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.

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.

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.
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.

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.

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.

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.

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.

**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.

- **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.

- **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.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>2019</th>
<th>By 2025</th>
<th>By 2030</th>
<th>By 2035</th>
<th>By 2040</th>
<th>By 2045</th>
<th>By 2050</th>
<th>Maximum Potential by 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
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<tr>
<td>Half of all cars are battery electric vehicles</td>
<td>&lt;1%</td>
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<tr>
<td>Exceeds 1GW of available vehicle-to-grid capacity</td>
<td>N/A</td>
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<tr>
<td>Heating</td>
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<tr>
<td>4 in 5 homes no longer using natural gas boilers (including hybrid heat pumps)</td>
<td>15%</td>
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<td>6 out of 10 homes rated EPC C or higher</td>
<td>37%</td>
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<td>Electricity generation</td>
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<tr>
<td>60% generation output from renewables</td>
<td>41% 120TWh</td>
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<tr>
<td>Offshore wind installation reaches 40GW</td>
<td>8.8GW</td>
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<td>Electricity storage</td>
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<tr>
<td>Exceeds 20GW electricity storage technologies</td>
<td>3.8GW</td>
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<tr>
<td>Natural gas supplies</td>
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<tr>
<td>Levels of unabated natural gas burned falls by 50%</td>
<td>794TWh</td>
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<tr>
<td>Hydrogen</td>
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<tr>
<td>Over 50TWh of low carbon hydrogen production</td>
<td>&lt;1TWh</td>
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<tr>
<td>Bioresources</td>
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<tr>
<td>Negative emissions in the energy system (e.g. BECCs)</td>
<td>N/A</td>
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<tr>
<td>Flexibility</td>
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<tr>
<td>10GW or more of electrolysis capacity</td>
<td>&lt;1GW</td>
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<tr>
<td>Industrial and commercial electricity demand side response exceeds 2.5GW</td>
<td>1GW</td>
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</tbody>
</table>

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)
8. Offshore Wind Sector Deal (2020)
### Key statistics in 2030 and 2050

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2030</th>
<th>2050</th>
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</thead>
<tbody>
<tr>
<td><strong>Emissions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual average carbon intensity of electricity (g CO₂e/kWh)</td>
<td>167</td>
<td>41</td>
<td>89</td>
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<tr>
<td><strong>Electricity</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Annual demand (TWh)</td>
<td>308</td>
<td>322</td>
<td>304</td>
</tr>
<tr>
<td>Peak demand (GW)</td>
<td>59</td>
<td>67</td>
<td>59</td>
</tr>
<tr>
<td>Total installed capacity (GW)</td>
<td>112</td>
<td>170</td>
<td>147</td>
</tr>
<tr>
<td>Low carbon and renewable capacity (GW)</td>
<td>54</td>
<td>106</td>
<td>93</td>
</tr>
<tr>
<td>Interconnector capacity (GW)</td>
<td>5</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Total storage capacity (GW)</td>
<td>4</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Total vehicle-to-grid capacity (GW)</td>
<td>0</td>
<td>2</td>
<td>0</td>
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<tr>
<td><strong>Natural Gas</strong></td>
<td></td>
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<tr>
<td>Annual demand (TWh)</td>
<td>893</td>
<td>627</td>
<td>744</td>
</tr>
<tr>
<td>Residential demand (TWh)</td>
<td>324</td>
<td>237</td>
<td>297</td>
</tr>
<tr>
<td>Import dependency (%)</td>
<td>58</td>
<td>73</td>
<td>68</td>
</tr>
<tr>
<td><strong>Hydrogen</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual demand (TWh)</td>
<td>0</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Blue hydrogen production (TWh)</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Green hydrogen production (TWh)</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Bioresources</strong></td>
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</tr>
<tr>
<td>Bioresource demand (TWh)</td>
<td>N/A</td>
<td>141</td>
<td>135</td>
</tr>
</tbody>
</table>

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.
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

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Write to us at:
Energy Insights & Analysis
Electricity System Operator
Faraday House
Warwick Technology Park
Gallows Hill Warwick
CV34 6DA

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