Future Energy Scenarios in five minutes

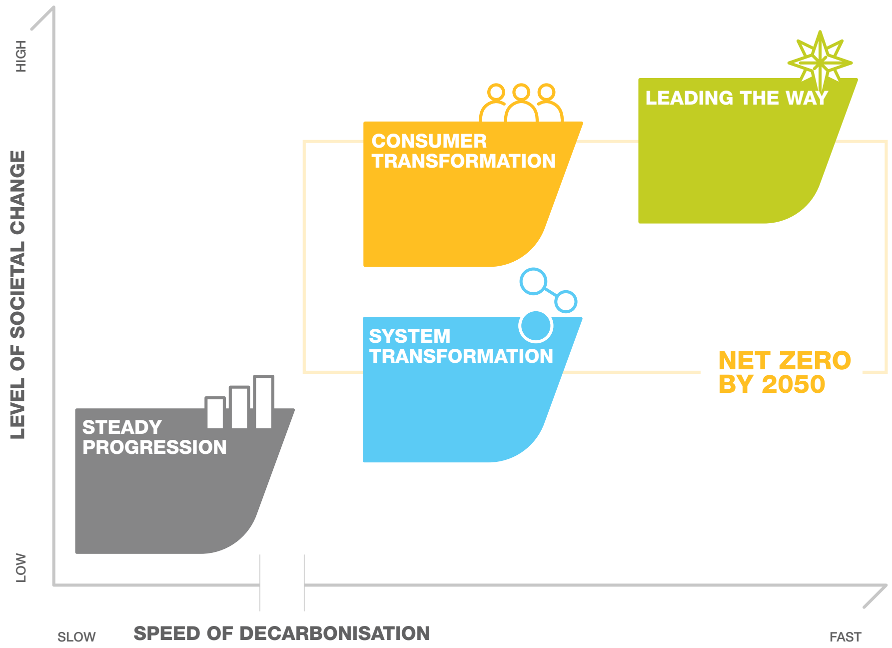
July 2020

nationalgridESO

What are the Future Energy Scenarios?

Our Future Energy Scenarios (FES) outline four different, credible pathways for the future of energy over the next 30 years. Each scenario considers how much energy we might need and where it could come from.

This year we have a new scenario framework, considering the impact of societal change as well as the speed of decarbonisation.



COVID-19 impact

COVID-19 will impact many aspects of the future of energy. However the uncertainty and lack of evidence of this impact at the time of analysis means it has not been included in FES 2020. The impact of COVID-19 will be discussed with stakeholders in the second half of 2020 and will form part of FES 2021.

Why are the Future Energy Scenarios important?

With an ambitious target for net zero emissions by 2050, our energy system will need to rapidly transform to meet the changing needs of consumers and society. FES 2020 considers the whole energy system; we've looked at a wide range of energy sources, including fuels like hydrogen and biomass, as well as electricity and natural gas.

2050 may seem far in the future but, in energy investment terms, it is just around the corner. Hitting the net zero target means starting the journey now. Awareness of the causes and impacts of climate change is rising, and more action is being taken across society. FES 2020 draws on information, insight and data from stakeholders across all sectors of the energy industry to develop a whole system view.

Unlike previous years, where an 80% target left some sectors relatively unchanged, FES 2020 must explore solutions for every sector and every activity to achieve net zero. Shifting away from high carbon fuels by 2050 will be hard and for some sectors it may not be possible. This means we need negative emissions in some sectors as well as using low carbon sources of energy and scaling up non-traditional sources of flexibility such as demand side response and storage.

Our stakeholders use FES for a variety of purposes:

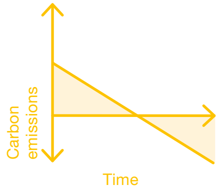
- For investment decisions in electricity and gas networks;
- To gain insight into the wider energy industry;
- To identify future commercial or policy opportunities;
- As a reference point or to compare with industry forecasts; and
- As a starting point for academic studies and research.

