Public

Innovation in the context of the energy transition

Claudia Centazzo
Innovation Portfolio Manager, NESO

05/11/24 Oxford Energy Network Seminar

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National Energy System Operator (NESO)

- The 2023 Energy Act established an independent system planner and operator for GB
- To help accelerate the energy transition
- NESO is built on previous experience as the Electricity System Operator (ESO)
- ESO balanced electricity supply and demand 24/7, and networks and markets roles.

Introducing NESO

- Independent & impartial public corporation
- System planning & operations
- Whole system view
- Holistic approach
- Most cost-efficient & sustainable solutions
- Optimal outcomes for energy consumers

NESO's Primary Duties

NESO will promote the following three objectives:

Net Zero

Enabling the government to deliver on its legally binding emissions targets

Efficiency & Economy

Promoting efficient, coordinated and economical systems for electricity and gas

Security of supply

Ensuring security of supply for current and future consumers of electricity and gases

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NESO's Secondary Duties

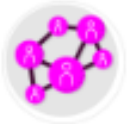
NESO will also have regard to:

Facilitating Competition

Creating and maintaining competitive energy markets and networks

Consumer Impacts

Understanding what changes mean for consumers



Whole System Impacts

Understanding linkages across systems

Facilitating Innovation

Creating an environment that enables others to help solve energy challenges

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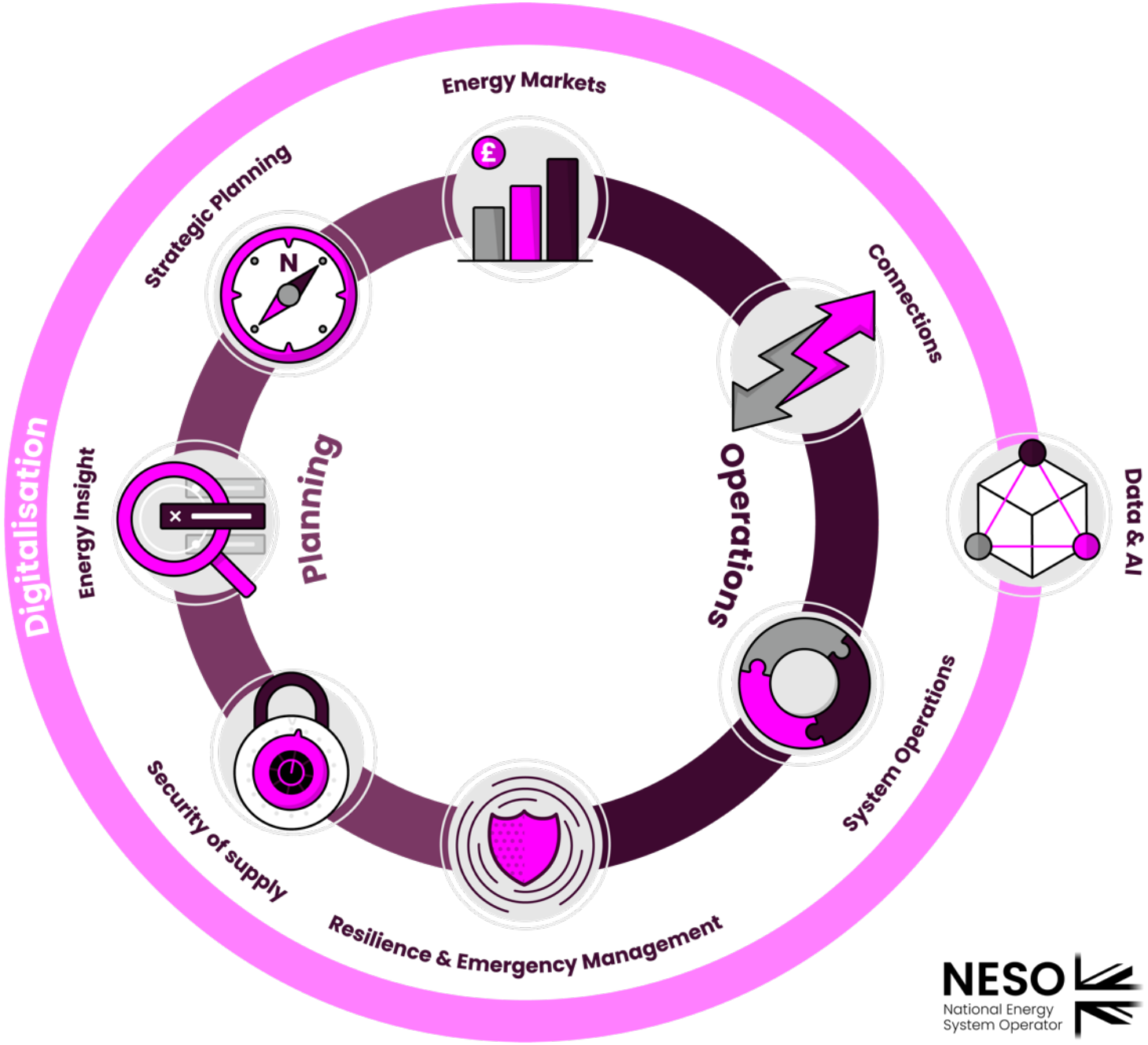
What We Do

- Eight activities delivering the plans, markets and operations of the energy system of today and the future.
- In one organisation for holistic thinking, cost efficiencies and sustainable solutions for the needs of our customers.



