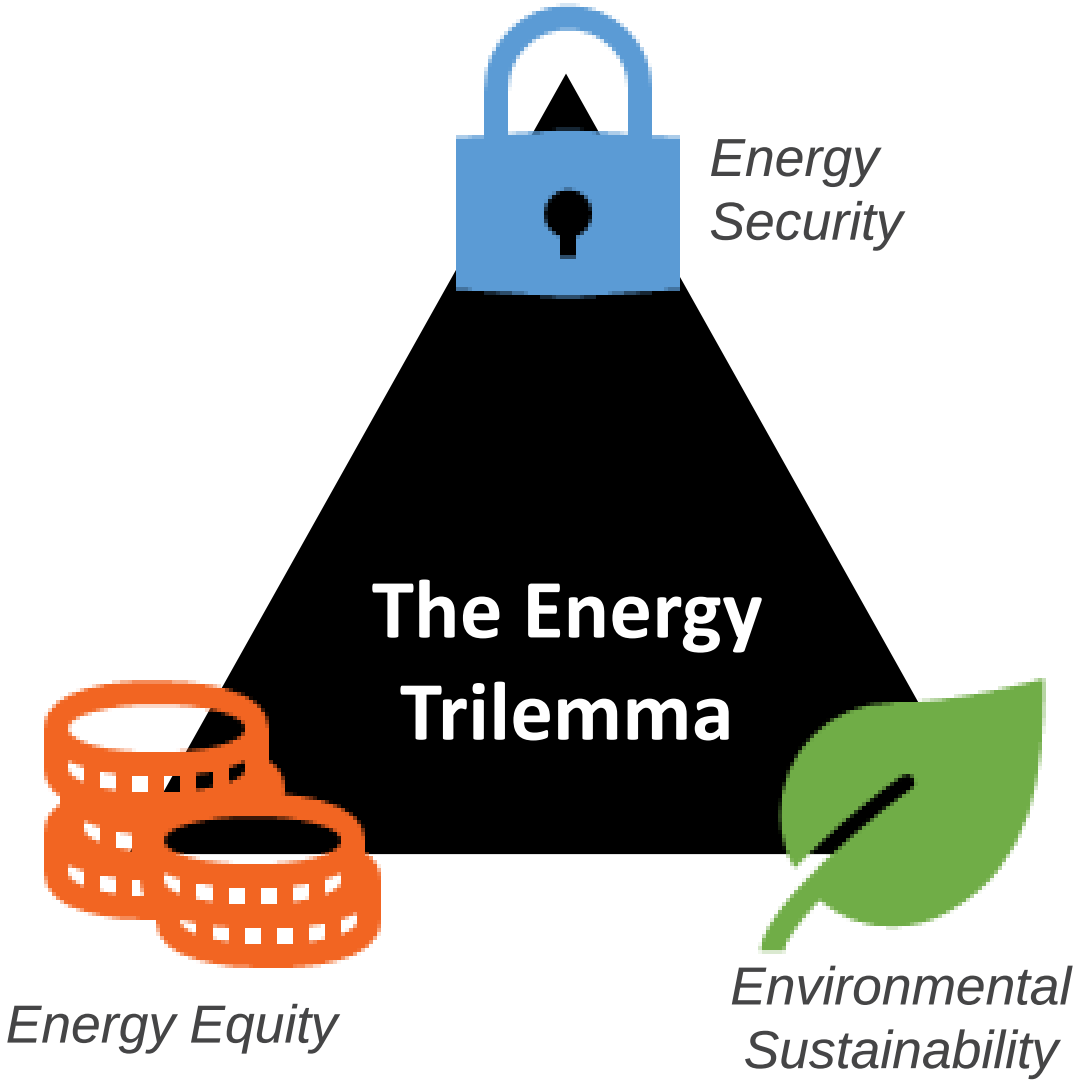
Digital technologies and the energy transition

Carolina Tortora, 28th September 2023

THE ESO EXISTS TO

- Ensure reliable, secure system operation to deliver electricity when customers need it
- Transform participation in smart and sustainable markets
- Unlock consumer value through competition
- Drive towards a sustainable, whole energy future

The Challenge



The challenge is always evolving...

