Innovation Annual Summary

2022/23

ESO

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Foreword

As the Electricity System Operator for Great Britain, we are responsible for operating the electricity network safely and efficiently, balancing electricity supply and demand second by second. Our position at the heart of the energy system means we are playing a central role in meeting the UK Government's target of a fully decarbonised energy system by 2035. We believe innovation is critical to meeting this target, allowing us to explore pioneering new technologies and solutions that will play a role in shaping the energy system of the future.

Fintan Slye
Executive Director,
Electricity System Operator (ESO)

As we transition to become the Future System Operator (FSO), our role will expand to take a whole energy system view, conducting strategic network planning and developing market strategy across both gas and electricity. This is reflected in our innovation activities in 2022/23 with a number of innovation projects exploring whole system topics such as the use of hydrogen for constraint management, the development of consumer archetypes to better understand consumer behaviours, and whole energy network planning across multiple energy vectors.

To deliver these key transformations, we have continued to expand our innovation capabilities in 2022/23, growing our team to ensure we have the right skills and expertise to maximise opportunities for innovation and collaboration. We have registered 28 NIA projects in the last twelve months, our highest number of NIA projects registered in a single year, with a sanctioned value of £10.2m. To support our innovation efforts, we were awarded an increase in our NIA funding by Ofgem for the remainder of the RIIO-2 control period, bringing the total allowance for innovation projects to £47M over the five years from April 2021 to March 2026.

Foreword

A number of ESO projects also secured funding from Ofgem's Strategic Innovation Fund (SIF), including Crowdflex, which is exploring how domestic flexibility can be used in grid operations as we decarbonise the energy system. Following successful completion of the Discovery phase (feasibility) at the beginning of 2022/23, Crowdflex progressed to Alpha (proof-of-concept) and has now submitted an application for Beta (full-scale demonstrator). In the last 12 months alone, we have worked with 36 different project partners on SIF projects including universities, networks, small-medium enterprises (SMEs) and non-profit organisations.

There have been many other highlights in the past year including hosting our first in-person Open Innovation Event since the pandemic in July 2022. Over 60 proposals were received from across industry and academia to address key challenges. The event brought together innovators and colleagues from the ESO and industry experts to rapidly develop five of the proposals and pitch them to an judging panel. All five proposals were successful in securing funding and have been developed into NIA projects. Our focus for 2023/24 is to continue growing our partner network by creating more opportunities to co-create innovative solutions to energy system challenges, the first of which will be the Energy Innovation Basecamp run by the Energy Networks Association (ENA) taking place in July 2023.

We also refreshed our Innovation Strategy for 2023/24, setting out our priorities for the year ahead informed by extensive stakeholder engagement, and illustrating how projects are delivering benefits for the ESO, the wider energy system, and consumers.

As we deliver our plans for RIIO-2 innovation remains at the heart of what we do. We will continue to challenge ourselves, and each other, to drive real change in our business and industry to achieve a fully decarbonised energy system.

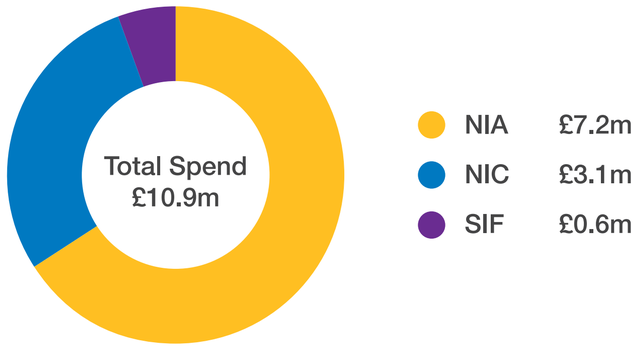
Portfolio Overview

Projects

Innovation funding is enabling us to deliver the ambitious innovation projects needed to accelerate the transition to net zero and shape the System Operator of the future.

Building on from our first Strategic Innovation Fund (SIF) Discovery projects in 2021/22, we successfully delivered our first Alpha project, Crowdflex. With collaboration central to our innovation journey, we also worked with a range of networks and innovation partners on a further eight Discovery projects and three Alpha projects in 2022/23.

Informed by our Innovation Strategy, our portfolio grew significantly in size, from 24 live projects in 2021/22 to 41 projects in 2022/23. Our projects focus on our longer-term priority challenges, with projects that are typically higher risk but with the potential to deliver significant benefits for the ESO, wider energy system and consumers.