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Our priorities to 2026

Clean Power

We will enable a zero-carbon electricity system by adopting a whole system approach, encouraging innovation and collaboration.

Decarbonised Energy

We will develop integrated plans for a decarbonised, efficient and flexible energy system fit for the future.

Consumer Value

We will have unlocked around £3 billion of consumer benefits by 2026 through delivery of our commitments.

Customer Centricity

We will understand and balance the different needs of our customers to form meaningful partnerships.

Digital Mindset

We will unlock the potential of technology and teamwork through a digital-first approach, enabling a future of seamless connectivity and innovation at pace.

People Value

We will invest in our people to ensure we're prepared and empowered to embrace the opportunities of the future.

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Our Governance

NESO is operationally independent of government. Taking a whole system approach, we plan the electricity and gas systems and operate the electricity system to deliver the government's policy outcomes.

Being independent enables us to make fair and unbiased decisions based on evidence and data. This means we can give impartial recommendations to the government and the regulator.

Our shareholder

Department for Energy Security & Net Zero

The Department for Energy Security & Net Zero is responsible for national policy and providing strategic direction and targets in relation to UK energy

Our regulator

ofgem
Making a positive difference for energy consumers

Ofgem is the energy regulator for Great Britain

Independent NESO Board

The NESO Board oversees our strategic direction, ensuring compliance with regulations and the mitigation of corporate risks. The Board ensures that we build strong relationships with customers and it evaluates performance, ultimately working to protect consumer interests and enable a reliable and secure, efficient, clean energy system.

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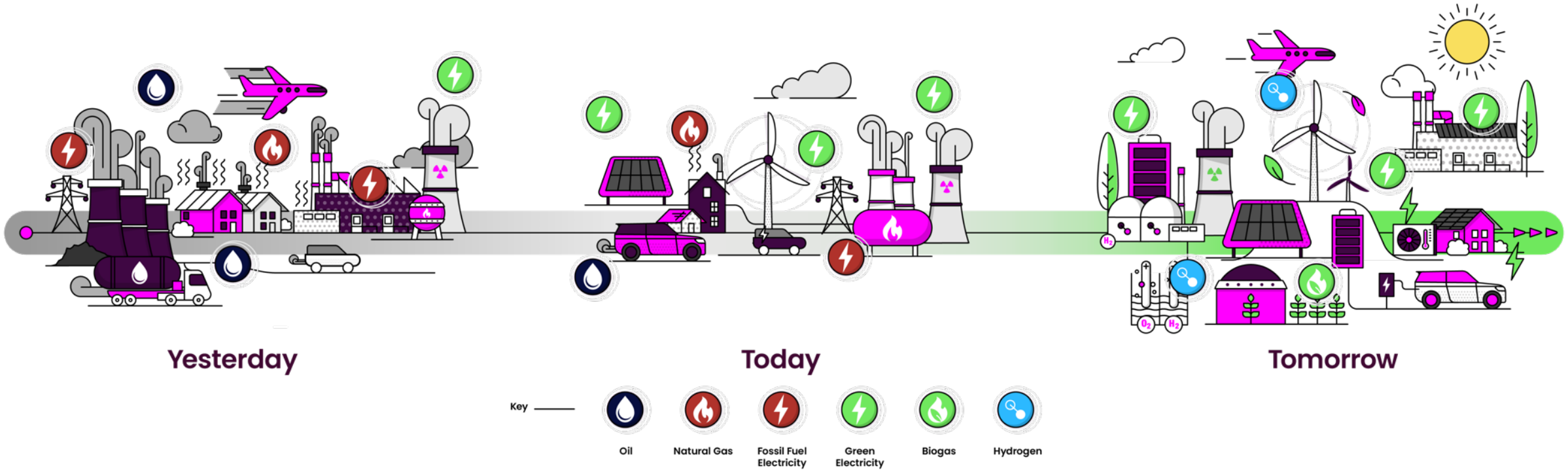
A Changing Energy Landscape

The energy system is fundamental to decarbonisation & ensuring energy is affordable



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Great Britain's Decarbonisation Journey

- The largest driver of the long-term fall in GB's emissions has been the decarbonisation of our electricity supply
- NESO has a goal of operating a secure net zero electricity system for short periods by 2025
- 2023 was GB's electricity system's greenest year on record, with average carbon intensity at 149gCO2/kWh

