Bridging the Gap to Net Zero
Our previous work
Flexibility timeline

Bridging the gap to a flexible energy system

Taking action to meet each set of milestones in sequence is fundamental to meeting the 2035 fully decarbonised electricity system target.

Today
- Flexible, centralised generation
- 50% renewable generation

Key Messages 2022

Milestones 2025
- Actions by ESO, BEIS, Ofgem & industry now

Achieve the first milestones and

Milestones 2030
- Enable more actions & subsequent milestones

Milestones 2035
- Fully decarbonised electricity system
- Whole system flexibility

Please see pages below for details of key messages and milestones.

Each bridge is made up of actions relating to:
- Investment
- Consumers
- Roles and responsibilities
- Markets
- Digitalisation
What is Bridging the Gap?

Exploring areas of uncertainty concerning Net Zero delivery through engagement
Sign up to this year’s events
Milestones

**2025 PRIORITY MILESTONES**

- **Investment**
  - Strategic flexibility Infrastructure projects are underway, e.g. long duration storage, electrolysis.

- **Consumers**
  - More flexibility enabling, end-consumer products and tariffs are on offer.

- **Roles and responsibilities**
  - Clarity on who is doing what in the future, flexible energy system.

- **Markets**
  - Revenue streams will be more certain for Investment in flexible assets.

- **Digitalisation**
  - Interoperability and resilience across the energy system is possible through greater digitalisation.

**2030 PRIORITY MILESTONES**

- **Investment**
  - Whole energy system approach is used to make strategic decisions about infrastructure.

- **Consumers**
  - Consumer facing businesses enable consumers to provide flexibility.

- **Roles and responsibilities**
  - Codes and standards in place to support different Net Zero roles and responsibilities.

- **Markets**
  - Reformatted markets create incentives for flexibility.

- **Digitalisation**
  - System balancing and stability actions are automatically deployed.

**2035 TARGET MET**

- **Investment**
  - Whole system flexibility Infrastructure is in place to enable decarbonised system operation.

- **Consumers**
  - The majority of consumers are able to deliver the flexibility needed seamlessly via automated products and services.

- **Roles and responsibilities**
  - A coordinated approach to whole energy system operation is achieved through clarity of roles and responsibilities for Net Zero.

- **Markets**
  - Markets enable flexibility of all durations through the right long-term investment and short-term dispatch signals.

- **Digitalisation**
  - Digitalisation is a fundamental part of the whole energy system as it enables greater market facilitation of flexibility actions.
CONSUMER FLEXIBILITY
A nationwide demonstration of a demand reduction service, enabling domestic consumers, industrial and commercial users to be incentivised for shifting demand to avoid the peak
KEY STATISTICS

- **Over 1.6 million reach**
- **c.350 MW contracted capacity**
- **31 DFS approved providers**
- **680 MWh delivered**
- **20 onboarding & regular Tests**
- **>2.6 GWh delivered**
Satisfaction levels were high but differed according to strategy.
"Have always tried to respond to a challenge and in my old age am still up for it. Does give me satisfaction looking after our wonderful world."

- Survey respondent
High willingness to participate again

83% of survey respondents are likely or extremely likely to take part in the scheme again.
Future System Operator
We will introduce the whole energy system capability for:

- Gas Strategic Planning and Whole Energy Planning
- Gas Markets Strategy and Whole Energy Markets Strategy
- The *Advisory* role to support BEIS/Ofgem in decision making
- Office of Energy Resilience & Emergency Management

The new capabilities will be empowered by two separate licences and the Strategy and Policy Statement, with *new statutory duties* to ensure security of supply for electricity and gas.