FES-in-5 provides you with the key headlines and statistics from the full FES report which can be found **here.**[1]

1. nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

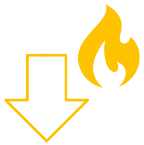
Key message 1

Reaching net zero carbon emissions by 2050 is achievable. However, it requires immediate action across all key technologies and policy areas, and full engagement across society and end consumers.

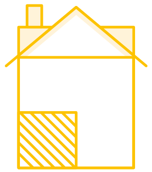


Net emissions from power sector are negative by 2033 in net zero scenarios

At least 40GW of new capacity is connected to electricity system in the next 10 years



Levels of natural gas burned unabated halves by 2038 across all net zero scenarios



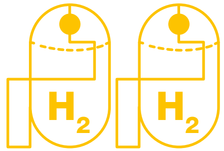
The input energy required to heat an average house could drop to as little as a quarter of what it is today

What this means

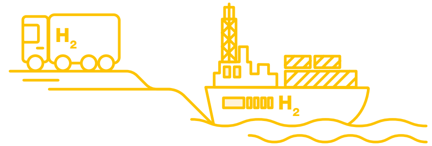
- Cross-sector regulations and services are needed to simplify the changes consumers need to make.
- Improving energy efficiency across all sectors is a no regret action. It enables all low carbon technologies - and supports meeting peak and annual demands.
- Significant investment in low carbon electricity generation will be required across all net zero pathways.
- Heat decarbonisation requires urgent policy decisions to drive change across the whole energy system.

Key message 2

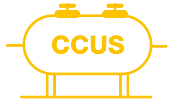
Hydrogen and carbon capture and storage must be deployed for net zero. Industrial scale demonstration projects need to be operational this decade.



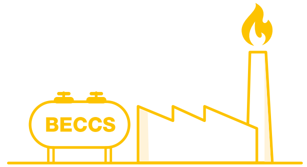
Hydrogen provides between 21% and 59% of 2050 net zero end-user energy needs



A minimum of 80TWh of hydrogen is required by 2050 to decarbonise shipping and HGV sectors in net zero scenarios



CCUS and methane-reformed hydrogen infrastructure develops in industrial clusters by 2030 in all net zero scenarios, expanding beyond clusters in some scenarios



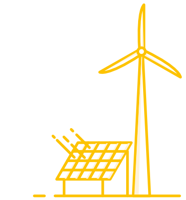
CCUS is paired with bioenergy to generate up to 62MTCO_2e of negative emissions by 2050 as well as being important for production of low carbon hydrogen from natural gas

What this means

- Many different technologies can be used to produce hydrogen. Policy support is required as market signals do not currently provide strong enough investment signals to scale the technology at the pace required. Strategic direction is required to deliver at lowest cost for consumers.
- Carbon Capture Usage and Storage (CCUS) development requires support and coordination across policy, regulation, and industry.
- Hydrogen electrolysers can support integration of renewable generation. When paired with hydrogen storage and power generation, they can also provide seasonal flexibility which is important for whole system planning.

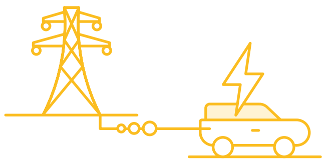
Key message 3

The economics of energy supply and demand fundamentally shift in a net zero world. Markets must evolve to provide incentives for investment in flexibility and zero carbon generation.



At least 3GW of wind and 1.4GW of solar need to be built every year from now until 2050

Zero marginal cost generation will provide up to 71% of generation output in 2030, and up to 80% in 2050



Vehicle-to-grid (V2G) services could provide up to 38GW of flexibility from 5.5m vehicles

What this means

- Future markets must reflect the economics of zero marginal cost generation and the value of flexibility in supply and demand.
- Current market arrangements for renewable investment need to evolve to deliver the generation capacity required for net zero in 2050.
- The concept of peak electricity demand and how it is applied in planning and operating the system is changing as the ability of demand to ramp up to take advantage of low prices increases.

Key message 4

Open data and digitalisation underpin the whole system thinking required to achieve net zero. This is critical to navigating increasing complexity at lowest cost for consumers.