Our Year in Numbers

NIA Projects

41	28	13	11
Projects Live in 2022/23	Projects Registered	Projects continued from previous year	Projects Completed

NIC Projects

01	01
Ongoing NIC Projects	Completed NIC Project

SIF Projects

02	08	01	03
Lead Discovery Projects	Partner Discovery Projects	Lead Alpha Project	Partner Alpha Projects

Portfolio Overview

Technology Readiness Levels

2022/23 saw the ESO register the highest number of projects to date with 28 NIA projects started in the twelve months. These projects form a balanced portfolio to research, develop and demonstrate new technologies and processes. This is measured in Technology Readiness Levels (TRL), a scale that measures the maturity of evolving technologies. Our innovation portfolio in 2022/23 was largely focused on research projects, this reflects our efforts at the start of RIIO-2 to build our capabilities and a robust pipeline of ideas that have now been developed into NIA and SIF projects and have been kicked-off in the past twelve months. As RIIO-2 progresses and the projects advance in TRLs, we expect to see the focus of the portfolio shift to development and demonstration.

Risk Profile

Inspired by the challenge of achieving a Net Zero energy system, we are reframing our innovation portfolio to demonstrate the balance between core, adjacent and transformational innovation projects.

Core Projects

Improving processes, systems and markets in order to reduce costs for consumers and/or improve the user experience.

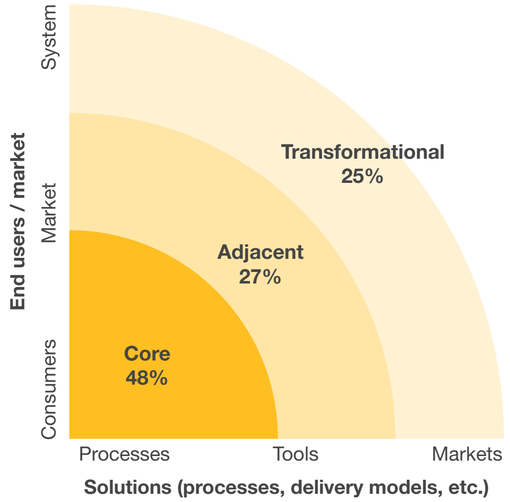
Adjacent Projects

Tailoring or extending existing programmes and capabilities to serve the growing and evolving needs of users and the industry.

Transformational Projects

Disrupting and transforming how the ESO operates and address new emergent needs for users as we move to a zero-carbon future.

Whilst a 70:20:10 ratio of core, adjacent and transformational projects is considered a well-balanced portfolio in general, our NIA innovation portfolio is weighted towards adjacent (26%) and transformational (26%) projects. Our innovation projects across the three categories are typically high-risk and are therefore eligible for innovation funding, whilst low risk ‘core’ innovation is delivered through Business as Usual.



Portfolio Overview

People

Our talented team has continued to grow over the past 12 months, extending our capabilities across our SIF, Technology Insights, Virtual Energy System and AI Centre of Excellence teams. We have continued refining our Business Partnering approach, growing our reach throughout the ESO to engage colleagues at every level. This approach is facilitating collaboration across the organisation, breaking down silos and identifying joint opportunities for innovation across National Control, Markets and Networks whilst ensuring colleagues are equipped with the opportunities and support to innovate.