In 2000, around

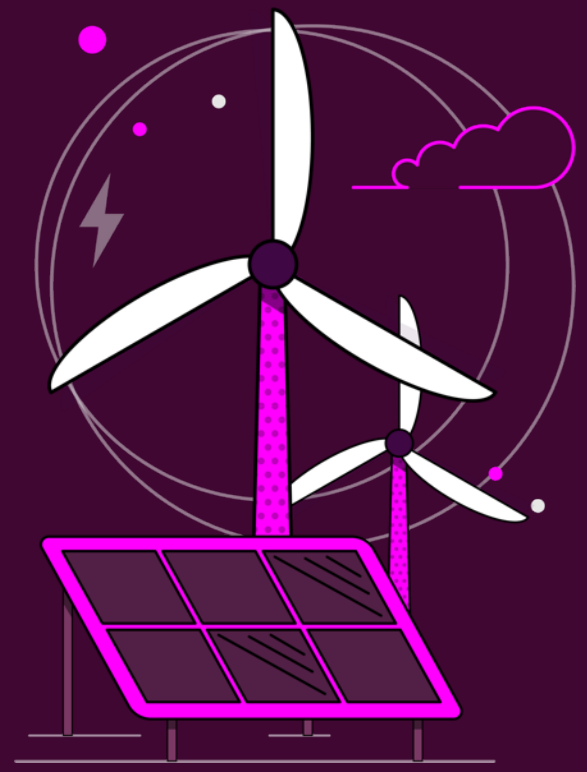
3%

of electricity generation came from renewable sources, such as wind and solar.

In 2023, around

40%

of electricity generation came from renewable sources.



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The energy system is evolving

September 2024

- The end of 142 years of burning coal to generate electricity in GB
- The first G7 member to close coal-fired power plants
- Half of electricity from zero carbon sources, peaking at 84% on 29th September at 10am
- Wind was the largest source of generation (26.2%)
- Gas the second largest source (25.3%)

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September 2024

Carbon intensity of electricity

Zero carbon

50% of electricity came from zero carbon sources

84% peak zero carbon share

Carbon intensity

121 gCO2/kWh average

Greenest time of the month 1pm on 14 September

Coal

0.3% use this month

This time **5 years ago** coal usage was **0.8%**

184 consecutive coal free hours

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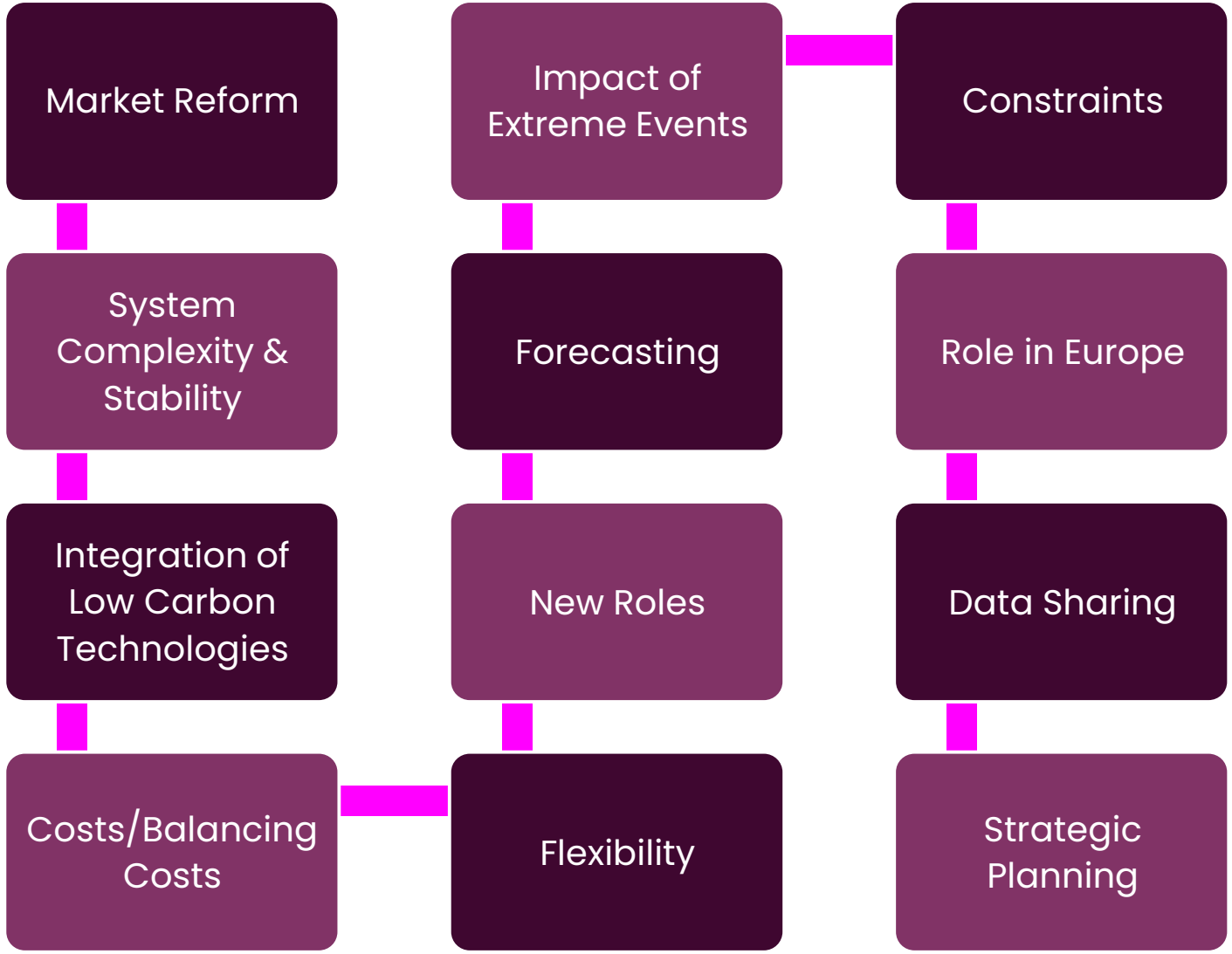
Current Challenges



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Innovation at NESO

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What is innovation?