Changing generation mix

- There was a 150% increase in wind generation between 2016 and 2020
- Interconnector capacity has increased by over 100% (4 new interconnectors since 2018)
- 65% of balancing instructions in 2020 were to small market participants

Increasing number of market participants

- There has been a 68% increase in notification data volumes to Control Centre since 2018
- 41% increase in the number of individual BMUs instructed from 2018 to 2021

Stability issues caused by move away from thermal stations

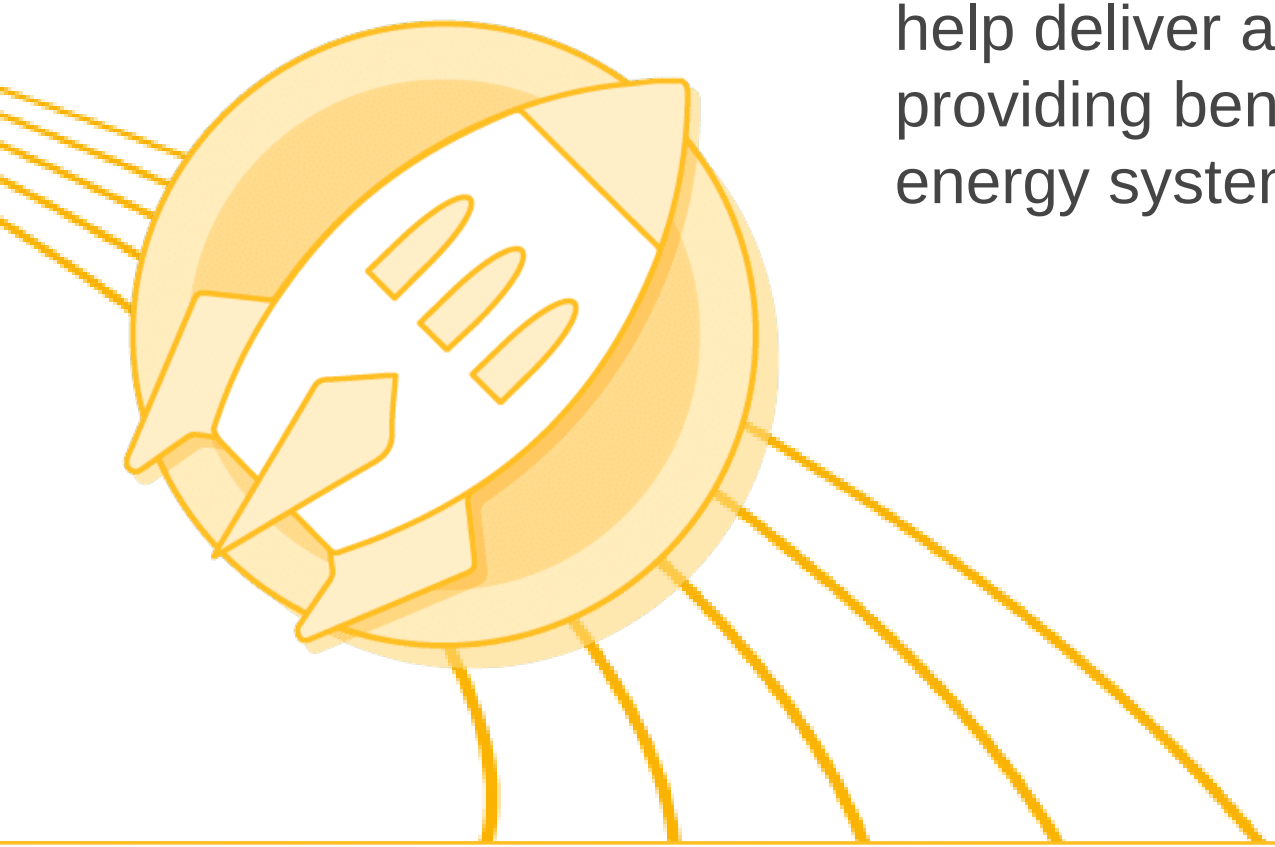
- Decreased inertia
- Reduced reactive power capacity

Increasing complexity of system operation

- Balancing actions now regularly exceed 50% of national demand - in 2012 the average was around 5%
- In 2021 we made 53,000 interconnector trades - in 2018 we made 3,700
- **Increasing balancing and constraint costs**

Figures are from ESO's RIIO-2 Business Plan 2023–2025, August 2022

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 the ESO, consumers and other energy system stakeholders.