Future responsibilities may extend to the following:

- Hydrogen
- Heat
- Transport
- CCUS

*Future of the FSO*

**2024**

- A new *Electricity System Operation* licence
- A new *Gas Strategic Planning* licence

**2024 - 2030**

Future responsibilities may extend to the following:

- Hydrogen
- Heat
- Transport
- CCUS

*Transforming enabling services*
### New roles

#### Whole Energy Networks

<table>
<thead>
<tr>
<th>Why are we doing this?</th>
<th>Co-ordinate across the energy system to provide insights and translate policy into immediate strategy to facilitate 'net zero'.</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are we looking to achieve?</td>
<td>Working across whole energy system solutions, providing strategic and investment recommendations so infrastructure is an enabler of the transition to net zero.</td>
</tr>
<tr>
<td>How will we deliver this role?</td>
<td>Recruiting expertise in strategy development and system planning whilst utilising business capabilities and processes to meet net zero more efficiently.</td>
</tr>
</tbody>
</table>

#### Whole Energy Markets

<table>
<thead>
<tr>
<th>Why are we doing this?</th>
<th>Create a holistic view of energy markets across multiple vectors to provide clear direction, increase efficiency/accessibility and give insights on how codes could be modified to facilitate improvement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are we looking to achieve?</td>
<td>Drive value by bringing industry experts together to collaborate on whole energy market challenges and develop holistic energy market strategies to drive innovative solutions.</td>
</tr>
<tr>
<td>How will we deliver this role?</td>
<td>Building a range of capability including business planning to data analysis to facilitate whole market participation and identify future challenges, trade-offs and routes for increased efficiency.</td>
</tr>
</tbody>
</table>
**New roles**

**Advisory**

**Why are we doing this?**
To provide strategic advice, information and analysis to the Gas and Electricity Markets Authority (GEMA) and Ministers of the Crown.

**What are we looking to achieve?**
Responding to requests for advice on the energy trilemma, energy strategy/policy and give awareness of new developments across the industry.

**How will we deliver this role?**
Creating a multi-disciplinary team aligned to the energy trilemma, spanning the whole energy system, to develop advice and facilitate engagement with stakeholders.

**Office of Resilience and Emergency Management**

**Why are we doing this?**
Responsible for cross-vector energy resilience, emergency preparedness and response coordination, to move towards a whole energy system response.

**What are we looking to achieve?**
Identify resilience interactions and opportunities, addressing vulnerabilities and, in time, providing whole energy system co-ordination during an energy emergency.

**How will we deliver this role?**
Recruiting cross vector expertise and whole energy system resilience knowledge, building on existing resilience and emergency activities as the role extends to the whole energy system.
High Level FSO Roadmap

Note: Current draft, timing subject to change

2023

- Royal Assent of Energy Bill
- Informal Licence Consultation
- SPS Consultation Concludes

2024

- Ongoing ESO Capability Build for New Roles
- Secondary Legislation underway
- Licence and Codes Notice of Decision
- Licence and Codes Go Live
- Framework Agreement Published
- Board Appointment
- Transfer Scheme Signed

Newly Owned Organisation (FSO Day 1)

2025 +

- New and Enhanced Industry Roles
  - Office of Energy Resilience and Emergency Management
  - Whole Energy System Market Strategy
  - Whole Energy System Planning
  - Advisory Role
- Potential Future New Roles
  - Regional coordination
  - Hydrogen
  - Heat
  - Transport
  - CCUS

End State Final TSA Exit (FSO Day 2)

Joint Separation programme established

End State Final TSA Exit (FSO Day 2)

Note: Current draft, timing subject to change

KEY:
- Future System Operator
- Government Process
- Relationship with National Grid Group
There are many different areas which could be considered when thinking about the whole energy system. Thinking to date is to focus on the central yellow areas as the FSO first goes live which could develop over time.
Evolution of the FES
Where we have come from and where we are going

Where we have been

• Originally designed to feed the Electricity and Gas 10 Year Statements
• A flagship publication for over 12 years
• Constantly evolving to provide new insights and serve more customers
• At the heart of ESO activities from network planning to security of supply
• Exploring uncertainty and managing risk through our scenarios