We define ‘Innovation’ as the **higher risk** activities which *research*, *develop* or *test* solutions that could help deliver a better future energy system for GB; providing benefits for NESO, consumers and other energy system stakeholders.

Innovation Strategic Priorities 2024/25

1. **Driving the Zero Carbon Transition –** We must enable new research and technology, developing and testing the solutions necessary to ensure the zero-carbon transition is delivered by NESO and wider energy system in a timely, responsible way, for the benefit of all consumers.
2. **Digital, AI & Data –** Digital, AI and Data underpins the success of NESO tackling almost all of its ambitions while leading the energy transition. The scale of the challenge, both internally and across the industry, is great.
3. **Whole Energy System –** As our energy system changes, we will take a leading role and deliver a holistic approach. With our unique position in the industry, we'll invest significant effort to encourage collaboration and find efficiencies, particularly with hydrogen, transport, heating and smart technologies.
4. **Future Markets –** Designing markets that are fit for purpose underpins NESO ambitions of 'competition everywhere' and zero carbon operation. We need to understand the long-term options for market design, and work with our customers and stakeholders to find the best whole system solutions.
5. **Constraint Management –** Building new transmission and distribution network capacity to meet peak flows on the system is not always the lowest cost solution for consumers, or the best for the environment, so we need to test a variety of innovative market-led solutions and technologies in this area.
6. **System Stability & Resilience –** Significant progress has been made on System Stability across NESO but there is still more to be done. As we transform to a zero-carbon electricity system, it will remain a key area of investment.

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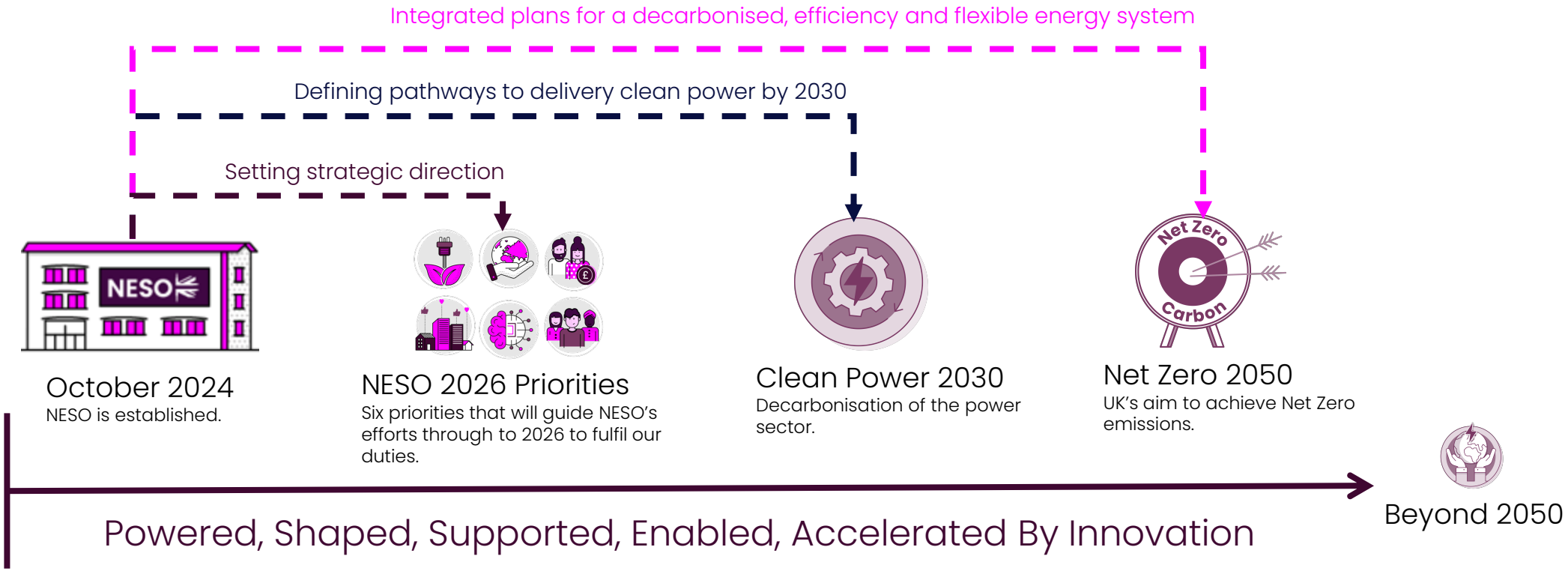
Short-term priorities with a long-term vision

NESO's innovation approach considers short-term targets whilst staying focused on long-term goals.