Our Innovation Priorities

1. Zero Carbon Transition

2. Digital & Data Transformation

3. Whole Energy System

4. Future Markets

5. Constraint Management

6. System Stability & Resilience

Our activities…

Horizon Scanning

External Engagement & Open Innovation

Innovation Portfolio

Strategic Programmes

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

Example technologies…

Current innovation projects:

- Machine Learning
- Digital Twins

Current horizon scanning activities:

- Generative AI
- Quantum Computing

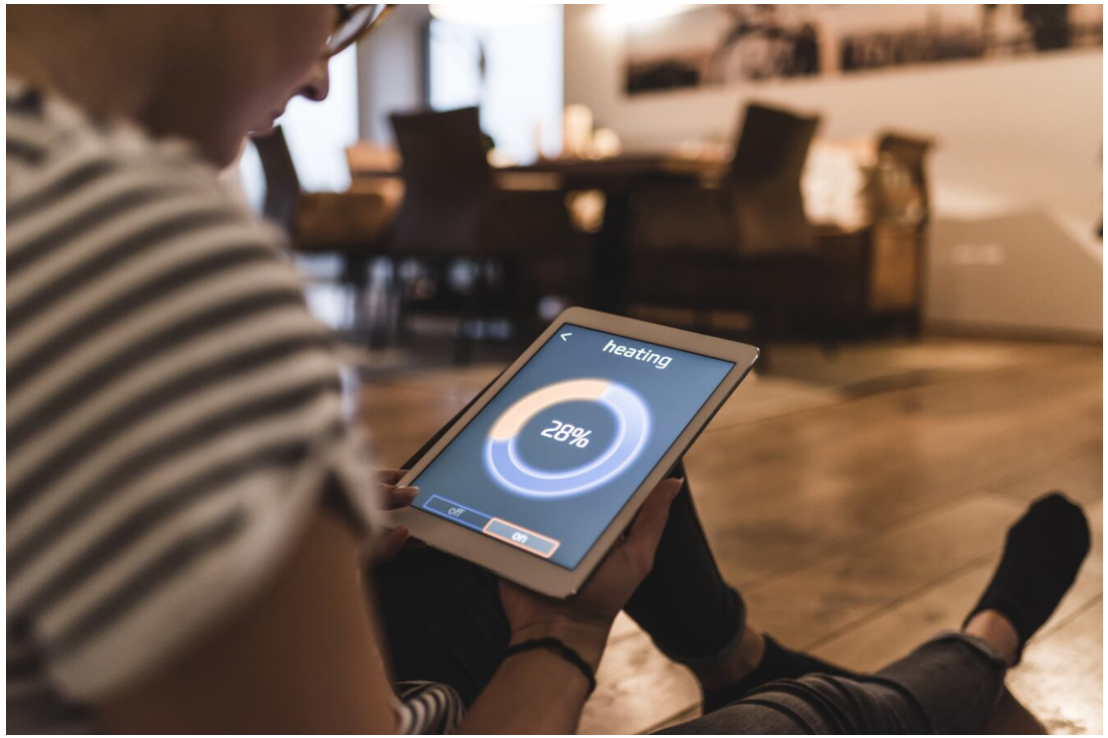
Case Study: CrowdFlex

Drivers

- Non dispatchable renewable energy generation increasing
- Flexibility to move from supply-side to demand-side
- A smart, flexible energy system 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 ESO and DNO requirements.



Key Deliverables

1. Demand and flexibility models for predicting consumer flexibility using common API.
2. Cost-benefit for flexibility services and ESO 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 ESO 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.