By 2050, up to 80% of households smart charge their Electric Vehicle (EV) and up to 45% actively provide V2G services

As many as 8.1m homes actively manage heating demand with residential thermal storage and load shifting by 2050

There could be over 8m hybrid heat pumps responding to market signals and shifting demand between hydrogen and electricity systems by 2050

What this means

- The complexity of energy system decisions is increasing. Transparent and advanced analysis is critical in making the best decisions for energy consumers.
- The number of energy market participants is rapidly expanding and open data access is fundamental to ensuring efficiency.
- Whole system interactions will increase, and progress towards net zero must be made in a way that includes all impacted parties.
- Consumer technology choices today will influence decarbonisation pathways and options for efficient whole system operation in the future. Visibility and interoperability standards must be embedded to maintain options for smart management and market participation.

Consumer View

Part of the challenge of the 2050 target is that the energy system alone cannot deliver decarbonisation. It exists to serve consumers and its evolution will reflect their behavioural changes over the next 30 years.

Industrial and commercial

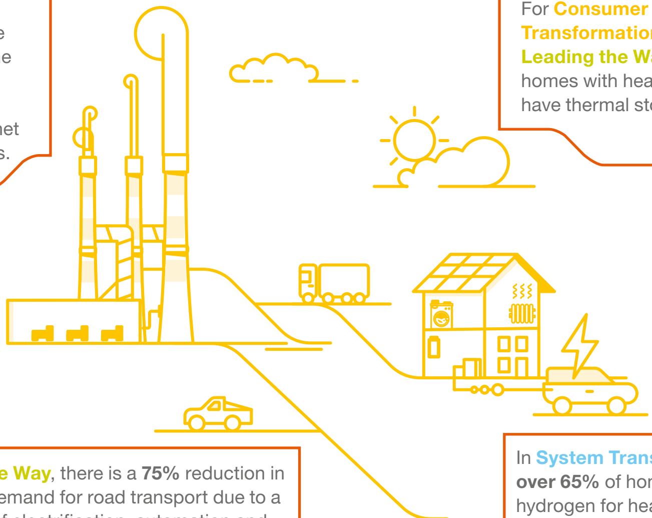
High levels of energy efficiency help to manage demand and enable industrial consumers to decarbonise by switching to new technologies and fuels.

Transport

Electrification is key to the decarbonisation of transport. Even in the slowest decarbonising scenario, there will be no new cars sold with an internal combustion engine after 2040.

Residential

Changes to all homes are needed to enable decarbonisation in the residential sector. Energy efficiency measures, low carbon heating systems and smart energy management all play a part in net zero homes.



Hydrogen and **CCUS** are required for the industrial and commercial sectors in all net zero scenarios.

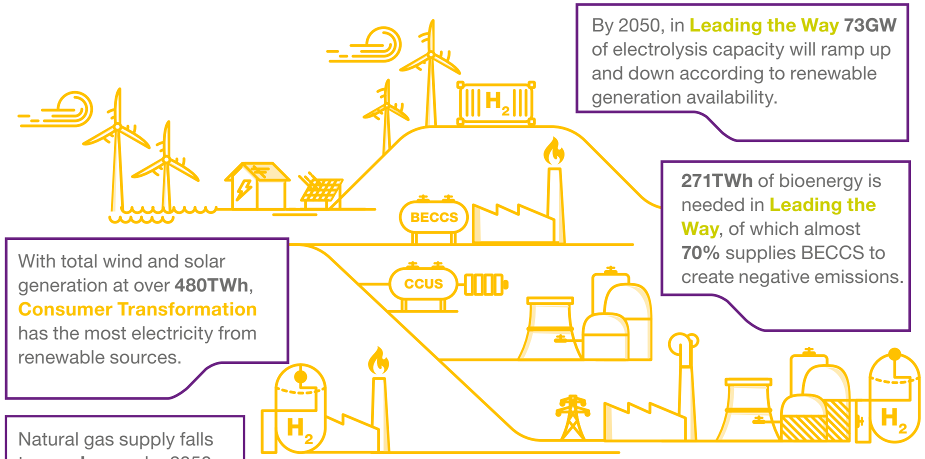
For **Consumer Transformation** and **Leading the Way**, **40%** of homes with heat pumps will have thermal storage.