Our Innovation Activities

- **Innovation Strategy & Horizon Scanning**
- **External Engagement & Open Innovation**
- **Innovation Portfolio**
- **Strategic Programmes**

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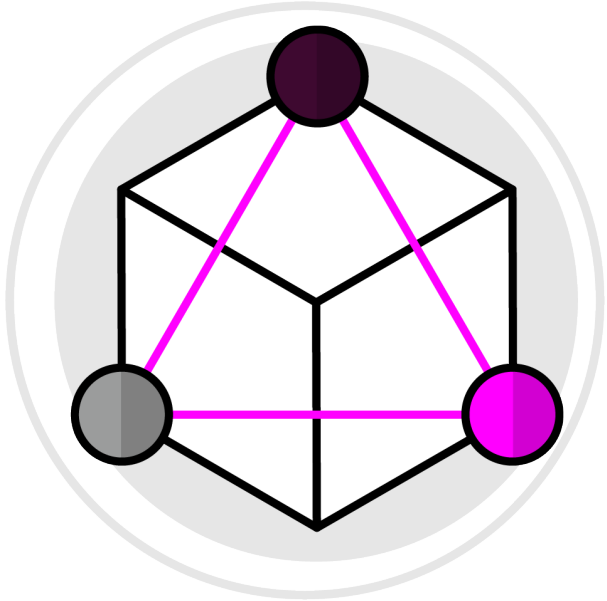
Digital & Data Transformation

- **Transparency:** Driving digitalisation and a whole system approach requires open access to data
- **Cyber-attacks:** Risks grow as electricity networks become more reliant on data and aging technologies
- **Consumer choices:** Need to be informed by insights and data provided by industry in an accessible way
- **Unlocking flexibility:** Will require access to large volumes of open data to support better forecasting and market signals



- **Current projects examples :** AI, machine learning, digital twins
- **Horizon scanning examples:** generative AI, quantum computing

Funding Innovation

Network Innovation Allowance (NIA)	Strategic Innovation Fund (SIF)
Each network receives a set allowance to administer as part of their network price control	**Ofgem administers funding** with support from Innovate UK (UKRI) – replaces Network Innovation Competition
NESO will have ongoing access to >**£47m** to fund innovation projects over RIIO-2	SIF is expected to invest **£450m by 2026**
Focused on funding **early-stage research and development** or **small-scale demonstration projects**. Each network has their own process for approving funding.	Focused on funding **large-scale transformational research and development** projects in 3 phases. UKRI open a funding round for each phase. **(Discovery £150k , Alpha <£500k, Beta <£30m)**
Projects must have the potential to deliver **benefits to consumers in vulnerable situations, or the energy transition to net zero**	For each funding round application, **Ofgem and UKRI publish challenge areas** related to the energy transition to net zero that projects should address

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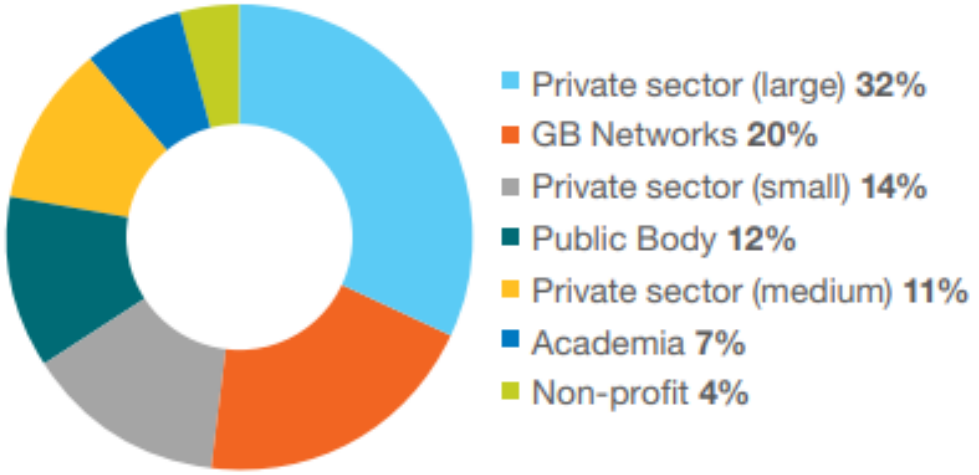
Delivering value through Collaboration

To innovate in the most effective way we share our knowledge, engage and work together with a broad range of partners.

In 2023/24 we worked with 74 project partners:



Innovation projects and programmes

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Case Study: Solar Nowcasting