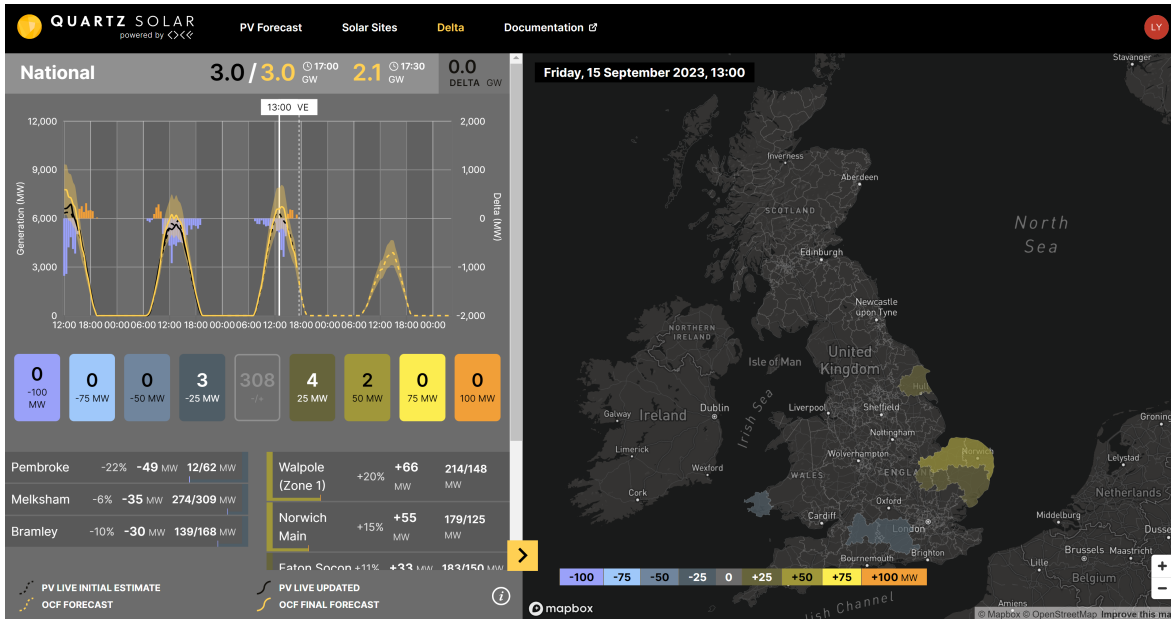
Case Study: Solar Nowcasting

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 and 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