In **Leading the Way**, there is a **75%** reduction in total energy demand for road transport due to a combination of electrification, automation and changing consumer behaviour.

In **System Transformation**, **over 65%** of homes use hydrogen for heating.

System View

The net zero target makes it more important than ever to consider all aspects of the whole energy system. This includes how different energy sources combine to provide negative emissions and whole system flexibility.



By 2050, in **Leading the Way** **73GW** of electrolysis capacity will ramp up and down according to renewable generation availability.

271TWh of bioenergy is needed in **Leading the Way**, of which almost **70%** supplies BECCS to create negative emissions.

With total wind and solar generation at over **480TWh**, **Consumer Transformation** has the most electricity from renewable sources.

Natural gas supply falls to **nearly zero** by 2050 in **Leading the Way**.

Hydrogen supplies **59%**[2] of total end-use energy in **System Transformation** by 2050.

Bioenergy

Without negative emissions from bioenergy with carbon capture and storage, net zero cannot be achieved.

Natural Gas

Natural gas remains central to all scenarios for heating into the 2030s, after which its use changes significantly.

Hydrogen

Hydrogen plays a role in every net zero scenario. It can be produced from either renewable electricity or from natural gas.

Flexibility

Increases in renewable generation capacity will require greater flexibility across the whole system.

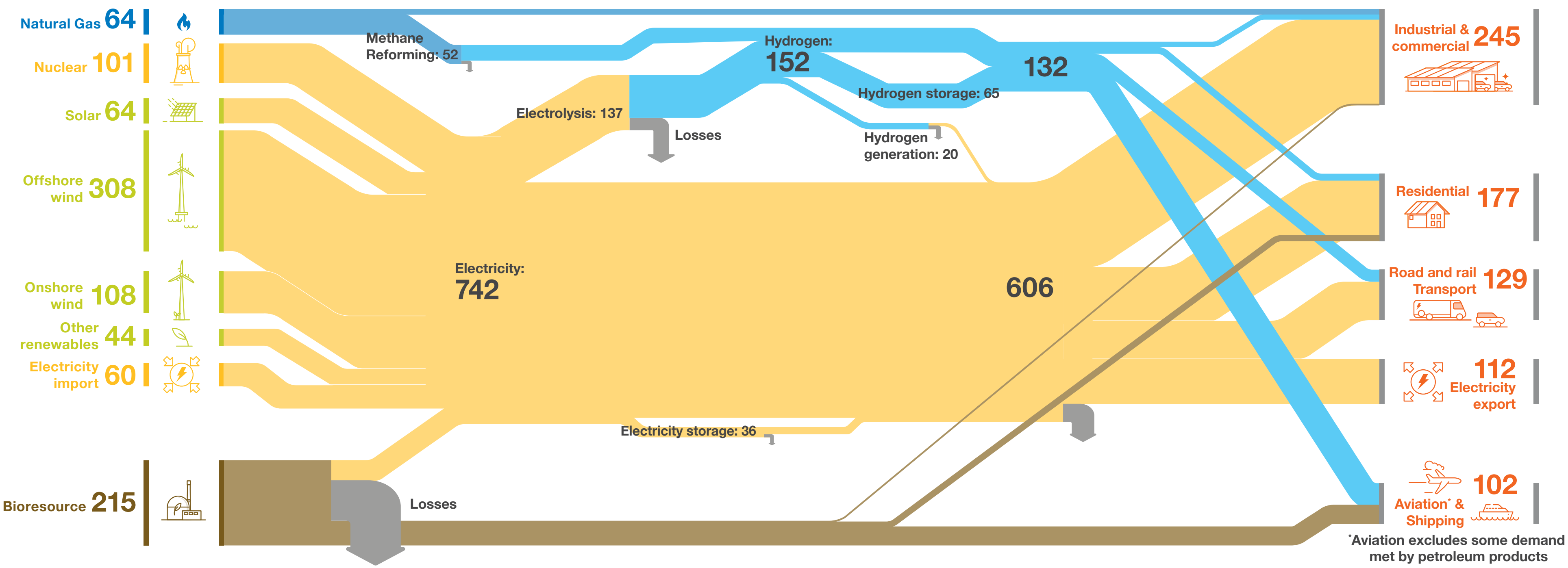
Electricity

By the mid-2030s, the net carbon intensity of electricity generated in GB has become negative in all net zero scenarios.