Drivers

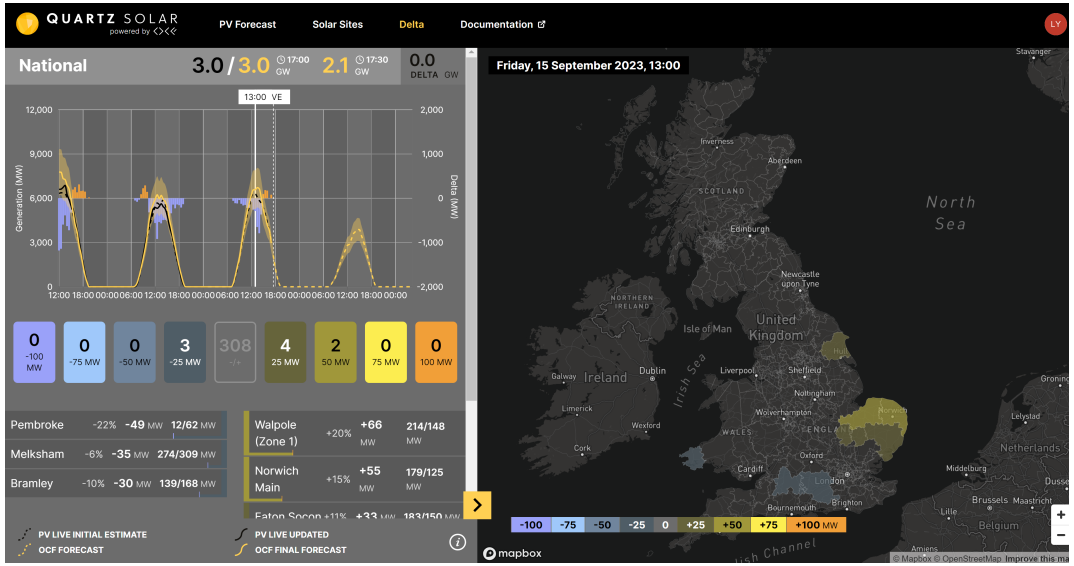
- PV generation is a growing part of generation mix
- Forecasting PV is hard, speed of change when weather fronts cross cause huge variation in output over short periods
- PV generation is “Invisible” to the electricity control room

Purpose

To create the world's best PV nowcasts using cutting-edge machine learning, 5-minutely satellite imagery, near-real-time solar PV power data, & numerical weather predictions

Key Deliverables

1. A machine learning model improving short term PV forecasts by utilising satellite imagery & real time estimates
2. A UI built designed and built to give greater visibility to users
3. Probabilistic PV forecasts to predict uncertainty



Expected Benefits

- Improved accuracy to weather data with the combination of satellite imagery
- Reduced PV forecast error leading to reduced balancing costs
- Greater enhanced situational awareness for the control room of sudden shifts in PV output

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Case Study: Dynamic Reserve Setting - demonstration

Drivers

- Reserve is held as ‘spare capacity’ to balance the grid as forecasts are never perfect.
- Securing reserve is not easy (generators play many roles to balance the grid and holding reserves limits their options in other services) and there is a cost impact to consumers.
- Currently reserve is set statically at clock-change and doesn't take into account dynamic aspects such as daily weather conditions.

Purpose

To develop a data-driven, probabilistic and explainable machine learning methodology for determining the optimal amount of reserve to hold.

Key Deliverables

A machine learning model which is:

1. Explainable - building confidence between the control room expert and the model
2. Responsive - able to dynamically update reserve values as weather conditions, system flows and time of year

Expected Benefits

- Could save up to c300MW reserve each settlement period
- Flexibility to set risk levels to respond to conditions
- Enabling control room engineers to act more efficiently, with more confidence

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Case Study: Powering Wales Renewably – SIF Beta

Drivers

Co-ordination and planning challenges across multiple stakeholders preventing the acceleration of renewable energy adoption to meet the Welsh Governments decarbonisation targets.

Purpose

Through delivery of a digital twin of the whole energy Welsh transmission and distribution system combined with other datasets, PWR will provide a digital common interface to accelerate the integration of renewable generation and decarbonised demand into the electricity system.

Key Deliverables

1. A national foundation for the representation of the whole electricity system.
2. A paradigm shift in user defined industry data exchange, stimulating additional innovation opportunities.
3. A holistic approach by which constraints and flexibility requirements can be coordinated across Network Operators, multiple markets, and response providers.
4. Better visibility for connections and capacity Management.

Expected Benefits

- Reduce curtailment by at least 10%, saving GB £28.2m per annum
- Energy price reduction between gas generation costs and renewables resulting in lower energy bills for consumers
- 1 gigawatt (GW) of Welsh owned renewable energy capacity in Wales to be locally owned by 2030.
- Reducing connections queues for renewable assets

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Case Study: CrowdFlex – SIF Beta

Drivers

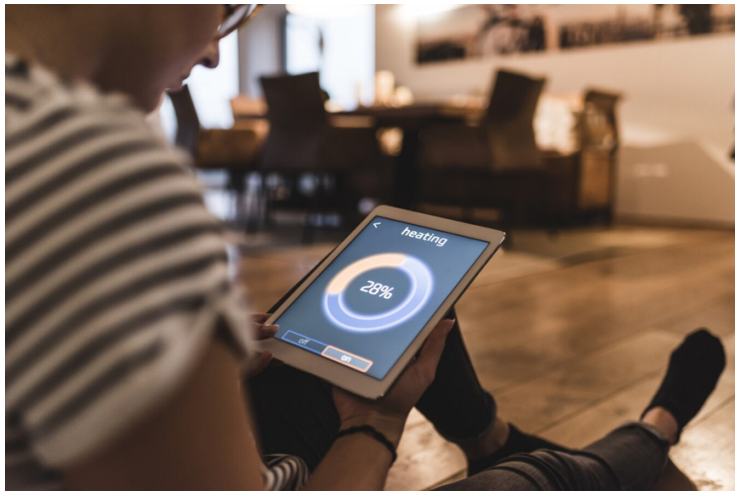
- Non dispatchable renewable energy generation increasing
- Flexibility to move from supply-side to demand-side
- A smart, flexible energy system is needed

Purpose

Establish domestic flexibility as a reliable energy and grid management resource by identifying the technology capability, understand the statistical nature of flexibility and aligning NESO and DNO requirements.