Case Study: Dynamic Reserve Setting

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

Case Study: Advanced Dispatch Optimiser

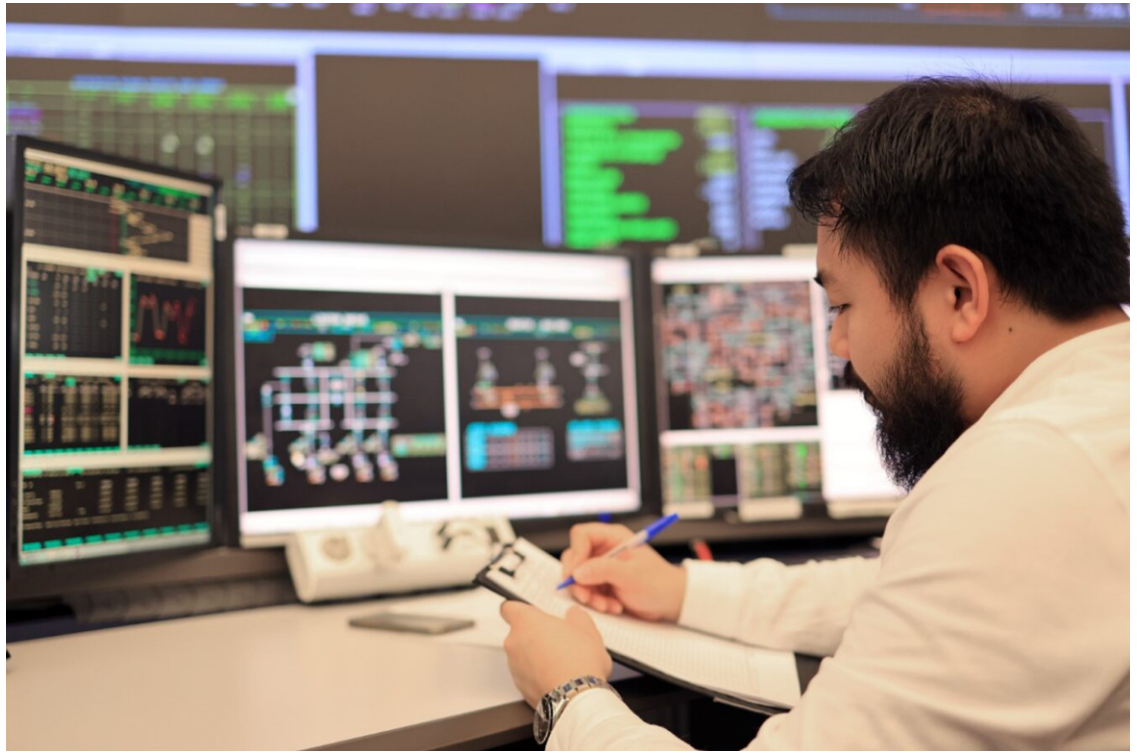
Drivers

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

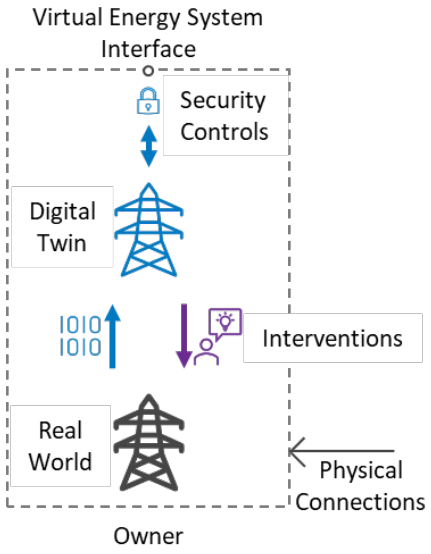
1. Production of a Data Model report detailing the type, source and quality of data required to run the Adaptive Input Models.
2. Gap analysis of projects addressing ADO scope.
3. Agile Plan – Roadmap for delivering ADO in an integrated way with BAU and business plans.