2. This total energy demand excludes aviation.

2050 energy flows in Consumer Transformation (TWh)

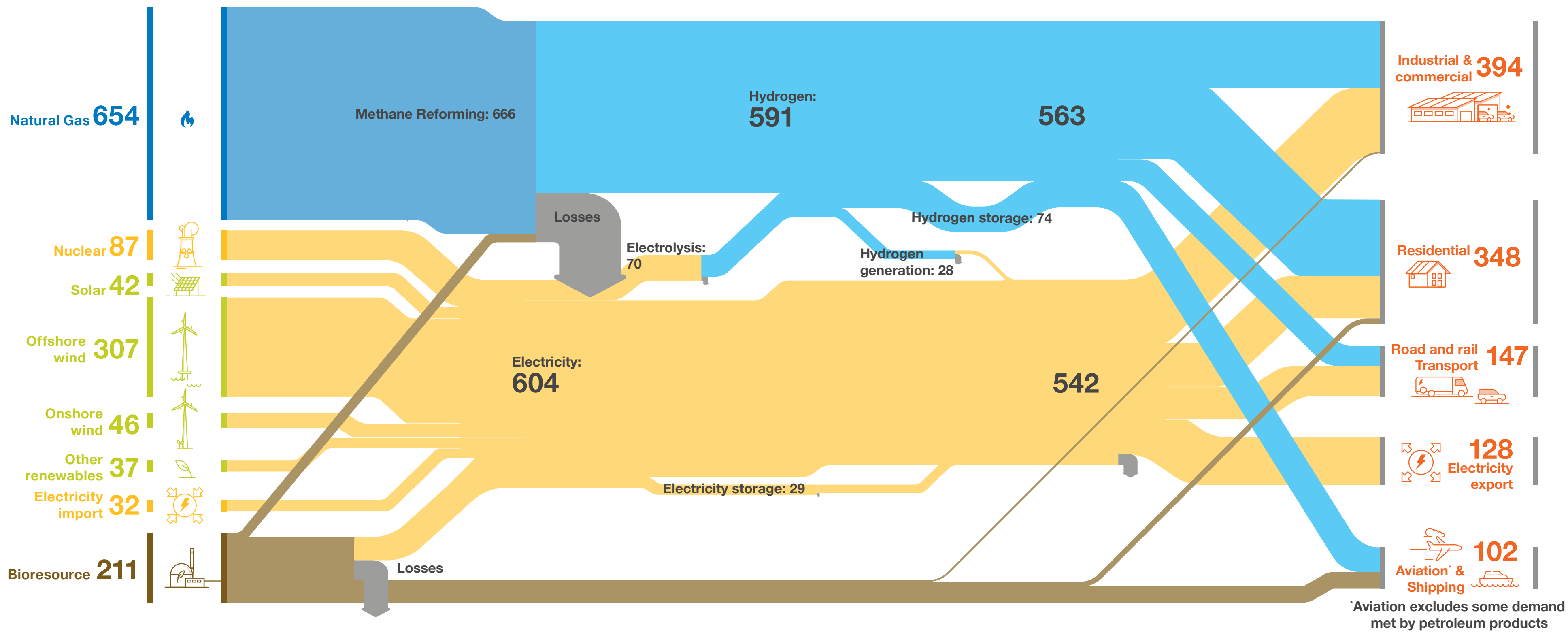
- Home heating, transport and industry largely electrified
- Hydrogen produced in the UK, primarily through electrolysis
- Electricity generation capacity is highest in this scenario
- Substantial increase in energy efficiency measures, lowest end-user energy demand
- Small amounts of natural gas used with CCUS to decarbonise industry, due to lower availability of hydrogen