Key Deliverables

1. Demand and flexibility models for predicting consumer flexibility using common API.
2. Cost-benefit for flexibility services and NESO system impact analysis.
3. Consumer understanding via recruitment materials, protection learning and behavioural insights.
4. Go-to-market commercialisation strategies for Flexibility Service Providers and a roadmap to BAU for NESO and DNOs.



Expected Benefits

- Understand the statistical nature of domestic flexibility thereby accelerating its growth, leading to savings in balancing the grid.
- Savings over the next 10yrs of £232.2m in avoided balancing costs and £740.6m from avoided network reinforcement (to manage thermal constraints).
- Reducing the need for thermal generation equates to a cumulative 10-yr benefit of avoided CO2 emissions of 5.91MtCO2eq.

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Case Study: Volta Programme

Drivers

Increasing uncertainty in forecasting power system conditions due to:

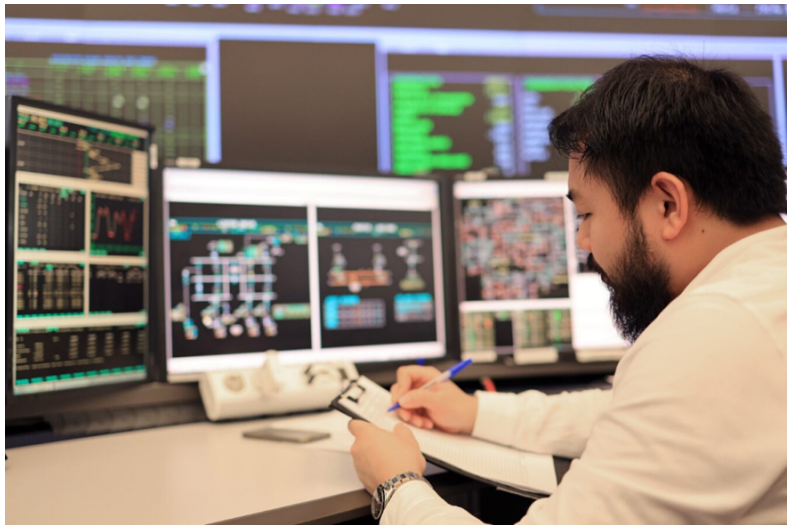
- Increase in distributed intermittent renewable resources being connected to the grid.
- Changes in customer behaviour due to EV's and smart home controls.

Purpose

Unlock the capability to deliver a control room of the future capable of assessing the multiple operational scenarios and providing control room engineers with informed risk profiles with which to make strategic operational decisions.

Key Deliverables

1. Production of a Data Model report detailing the type, source and quality of data required to run the Adaptive Input Models.
2. Gap analysis of projects addressing Volta scope.
3. Agile Plan – Roadmap for delivering Volta in an integrated way with BAU and business plans.



Expected Benefits

- Optimised forecasting and dispatch by leveraging flexible demand and storage technologies reducing BM costs.
- Management of increasingly complex grid operations through utilising adaptive input models and machine learning.
- Improved performance monitoring, evaluation and feedback of the system through machine learning and operator education.