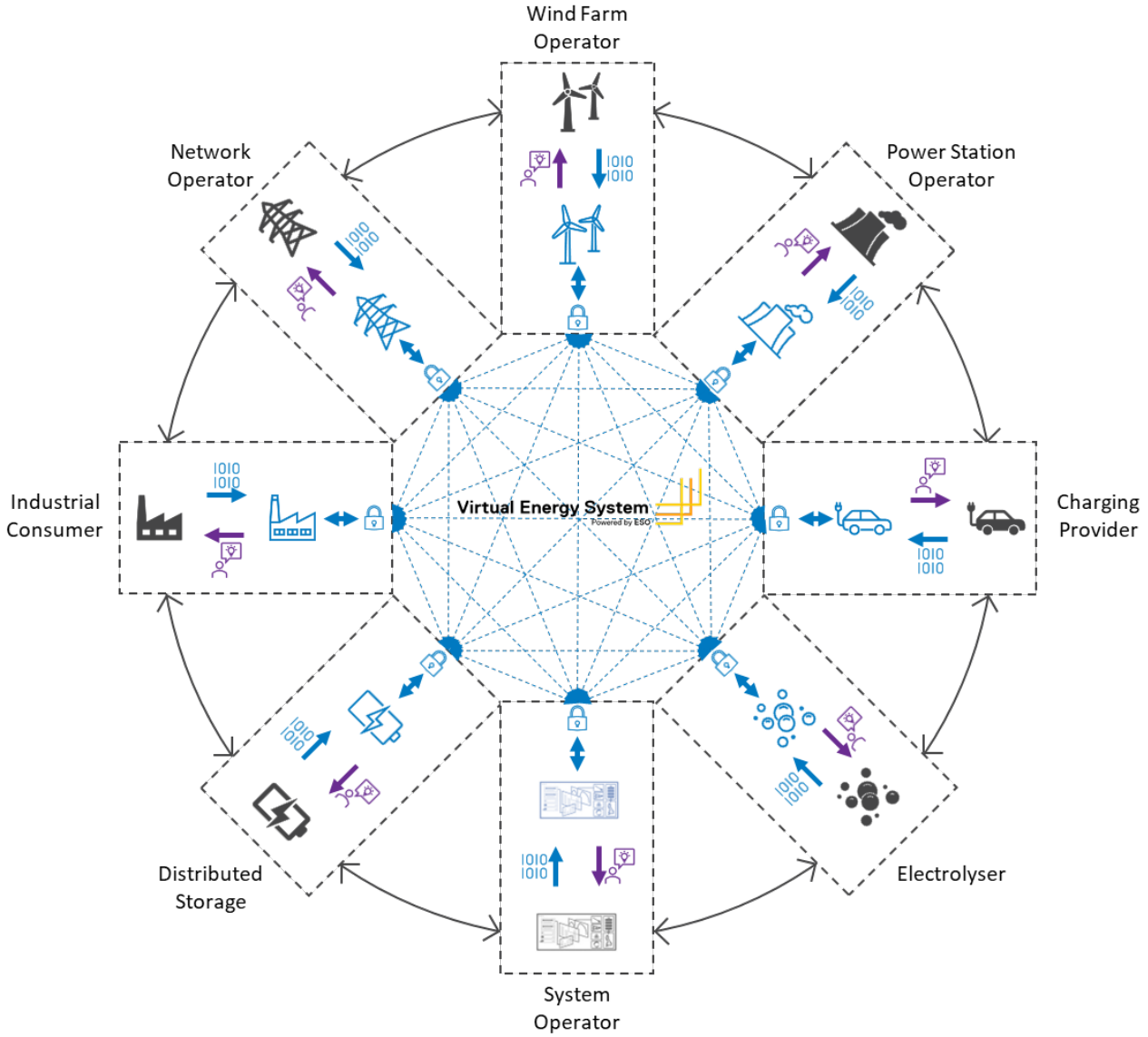
Expected Benefits

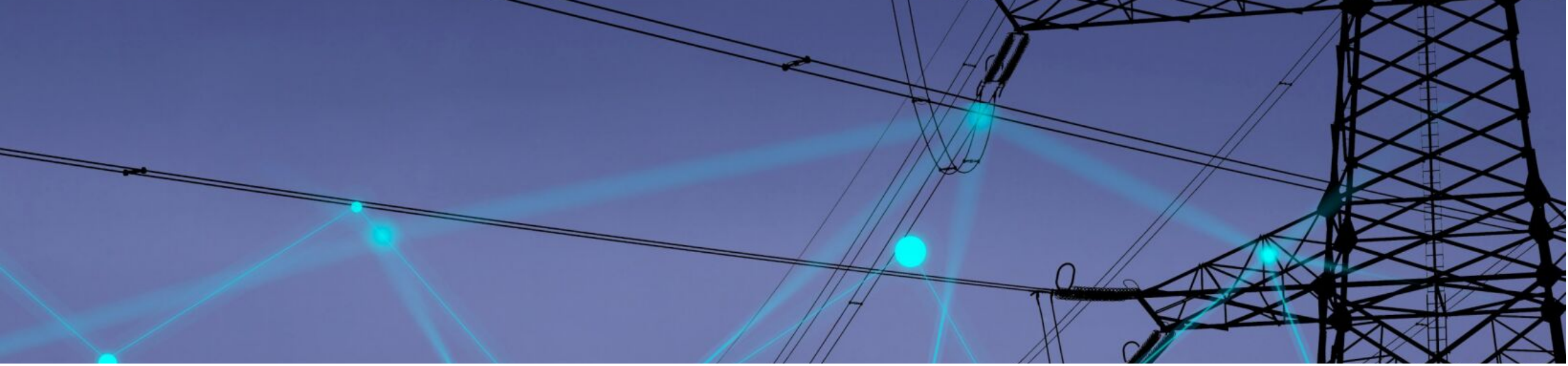
- Optimised forecasting and dispatch by leveraging flexible demand and storage technologies reducing BM costs.
- Management of increasingly complex grid operations through utilising adaptive input models and machine learning.
- Improved performance monitoring, evaluation and feedback of the system through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

Strategic Programme: Virtual Energy System

Connected digital twins of the GB energy system







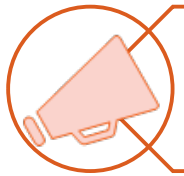
Achieving a zero carbon grid will require innovation enabled by technology.
So we must monitor and evaluate technology trends through horizon scanning and collaborate with technology ecosystems on what comes next.