What’s coming next

• Through the CSNP Ofgem’s aims to enable coordinated strategic planning of a wholistic future energy system
• The FES process will evolve to form the foundation for the CSNP
• The focus of our analysis will expand from what could happen to explore what should happen
• By doing this the FSO will take an active role in steering the future of energy
FSO and Advisory Role

- In 2024 the ESO will become the Future System Operator
- The FSO will be in the public sector, with operational independence from government
- Utilising our expertise built on years of experience, as well as our analytical tools and techniques, we will provide impartial advise to government on decisions on the route to net zero
- Scan the QR code to find out more about the FSO
From Scenarios to Pathways

Scenario
- Informed through extensive research and stakeholder engagement
- By varying sets of input assumptions the FES explores and models different ways we might use and generate energy in the future
- By seeking out credible yet distinct outcomes we provide a wide range of possible futures to our downstream customers to allow them to assess risk

Pathway
- An evolution of our scenarios
- Continue to explore what could happen through the same rigorous process
- Go one step further to determine the routes to net zero that provide the highest consumer value
- Use our analysis to present what could happen, what should happen and where our current trajectory is heading
Ofgem Consultation

- Ofgem consulted on how the future of supply and demand modelling (FES) should evolve to fulfil the requirements of the CSNP
- Their consultation closed on 23rd June 2023
- Scan the QR code for a link to Ofgem's consultation
Let us know what you think

We would love to hear what you think about the future evolution of the FES process

Please let us know and ask us any questions, we are here to chat
Markets Roadmap
Reforming our markets

The Markets Roadmap outlines the ESO’s plans to reform our markets to enable zero-carbon operation by 2025 and fully decarbonise by 2035.

The markets roadmap also:
- Provides key insights into the different ESO markets as well as the key drivers for reform.
- Gives stakeholders confidence that we are making the right market reform and design decisions.
- Shares strategic questions we are currently tackling and signposts how industry can work with us to answer them.

Our product suite
2025: Zero carbon ambition

- By 2025, our target is to operate the electricity transmission system for at least one settlement period with 100% zero carbon generation.

- We need the market to deliver a 100% zero carbon position, but we also need the right ancillary services.

- This includes fast-acting response products, zero-carbon stability and voltage support.

- Our new Dynamic Frequency Response products and Pathfinders will be crucial to achieve zero carbon operation.
In the roadmap, we:

• Outline the drivers for reform and planned changes to improve the markets in the near term.
• Demonstrate how we’re looking for market solutions, which are cost-effective for the consumer as well as ensuring system operability.
• Provide more clarity on the strategic direction of travel for 2025-30 and how we’re thinking about the wider market changes.

If you have feedback/suggestions for improvement, please get in touch: market.dev@nationalgrideso.com
## Market Roadmap in 5 minutes

<table>
<thead>
<tr>
<th>Market Area</th>
<th>Volumes</th>
<th>Costs</th>
<th>Summary of reforms / key points to note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Response</td>
<td>![up]</td>
<td>![down]</td>
<td>Co-optimisation of existing products, phase out of FFR, development of Static Recovery.</td>
</tr>
<tr>
<td>Reserve</td>
<td>![down]</td>
<td>![up]</td>
<td>Development of new Quick &amp; Slow Reserve products, revised plan to launch Balancing Reserve, future co-optimisation opportunities.</td>
</tr>
<tr>
<td>Thermal Constraints</td>
<td>![up]</td>
<td>![up]</td>
<td>Delivery of Constraint Management Intertrip Service (CMIS), Local Constraints Market launch, MW Dispatch, longer-term wholesale change through REMA.</td>
</tr>
<tr>
<td>Restoration</td>
<td>N/A</td>
<td>![up]</td>
<td>Embedding learnings from Distributed ReStart, feasibility and economic assessment of 3 new tenders launched in 2022.</td>
</tr>
<tr>
<td>Stability</td>
<td>![up]</td>
<td>![down]</td>
<td>Go-live of all Phase 1 Stability Pathfinder units, design of 3 new stability markets through innovation project, indication to launch Y-1 market as a priority.</td>
</tr>
<tr>
<td>Voltage</td>
<td>![up]</td>
<td>![up]</td>
<td>Reactive power market design innovation project, new Network Services Procurement tender for 2026, harness new capability through CSA.</td>
</tr>
<tr>
<td>Balancing Mechanism</td>
<td>![up]</td>
<td>![up]</td>
<td>Removing actions from BM through new specific markets, lowering barriers to entry (e.g., operational metering), Balancing Transformation.</td>
</tr>
</tbody>
</table>
Managing system stability