*Aviation excludes some demand met by petroleum products

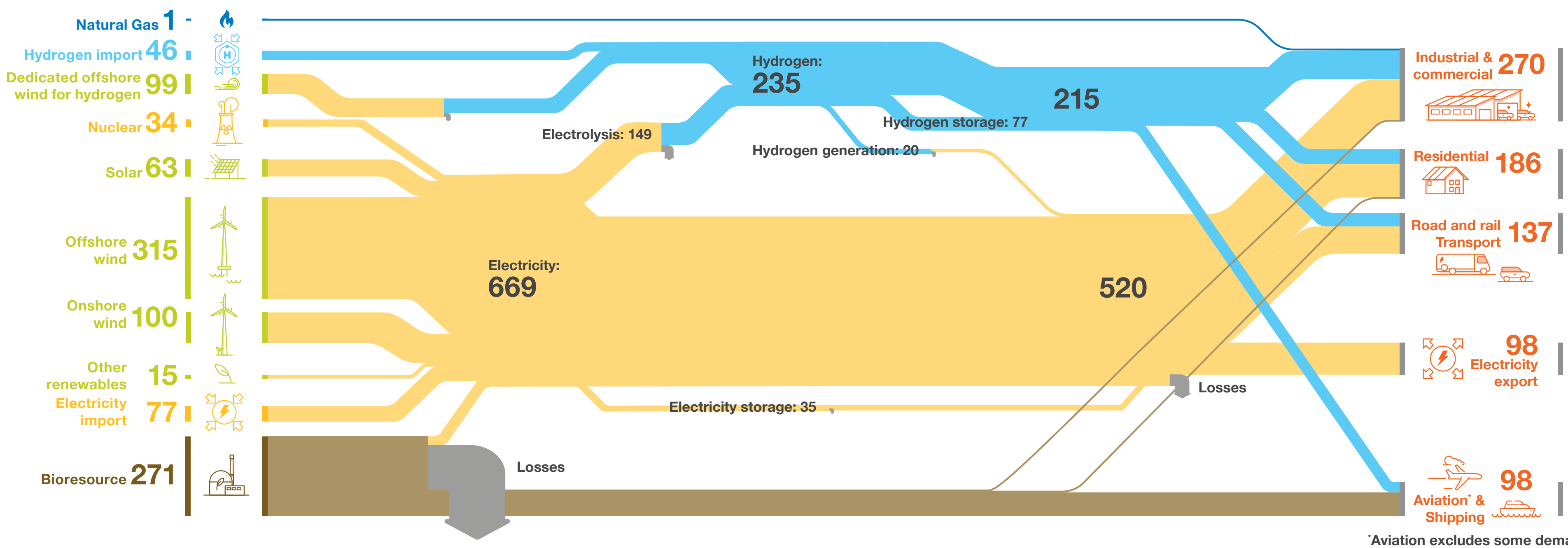
2050 energy flows in System Transformation (TWh)

- Highest proportion of hydrogen with widespread use for home heating, industry and HGVs
- Hydrogen produced in the UK, mainly through methane reforming, with large requirement for natural gas with CCUS
- Some negative emissions from hydrogen production from bioresources with CCUS
- Less energy efficiency improvements than other net zero scenarios



2050 energy flows in Leading the Way (TWh)