19,583 hrs spent on innovation

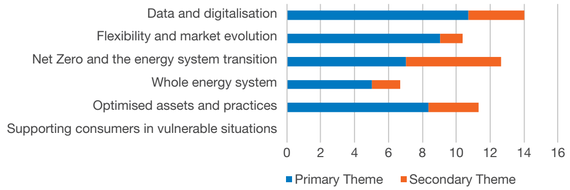
11.5 FTEs

73 employees worked on innovation projects

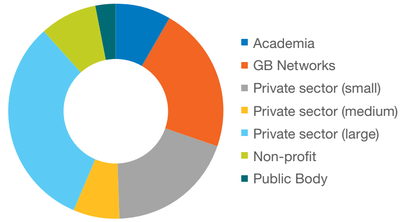
NIA and SIF Scorecard

Higher level enablers of innovation

	Initiation & Evaluation	Demonstration, Iteration & Learning	Deployment & Optimisation
Strategy & Vision	Strategies: • ESO Innovation Strategy 2023/24 • Electricity Networks Innovation Strategy	**8.36** Average Stakeholder & Customer Satisfaction Score	Spread of projects across ENA themes
Organisation & Culture	**116** Innovation ideas generated	TRL Map / % No. Projects / % Spend	**28** Projects registered
Capabilities & Technology	**94** 3rd party Big Ideas received **19** 3rd party Big Ideas approved	**32%** Projects registered from 3rd party ideas	**59** Project Partners
Results & Outcomes	**33%** Ideas approved at Big Idea stage	**25** Big Ideas being developed into projects	**76 days** Average length of time from Big Idea submission to initial decision



TRL Map	% No. Projects	% Spend
TRL 2	4%	4%
TRL 3	53%	47%
TRL 4	18%	20%
TRL 5	14%	18%
TRL 6	2%	1%
TRL 7	7%	9%
TRL 8	2%	1%



NIA and SIF Scorecard

Our second iteration of the Innovation Measurement Framework (IMF) Scorecard showcases our NIA and SIF activities over the past 12 months, providing insight into the culture of innovation at the ESO and highlighting opportunities for improvement.

Ideas

We received 116 ideas (what we call ‘Big Ideas’) in 2022/23, 81% of which were submitted by third parties and the remainder by our colleagues internally. This reflects our efforts to share our challenges externally through open calls for innovative proposals, such as our Open Innovation Event in July 2022. 38 ‘Big Ideas’ were approved in 2022/23, 13 of which are in delivery and 25 are currently in the ‘Plan and Refine’ stage. Innovation projects developed from these Big Ideas are an even split between internal and external ideas, demonstrating the crucial role of external innovators in shaping the energy system of the future.

Approval Process

The average length of time from ‘Big Idea’ submission to providing a decision increased to 76 days, up from 45 days in 2021/22. This differed based on whether a ‘Big Idea’ was progressed to an innovation project (44 days) or not taken further (101 days).

‘Big Ideas’ submitted undergo a sense check within the ESO against a number of criteria including: fit with our innovation strategy, availability of internal resource, duplication of existing work and funding stream eligibility. In addition to our Innovation Business Partners, this initial review relies on input from our Subject Matter Experts (SMEs) to determine if an idea should fail fast or progress to the ‘Plan and Refine’ stage where it is developed into a more detailed project proposal to ensure it can be delivered successfully and optimise the benefit to the energy system and consumers.

Operating the electricity system during the challenges of last Winter, meant that many of our SMEs were focused on activities to support the safe and reliable operation of the system. This resulted in reduced SME resource to review and feedback on ‘Big Ideas’ which has contributed to the increased length of time between ‘Big Idea’ submission and providing an initial decision. To help address this and provide a more consistent experience to innovators, we will be implementing a standard methodology for assessing ideas developed with the ENA and energy networks in 2023/24.