- **Dynamic Moderation**: Assists with keeping frequency within 0.2Hz, especially during more volatile conditions.
- **Quick Reserve**: Used to recover frequency back towards 50Hz.
- **Dynamic Regulation**: Assists with keeping frequency near to 50Hz during normal conditions.
- **Balancing Reserve**: Replace activated reserves, and recover frequency to 50Hz.
- **Dynamic Containment**: Prevents frequency deviations outside -0.8Hz / +0.5Hz following large losses.
- **Static Recovery**: Recover frequency to 0.5Hz within 60 seconds following large losses.
- **Slow Reserve**: Replace activated reserves, and recover frequency to 50Hz.
Net Zero Market Reform
Current markets require reform

Our current market was not designed for a high-renewable, flexible, low carbon system, and requires reform for net zero

<table>
<thead>
<tr>
<th>Priorities for market design/policy:</th>
<th>Electricity</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Flexible:Firm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Decarbonisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current market arrangements introduced</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Market Reform (EMR) investment policy introduced</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Current market design is not appropriate for the future system</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% of total capacity</th>
<th>2001</th>
<th>2013 (EMR)</th>
<th>2021</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel</td>
<td>77%</td>
<td>74%</td>
<td>38%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Renewables</td>
<td>2%</td>
<td>7%</td>
<td>42%</td>
<td>62%</td>
<td>67%</td>
</tr>
<tr>
<td>Storage</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>13%</td>
<td>15%</td>
</tr>
<tr>
<td>Interconnectors</td>
<td>3%</td>
<td>5%</td>
<td>6%</td>
<td>9%</td>
<td>8%</td>
</tr>
<tr>
<td>Total capacity</td>
<td>71 GW</td>
<td>75 GW</td>
<td>107 GW</td>
<td>209 GW</td>
<td>344 GW</td>
</tr>
<tr>
<td>Zero carbon % of total capacity</td>
<td>19%</td>
<td>20%</td>
<td>49%</td>
<td>64%</td>
<td>70%</td>
</tr>
</tbody>
</table>

Note: Fossil fuel = coal, gas and oil; Renewables = wind, solar and other renewables (e.g. tidal etc); Zero carbon includes nuclear and renewables, but not storage and interconnectors

Source: DUKES 5.8 for all 2001 and 2014 data except interconnector data from Ofgem; FES2022 for all 2021, 2030, 2050
Challenges to be addressed

Our ‘Case for Change’ identified three key challenges facing the GB electricity market that need to be addressed by reform:

1. **Investment**
   There is a need to invest at unprecedented scale and pace.

2. **Location**
   There is a need to incentivise assets to locate and dispatch where and when they can minimise whole system costs.

3. **Flexible:Firm**
   There is a need for flexible and firm technologies across both supply and demand.
We first assessed wholesale market design when considering options for reform from both an operational and investment perspective.
Summary of our assessment

Market reform must be implemented with clear transitional pathways to retain investor confidence in order to achieve net zero at lowest cost.

Our market reform priorities:

- Re-establish link between wholesale market incentives and real-time system needs, by introducing locational energy pricing.
- Retain investment policy but reform to address distortions and ensure participants’ incentives align with market signals.

