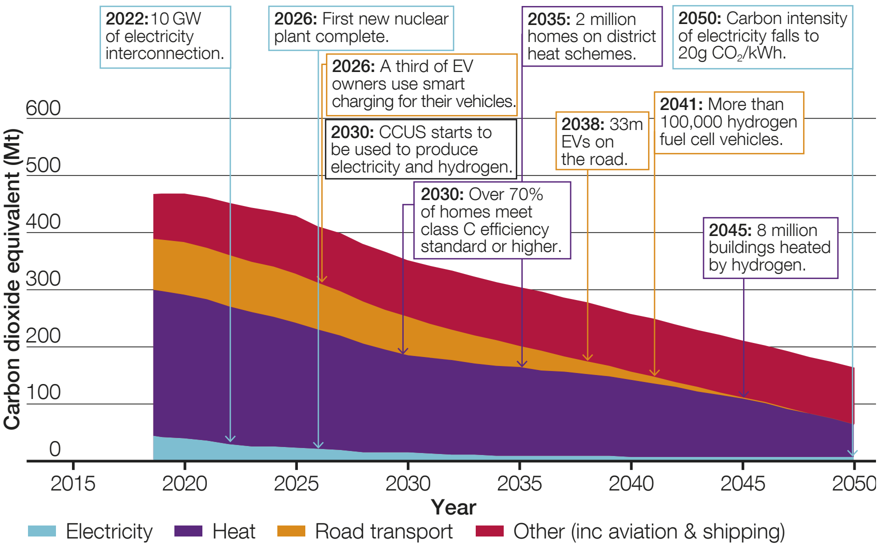
Two of our four scenarios, Two Degrees and Community Renewables, meet the 2050 carbon reduction target but in different ways.

Community Renewables shows a more decentralised approach. In this world, factors like the large growth of renewables, supported by storage and smart appliances, enable a large reduction in the carbon intensity of electricity. Transport is almost completely decarbonised, thanks to a very high number of EVs and some vehicles that use hydrogen created by electrolysis using excess renewable power. Significant progress is made in the decarbonisation of heat due to factors such as the improved thermal efficiency of homes and the rollout of electric and hybrid (gas and electric) heat pumps.



Decarbonisation

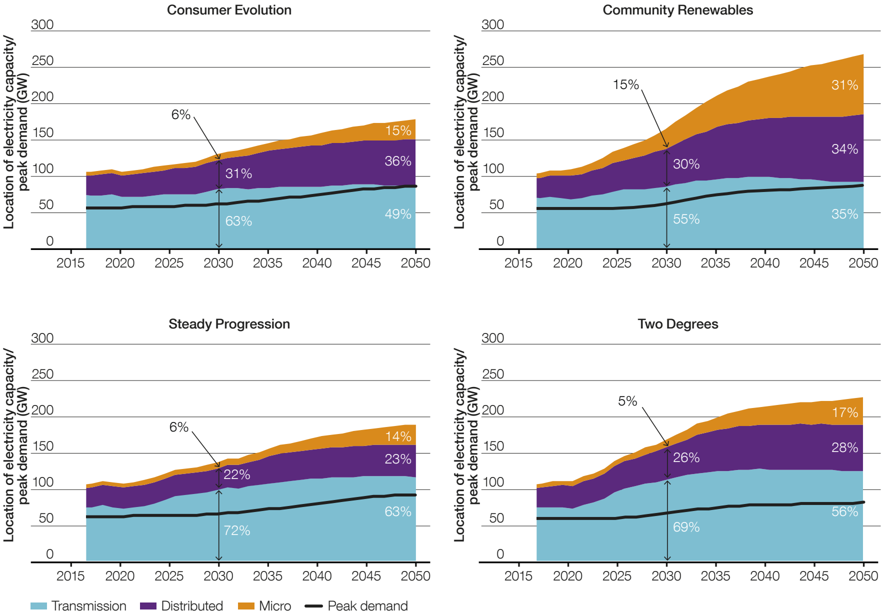
Two Degrees meets the 2050 carbon reduction target through a more centralised approach. In this world, factors like large growth of renewables, nuclear and gas-fired generation using carbon capture utilisation and storage (CCUS) bring about a very large reduction in the carbon intensity of electricity. Transport is almost completely decarbonised, thanks to a very high number of EVs, and some vehicles that use hydrogen created by steam methane reforming paired with CCUS. Significant progress is made in the decarbonisation of heat due to factors such as the improved thermal efficiency of homes and the rollout of low carbon district heating and hydrogen networks for heating in a number of city regions.



Decentralisation

In all our scenarios, the level of decentralised energy increases. In terms of electricity supply, there is a significant increase in smaller scale generators, such as solar and wind turbines, which are not connected directly to the transmission network. Decentralised gas supplies will increase from a low base in all the scenarios. On the demand side, data exchange technologies and business models are developing and these allow consumers to move away from traditional models of energy trading.

The figure below illustrates changes in electricity generation capacity. In the decentralised scenarios, **Community Renewables** and **Consumer Evolution**, there are more small scale electricity generators.

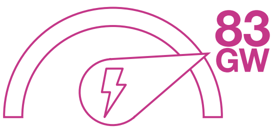


Energy demand overview

The current annual demand for gas in GB is 810 TWh and for electricity 297 TWh. In all our scenarios, the total energy demand reduces by 2050. A major component is the decline in the use of gas for electricity generation, although gas continues to provide the majority of energy in all but one of the scenarios by 2050. In the more centralised scenarios, the use of CCUS leads to an increase in gas use from the 2030s.