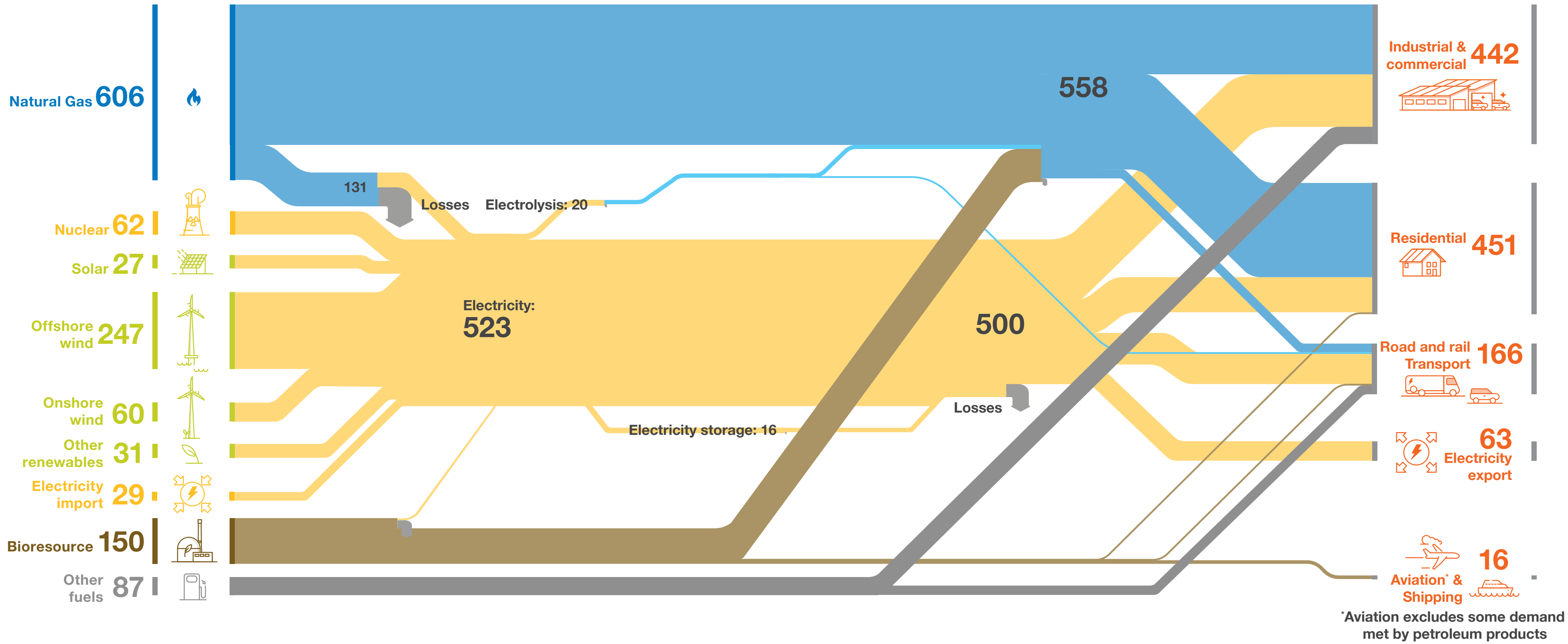
- Combination of hydrogen and electricity used in industry and to heat homes using hybrid heat pumps
- Hydrogen produced in the UK with electrolysis along with some imports
- Significant amounts of hydrogen are produced from dedicated, non-networked offshore wind
- Highest bioresource use, deployed mostly for BECCS, aviation and shipping
- Highest utilisation of hydrogen storage to manage variable production of hydrogen from electrolysis



*Aviation excludes some demand met by petroleum products

2050 energy flows in Steady Progression (TWh)

- High levels of natural gas, particularly for domestic heating and industry
- No negative emissions technologies
- Small private vehicles fully electrified (including some plug-in hybrids) whilst HGVs rely on fossil fuels
- Highest total end-user energy demand, due to minimal increase in energy efficiency measures



FES key comparison chart

CT Consumer Transformation · LW Leading the Way · ST System Transformation · SP Steady Progression · ⌖ UK Government target

		2019	By 2025	By 2030	By 2035	By 2040	By 2045	By 2050	Maximum potential by 2050
Transport	Half of all cars are battery electric vehicles	<1%			CT LW	ST SP UK Government target[6]			100% 28m vehicles CT
Transport	Exceeds 1GW of available vehicle-to-grid capacity	N/A		LW CT		ST	SP		38GW 5.5m vehicles LW
Heating	4 in 5 homes no longer using natural gas boilers (including hybrid heat pumps)	15%					LW CT ST		100% LW CT ST
Heating	6 out of 10 homes rated EPC C or higher	37%			CT LW UK Government target[7]	ST			84% LW
Electricity generation	60% generation output from renewables[3]	41% 120TWh	LW CT ST	SP					82% 495TWh LW
Electricity generation	Offshore wind installation reaches 40GW	8.8GW		LW UK Government target[8]	CT ST	SP			88GW[4] ST
Electricity storage	Exceeds 20GW electricity storage technologies[5]	3.8GW			LW	CT		ST SP	40GW
Natural gas supplies	Levels of unabated natural gas burned falls by 50%	794TWh			LW CT	ST			1TWh LW CT
Hydrogen	Over 50TWh of low carbon hydrogen production	<1TWh			ST	LW CT			591TWh ST
Bioresources	Negative emissions in the energy system (e.g. BECCs)	N/A		LW CT ST					-61MtCO2e LW
Flexibility	10GW or more of electrolysis capacity	<1GW			LW CT	ST	SP		73GW LW
Flexibility	Industrial and commercial electricity demand side response exceeds 2.5GW	1GW	CT LW	ST				SP	13GW CT