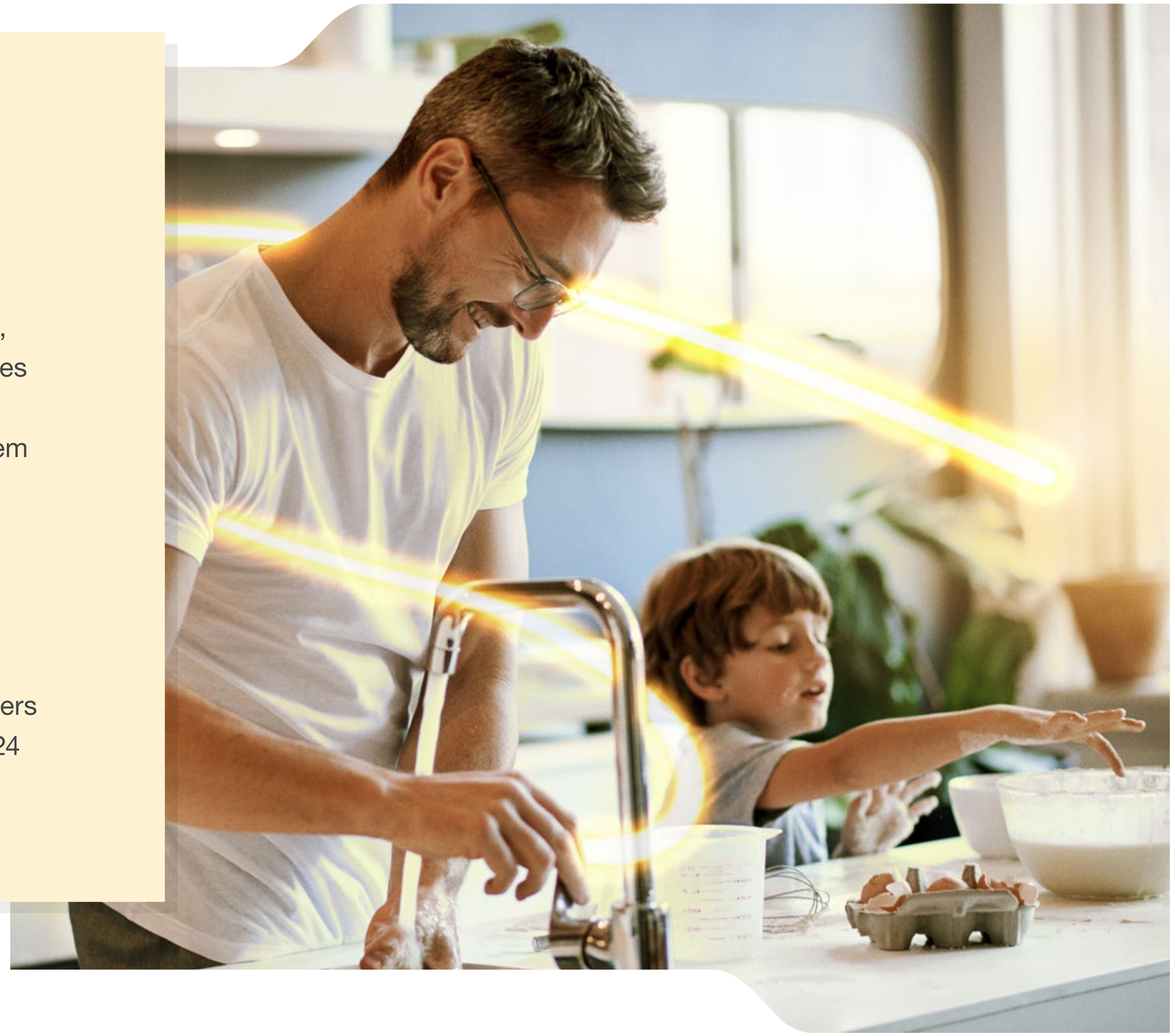
NIA and SIF Scorecard

TRL

The TRL Heatmap demonstrates that the majority of our NIA and SIF projects fall into the research stage with 57% of projects TRL 3 and below. This reflects the early nature of SIF (Discovery and Alpha stages to date) and the RIIO-2 NIA criteria which specifies a project must have an unproven business case with a degree of risk that warrants a limited research, development or demonstration project to demonstrate its effectiveness. As RIIO-2 progresses and SIF matures, we expect the focus of the portfolio will shift to higher TRLs as research projects look to demonstrate the effectiveness of the solution and where proven, embed them into business-as-usual and realise the benefits to the consumer and the energy system.

Project Partners

We believe collaborating with SMEs is crucial to access new ideas, fresh thinking and more agile ways of working to facilitate the energy transition; to achieve this we are continually looking to engage a wide network of partners. In 2022/23 we worked with 59 different partners from academia, energy networks, non-profit organisations and private companies. In 2023/24 we will extend our efforts further through hackathons and Open Innovation Events and developing ideas for a Technology Partner Network.



Performance Against our Innovation Strategy

Our Innovation Strategy sets out our priority areas for the year ahead, sharpening the focus of our activities and ensuring our portfolio is addressing the energy industry's long-term challenges.

Figure 1 shows how we performed against these priorities, demonstrating the focus of our efforts (indicated by Number of projects) and funding (Sanctioned value for NIA and SIF projects live in 22/23) over the last twelve months. Our projects typically address more than one priority area, Figure 1 shows how our innovation activities tackle the priorities across the entire portfolio.