The demand for electricity increases in all our scenarios. This is brought about mainly by the increase in EVs and the resulting demand will become one of the dominant features in the overall energy demand mix. However, opportunities exist to harness the battery storage ability of EVs and supply electricity back to the system to support the rollout of renewables.

We have included production of hydrogen in our models this year. Hydrogen can be used as a fuel, for example for heating or transport, and as a flexible resource to store excess renewable electricity.



Peak electricity demand reaches 83 GW by 2050 in **Community Renewables**

(59 GW in 2017)

In Two Degrees hydrogen could provide **265 TWh** of energy annually by 2050

(0 TWh in 2017)

Steady Progression sees the highest annual gas demand at **638 TWh** in 2050

(810 TWh in 2017)

Gas supply overview

Gas continues to be an important fuel for the whole energy system, although total supply is falling in all scenarios. This reflects lower gas demand but, as sources of gas change, we will still need to manage a wide range of gas supply patterns.

Production from the UK Continental Shelf declines in all scenarios and finishes before 2050 in all but **Steady Progression.** Imported gas from Norway and Continental Europe and imported liquefied natural gas are important in all scenarios. Shale gas is included in **Steady Progression** and **Consumer Evolution,** and there is more green gas in the two decarbonised scenarios, **Two Degrees** and **Community Renewables.**

In the two more decentralised scenarios, **Consumer Evolution** and **Community Renewables,** more gas supplies are connecting to the local distribution networks rather than the National Transmission System.

green gas
makes up 39%
of total GB gas demand in
Community Renewables
in 2050
(<1% in 2017)

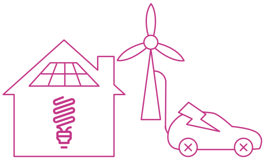
imported gas makes
up 90%
of total supply in
Two Degrees in the
mid 2040s
(51% in 2017)

Electricity supply overview

Local and low carbon generation is becoming an increasing feature of electricity supply in GB. While subsidy support for most renewable generation is now reducing, growth will continue at pace for most low carbon technologies.

This is thanks to factors such as continued reductions in cost, technology developments and co-location with storage allowing access to new revenue streams. Consequently, there is high growth of electricity storage in all scenarios, particularly in the more decarbonised ones, where storage is increasingly important in balancing renewable output.

Electricity interconnector capacity increases in all scenarios. From 2030, particularly in the more decarbonised scenarios, we anticipate times where there may be an excess of electricity. This is because electricity output from inflexible and intermittent generation will outstrip demand and at times it will not be possible to export this electricity, as connected markets will have the same excess as GB. Market development, new technologies and new ways of designing and operating networks will be needed to address the operational challenges that arise as a result.



Decentralised generation reaches **65% of overall** generation capacity by 2050 **in Community Renewables** (27% in 2017)

In all scenarios, thermal plant will increasingly be reliant on providing flexibility and key network services to remain economic. However, particularly in the less decarbonised scenarios, gas will also provide some baseload power.

43 GW
Amount of offshore wind capacity by 2050 in Two Degrees (6 GW in 2017)

66 GW
Amount of solar capacity by 2050 in Community Renewables (12 GW in 2017)

Key statistics in 2030 and 2050

Electricity	2017	2030 CR	2030 TD	2030 SP	2030 CE
Annual demand (TWh)*	297	302	293	304	308
Peak demand (GW)	59	62	64	62	64
Total installed capacity (GW)	103	158	161	134	131
Low carbon and renewable capacity (GW)	47	99	100	70	70
Interconnector capacity (GW)	4	17	20	15	10
Total storage capacity (GW)**	3	10	10	6	7
Vehicle-to-grid total capacity (GW)	0	1.1	1.0	0.2	0.2

Gas	2017	2030 CR	2030 TD	2030 SP	2030 CE
Annual demand (TWh)	810	487	506	671	700
1-in-20 peak demand (GWh/day)	5,522	3,925	4,013	5,083	5,068
Residential demand (TWh)	332	239	244	310	302
Gas imports (%)	51%	81%	69%	57%	51%
Shale production (bcm/yr)	0	0	0	10	22
Hydrogen production (TWh)	0	1	3	0	0
Green gas production (bcm/yr)	0.3	2	1.3	0.3	0.8

*Excludes losses
**Includes vehicle-to-grid

Key statistics in 2030 and 2050

2050				
CR	TD	SP	CE	**Electricity**
441	373	386	392	Annual demand (TWh)*
83	79	87	87	Peak demand (GW)
268	224	189	199	Total installed capacity (GW)
178	160	110	116	Low carbon and renewable capacity (GW)
17	20	15	10	Interconnector capacity (GW)
50	35	27	34	Total storage capacity (GW)**
20.6	17.9	15.5	17.7	Vehicle-to-grid total capacity (GW)

2050				
CR	TD	SP	CE	**Gas**
244	565	638	548	Annual demand (TWh)
2,047	2,992	4,817	4,147	1-in-20 peak demand (GWh/day)
77	68	281	255	Residential demand (TWh)
61%	89%	75%	46%	Gas imports (%)
0	0	16	32	Shale production (bcm/yr)
33	265	2	2	Hydrogen production (TWh)
11.9	6.7	0.3	3.6	Green gas production (bcm/yr)

Continuing the conversation

Email us with your views on FES or any of our future of energy documents at: **fes@nationalgrid.com** and one of our experts will get in touch.

Access our current and past FES documents, data and multimedia at: **fes.nationalgrid.com**

Get involved in the debate on the future of energy and join our LinkedIn group Future of Energy by National Grid.

Keep up to date on key issues relating to National Grid via our Connecting website: **nationalgridconnecting.com**

Write to us at:
Energy Insights
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

fes.nationalgrid.com

Future of Energy

fes@nationalgrid.com

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