Technology Horizon Scanning

Identifying and monitoring emerging technologies

Discovering opportunities and threats for ESO and the GB energy system

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

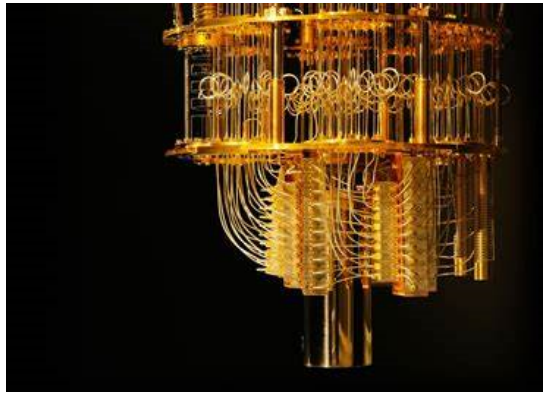


Transferring knowledge to the wider business

Developing relationships with technology ecosystems

Emerging Technologies

Quantum Computing



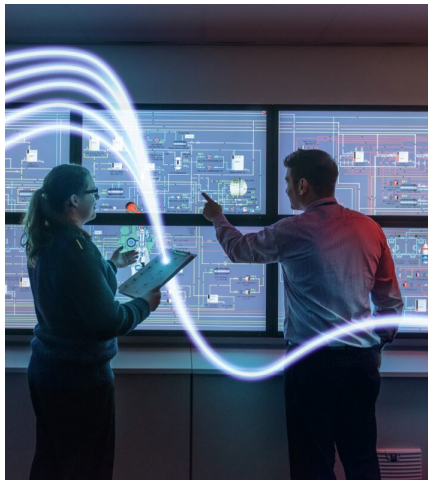
What is it?

Quantum Computing is a completely new approach to computing that uses principles of sub-atomic particles to solve complex problem in seconds that would take classical computers orders of magnitude longer.

Why are we interested?

- Optimisation: Quantum algorithms are well suited to multi-objective optimisation problems. For e.g. help address the complexity and scale of balancing the future energy system; large scale coordination of flexible distributed resources.
- Simulation: Close to real-time simulation for situational awareness
- Cyber security: Threat to public key encryption.

Generative AI



What is it?

Unlike traditional AI models that rely on large datasets and algorithms to classify or predict outcomes, generative AI models are designed to learn the underlying patterns and structure of the data and generate novel outputs that mimic human creativity.

Why are we interested?

- Discovery: Gen-AI is a disruptive technology which can be applied to a range of use cases spanning network design, customer operations and internal knowledge management.
- Data governance and security: Developing understanding of threats and limitations to aid governance and AI policy decisions.

Strategic Programme: AI Centre of Excellence

Issue Data science and AI skills gap widening within the energy industry

CAUSES

Changing Market Demand

- Demand for data skills in the UK is outpacing the supply, as more companies adopt a data-driven approach
- The need for data-driven decision-making is growing as the volume of data expands and technology advances
- High variance in pay between Big Tech and Energy companies

Changing Energy Landscape

- Complex energy industry in GB
- Fragmented understanding of how the industry works
- Transition to whole system approach, including evolving role of ESO

Data Science Maturity

- Demonstrating the impact of data science efforts within an organisation is more likely to attract top talent
- ESO is not currently able to fully exploit the opportunities presented by data science
- Low data skills maturity which applies to a variety of data roles

EFFECT

1. ***Talent Stagnation****: Lack of diversity in talent and data science skills shortage*
2. ***Attrition Rates:*** *Increasing our risk of losing talent to other organisations; and*
3. ***Innovation Slow Down:*** *ESO business left behind on the ability and promise to innovate advanced analytics products to benefit the whole energy system*

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.

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.

Reach out to us

Get involved!	Annual publications	Virtual Energy System	Work with us
Innovate with us webpage	Annual Summary document	VirtualES webpage	Careers webpage


Thank you