3. GB domestic generation only (excludes imports). Excludes storage.
4. Excludes non-grid connected offshore wind for electrolysis production.
5. Excludes V2G charging.
6. The Road to Zero (2018)
7. Clean Growth Strategy (2017)
8. Offshore Wind Sector Deal (2020)

Key statistics in 2030 and 2050

	2019	2030			
Emissions		CT	ST	LW	SP
Annual average carbon intensity of electricity (g CO_2e/kWh)	167	41	66	-6	89
Electricity					
Annual demand (TWh)[9]	308	322	304	305	328
Peak demand (GW)[10]	59	67	59	61	62
Total installed capacity (GW)[11]	112	170	147	178	145
Low carbon and renewable capacity (GW)[12]	54	106	93	117	82
Interconnector capacity (GW)	5	19	18	22	16
Total storage capacity (GW)	4	13	7	16	6
Total vehicle-to-grid capacity (GW)[13]	0	2	0	3	0
Natural Gas					
Annual demand (TWh)[14]	893	627	744	566	824
1-in-20 peak demand (GWh/day)	5,771	4,484	5,228	4,138	5,936
Residential demand (TWh)	324	237	297	214	325
Import dependency (%)	58	73	68	64	69
Hydrogen					
Annual demand (TWh)	0	2	11	5	2
Blue hydrogen production (TWh)[15]	0	1	9	0	0
Green hydrogen production (TWh)[16]	0	1	2	5	2
Bioresources					
Bioresource demand (TWh)	N/A	141	135	175	126

2050				
CT	ST	LW	SP	**Emissions**
-72	-82	-99	61	Annual average carbon intensity of electricity (g CO_2e/kWh)
				Electricity
627	479	567	452	Annual demand (TWh)[9]
96	78	76	78	Peak demand (GW)[10]
334	286	312	224	Total installed capacity (GW)[11]
248	213	220	140	Low carbon and renewable capacity (GW)[12]
25	22	27	16	Interconnector capacity (GW)
54	31	60	25	Total storage capacity (GW)
34	15	38	7	Total vehicle-to-grid capacity (GW)[13]
				Natural Gas
65	753	2	845	Annual demand (TWh)[14]
167	2,945	69	5,471	1-in-20 peak demand (GWh/day)
0	0	0	307	Residential demand (TWh)
100	98	0	70	Gas imports (%)
				Hydrogen
152	591	235	16	Annual demand (TWh)
42	527	0	0	Blue hydrogen production (TWh)[15]
110	56	188	16	Green hydrogen production (TWh)[16]
				Bioresources
215	212	271	149	Bioresource demand (TWh)

9. Customer demand plus on-grid electrolysis plus losses. 10. Refer to data workbook for further information on winter average cold spell (ACS) peak demand. 11. Total installed capacity and total storage capacity including vehicle-to-grid. Includes all network connected generation. 12. CCUS, nuclear, solar, wind and other renewables.

13. Less capacity than this is likely to be available during winter peak 5-6pm due to derating. 14. Includes shrinkage, exports and natural gas for methane reforming. 15. Blue hydrogen is created via methane reforming using natural gas as an input plus CCUS. 16. Green hydrogen is created via electrolysis using zero carbon electricity.

Notes

Continuing the conversation

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

Access our current and past FES documents, data and multimedia at: **nationalgrideso.com/future-energy/future-energy-scenarios**

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

For further information on ESO publications please visit: **nationalgrideso.com**

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