Implementation considerations:

- Enduring investment reforms should be coherent with future wholesale market design.
- Potential short-term reforms, to partially address emerging issues, must be carefully considered due to additional disruption and potential for unintended consequences.
- Reform pathways which set out how the package of reforms are phased in over time are critical to minimise regulatory risk and ensure investor confidence.
- Need to coordinate with complementary strategic transmission network build.

Our preferred pathway (next slide)
Our holistic vision for markets

Our holistic long-term vision for GB electricity market design emerges from three key implementation phases

1. Flex foundations (present to 2027)
2. Investment policy realignment (2025-2030)
3. Wholesale market transition (2028-2035)

More detail in our autumn report.
To keep up to date:
Network Reform
Connections Reform

We recognise the challenges currently facing our connections customers and the need to update the connections application process. As a result, we have launched the Connections Reform project to address these challenges and put our customers and stakeholders at the heart of this change. Our 5-Point Plan is helping to manage some of these immediate challenges.

1. TEC Amnesty
   This was the first TEC Amnesty since 2013. We received a total of 8.1GW of applications and are currently working with Ofgem to allow the termination/reduction of TEC process from connection agreements.

2. Construction Planning Assumptions Review
   We are reducing the assumptions around how many projects in the queue will connect. We expect this will allow some connection dates to be brought forward and reduce works in existing agreements.

3. Treatment of Storage
   We are revising the way storage connections are modelled using insight resulting of a better understanding of its behaviour. These changes will allow storage to connect quicker and support unlocking more capacity to connect others.

4. Queue Management
   There is currently no mechanism in the CUSC to terminate projects that are not progressing. If changes are approved, it would allow us to terminate projects that are not progressing against their contracted milestones and agreed timescales.

5. Non-firm Offer Development
   The policy aims to accelerate the connection of energy storage projects by removing the need for non-critical enabling works to be complete before they connect. We continue to look at the opportunity to roll out this approach to other connections.

How do we get there?

- **ESO 5-Point Plan**
  Tactical initiatives designed to alleviate as much of the pain as possible and introduce improvements, which are aligned initiatives coordinated by others e.g. SCG

- **Implementation and Transition**
  Implementation of the reformed process, including potential phasing / quick wins and any transitional activities required to move between the current and future process

- **Reformed Process**
  Ultimate solution in place fully reflected in relevant licences, codes, policies and procedures with steady state changes possible through enduring change mechanisms
Connections Reform

We started Phase 1 of the connections reform project in October 2022 to understand stakeholder needs and published our Case for Change in December. Phase 2, which commenced in January, was structured based on the work and learnings from the case for change.

We have now launched our Connections Reform Consultation to get industry views on our proposed recommendations.

The Connections Reform Consultation can be found on our website and will be open until Friday 28 July for formal feedback.

Email us
Box.connectionsreform@nationalgrideso.com

Get in touch to share your views!
Future Of Network Planning

Net Zero will change how our energy is sourced, used and transported, with the energy network at the forefront of the transition. Evolution of the network planning investment is underway to support the delivery of the UK’s net-zero ambition.

Centralised Strategic Network Plan will provide insights and direction across all system needs, under a single framework.

Focusing on system requirements in the short term whilst anticipating the network of the future.

The framework will have built-in ability to consider different fuel sectors.

The multiple pathways to Net Zero will require robust approach to determine the exact approach

Where are we today? What do we know? What is the gap? How do we bridge the gap? Where are we heading? What are the unknowns?

Pathways identifying the long term direction of travel for Net Zero

Onshore and offshore ET networks (including interconnection), are planned holistically

Environmental and community factors considered alongside economic are considered in the high-level designs

Detailed view and assessment

Here and Now

Next Decade

Future

Pathways multiple and divergence widens

Detailed view and assessment

Pathways diverge

Detailed view and assessment

Detailed view and assessment

Pathways diverge

Detailed view and assessment

How will the future unfold?

Detailed view and assessment

What is the network of the future?