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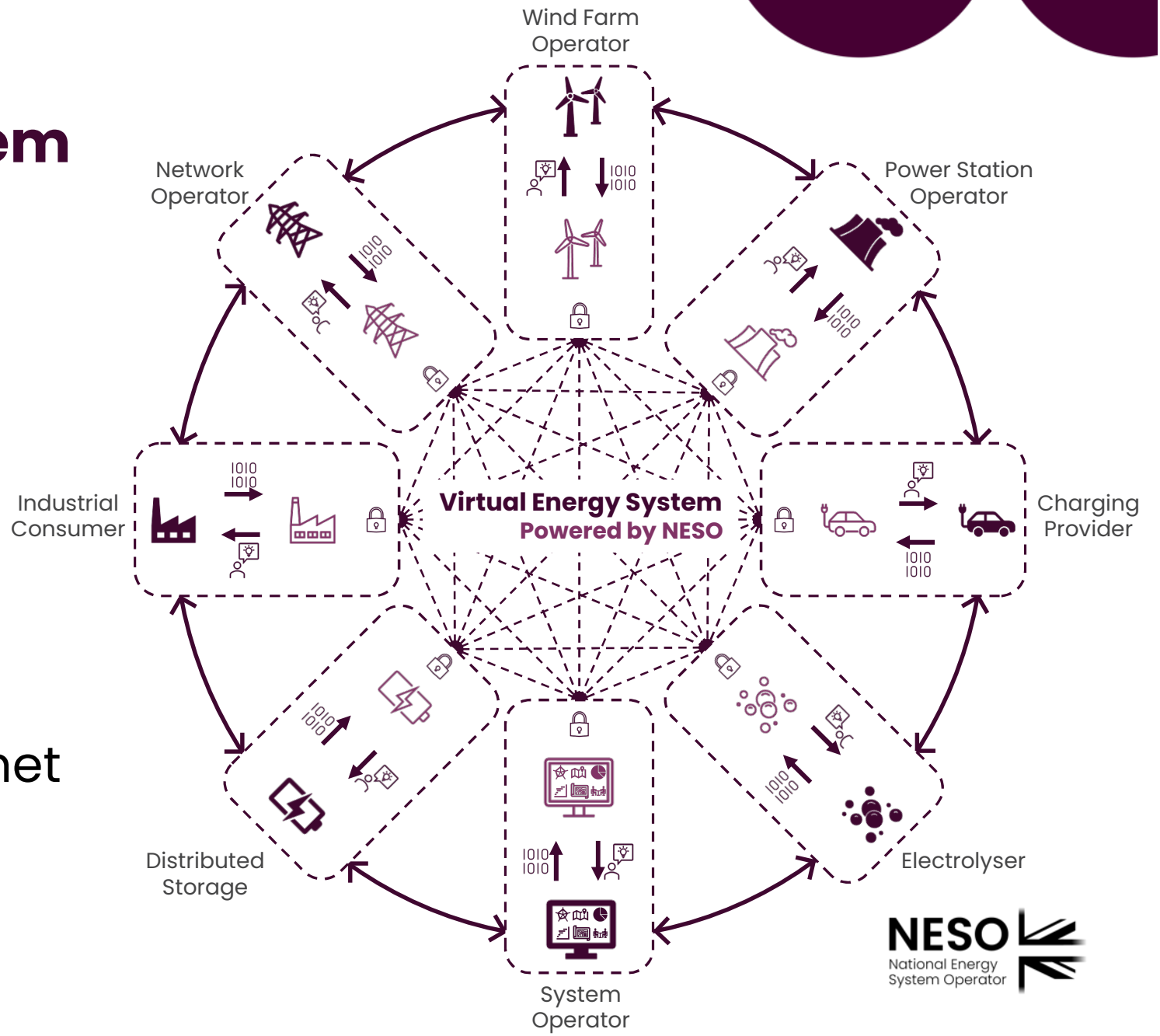
Strategic Programme – The Virtual Energy System

Creating the **common data sharing infrastructure**.

Enabling an ecosystem of **connected digital twins**.

Facilitating the transition to net zero.



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How Has The Virtual Energy System Concept Developed?

Discovery

- Explored potential use cases, users, high level problem and global best practice

Alpha

- Defined implementation roadmap, user journeys, data products and high-level design

Private Beta

- Development of the Pilot and MVP

Research has defined the need:

2022: Energy Digitalisation Taskforce recommended the Digital Spine and Data Sharing Fabric

2023: Future System Network Regulation and Distributed Flex consultations recommend Data Sharing Infrastructure.

2024: Digital Spine Feasibility Study recommendations published

Strategic Programme – AI Centre of Excellence

Our Vision

To unify and grow a collective AI workforce in the energy industry to decarbonise the whole system through digitalisation

AI Centre of Excellence

- **Academy** - Equipping data scientists with necessary skills through training, talent pipelines, and university degrees
- **Library** - Promoting collaboration, innovation, and efficiency through shared best practices, code repositories, and industry knowledge
- **Resource Market** - Providing a platform for data and resource exchange to solve BAU problems effectively
- **Resource Exchange** - Establishing secondment, placement, and internship programs to expand skills and identify future talent
- **Innovation Lab** - Creating a safe space for data scientists to develop and test AI solutions before deployment.

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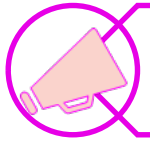
Technology Horizon Scanning

Monitoring & evaluating technology trends, and collaborating with technology ecosystems

Identifying and monitoring emerging technologies

Discovering opportunities and threats for NESO and the GB energy system

Informing NESO strategy and decision-making, including for our innovation portfolio



Transferring knowledge to the wider business

Developing relationships with technology ecosystems

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Technology Horizon Scanning – 2024 Monitoring Topics

Our innovation strategy and portfolio decision-making is informed by research on emerging technologies. We identify, monitor and evaluate immature digital and energy technologies that have the potential to have large impacts in the UK energy sector.

We identified over 70 relevant emerging technology topics in 2023. Of these, we have selected 24 for active monitoring in 2024, in a prioritisation process informed by external advisors.

In addition, 6 technology topics will be the subject of Deep Dives in 2024, in which we will further investigate energy sector opportunities and threats, adoption considerations and external ecosystems. We will identify potential future partners and collaborators through the Deep Dives.

Deep Dives			
Nuclear Fusion	Artificial Photo-synthesis	CCU for industrial processes	Electrofuels
H2 Aviation	Gravitational Storage	Direct Air Capture	Small Modular Reactors
Electrification of process heat	Thermal Storage	Autonomous Energy Systems	Solid State Batteries
Neuro-symbolic AI	Quantum Computing	Graph Data Science	Homomorphic Encryption
6G	Neuromorphic Computing	Immersive Reality	AI Simulation
Distributed Ledger Technologies	Generative AI for Cybersecurity	Exascale Computing	Earth Observation Technology

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Any questions?

Innovation@nationalenergyso.com

www.neso.energy