Detailed view and assessment

What are our key assumptions?

Detailed view and assessment

Detailed view and assessment

Detailed view and assessment

Detailed view and assessment

What are the unknowns?

Detailed view and assessment

The key building blocks for network investment will remain unchanged; how will they be delivered will evolve, requiring development of new tools and capabilities.

Agility, transparency, governance and robustness are key enablers for the new framework
Holistic Network Design

• **Connects offshore wind** and **transports** the electricity generated to where it will be used.

• Helps to **unlock 50 GW of offshore wind by 2030** when combined with wind further advanced in its development.

• Moves towards a more **centralised, strategic network planning** that is critical for delivering affordable, clean and secure power, as we journey towards our net zero future.

• **A first of its kind, integrated approach** for connecting 23GW of offshore wind (18 offshore wind farms) to Great Britain and transporting the electricity generated to where it will be used.

• **Balances the four objectives** of cost to consumers, deliverability and operability and impact on the environment and on communities.

• We are finalising the **ScotWind HND Follow Up Exercise** for connecting an additional 20.7GW of offshore wind (16 offshore wind farms) to Great Britain.
Holistic Network Design

Key Benefits compared to the radial design

- Save consumers £5.5bn in costs from 2030
- £54bn network investment
- Increases availability of offshore wind by 32 TWh over 10 years from 2030
- 2 million tonnes CO₂ equivalent savings between 2030 and 2032

Reduces the impact on the seabed by up to a third smaller footprint of cables coming to shore compared to the radial design
Resource Adequacy
Net Zero Adequacy Modelling

Key questions on ensuring security of supply in the 2030s

❖ What mix of supply, demand-side response, interconnectors and storage is needed to ensure security of supply, whilst meeting our net-zero 2035 target?
❖ What are the potential risks and how do we mitigate these?
❖ Which metrics are needed to measure security of supply?
❖ What policy changes and mechanisms are required?

Initial study

An initial study has been published in collaboration with AFRY.

This implemented a Europe-wide network model in order to assess the impact on resource adequacy of different future portfolios.
### Initial Study with AFRY

#### Four key messages

1. There is no trade-off between adequacy and meeting net-zero but we need to bring forward investment in clean, reliable technologies.

2. Understanding risks due to weather patterns will become increasingly important to ensure adequacy in a fully decarbonised system with high levels of weather-dependent generation.

3. New modelling approaches and metrics will be required to assess risks to adequacy in a fully decarbonised power system.

4. It will become more important to consider adequacy in the context of developing the right markets, the right networks and future operability challenges to be confident that adequacy is ensured in a cost-effective way.
Similar Loss of Load Expectations (about 1 hour/year) were met by different technology mixes whilst also meeting our 2035 net-zero target.
The duration of critical stress events in the GB system were found to increase over time, especially in scenarios using batteries to ensure security of supply.

<table>
<thead>
<tr>
<th>Year</th>
<th>Distribution of length of critically tight periods (hours)</th>
<th>Mean length of critically tight periods (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;3</td>
<td>3-4</td>
</tr>
<tr>
<td>2025</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>2028</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td>2030</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>2033</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2035</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2038</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2040</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **'Consumer Transformation (reference)'**
- **'Gas CCS, H2 and battery storage'**
- **'Nuclear, H2 and battery storage'**
- **'H2 and battery storage'**
## Project Plans

<table>
<thead>
<tr>
<th>Demand</th>
<th>Extreme weather</th>
<th>Networks</th>
<th>Interconnectors</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Storage</th>
<th>New technology</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential alternatives to Loss of Load Expectation.</td>
<td>A range of storage durations and approaches. To include hydrogen.</td>
<td>Including build-rates and consideration of non-delivery risks.</td>
<td>The impact of uncertainty and stochasticity (e.g. in fuel prices) on our model outputs.</td>
</tr>
</tbody>
</table>

We plan to publish a **full resource adequacy study in 2024**.