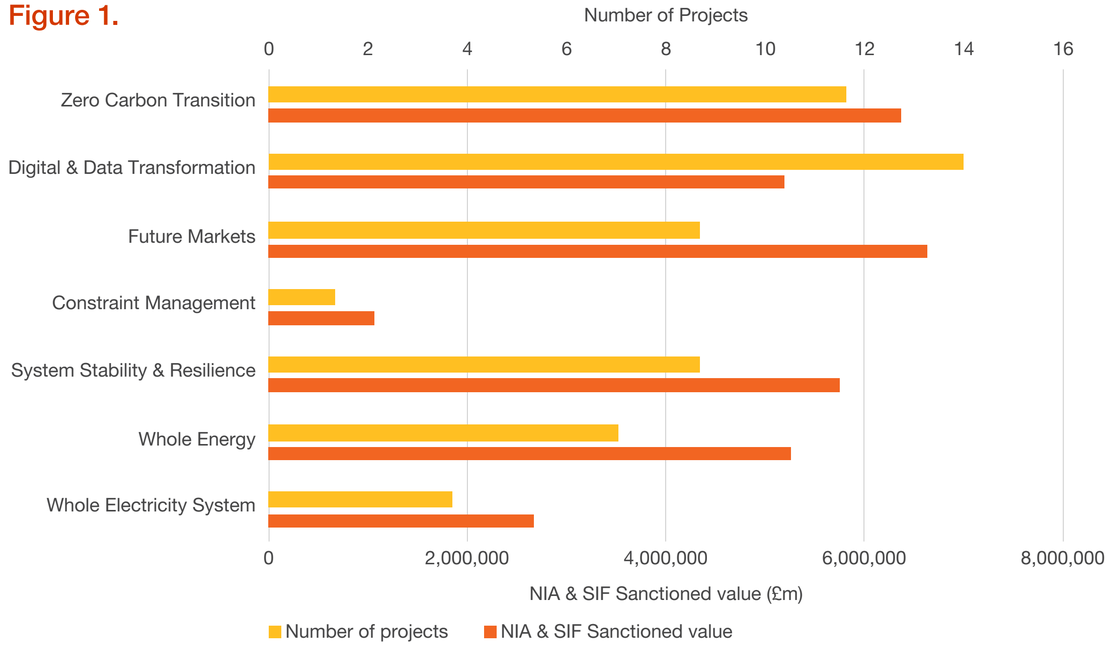
Digital & Data Transformation, our second highest priority, had the highest number of projects and spend. As digitalisation is a key enabler of the transition to a low-carbon energy system, it underpins many of the solutions that address our other priority areas. In 2022/23, two of our ambitious digitalisation NIA projects have also begun the productionisation process to embed them in the business and start realising benefits for the ESO, industry and the consumer, Dynamic Reserve Setting and Optimal Outage Planning System.

The number of projects developed to address Constraint Management is lower than expected, this is due to the main work addressing this priority being carried out through Business as Usual as part of the Constraint Management Pathfinder, and innovation projects will support this work where possible.

In 2022/23 we focused more heavily on System Stability than would be expected based on our strategic priorities. The global energy landscape has continued to change dramatically over the last twelve months and, as such, System Stability remains a key area of investment. We expect this continued focus to be reflected in our project portfolio as we head towards our goal of operating the electricity system with zero carbon by 2025.

The number of NIA and SIF projects addressing Zero Carbon Transition and Future Markets, number one and three in our top priorities, also broadly follow this order with the second and fourth highest number of projects in our portfolio respectively. In 2022/23 we launched the Alpha phase of CrowdFlex, a ground-breaking SIF project which is addressing both of these priorities, investigating the role domestic flexibility can play in addressing the system challenge of decarbonisation.

Figure 1.



Number of projects linked to our strategic priorities (live projects in 2022/23) and sanctioned value for NIA and SIF projects per strategic priority.

Our Strategic Priorities

Our Innovation priorities have been refreshed for 2023/24, directing our focus for the next twelve months as we continue to transform the energy system for a zero carbon future. These priorities have been established following extensive engagement with internal experts and wider industry, and our evolved understanding of the challenges from our innovation project portfolio.

Our Innovation priorities also help innovators better understand how we can work together to help tackle the challenges of the net zero transition. The following section contains case studies illustrating how our priorities are being addressed through innovation projects we are delivering with our partners.

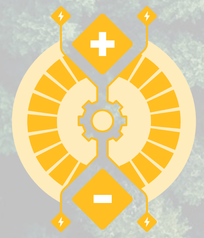
Find out more about our strategic priorities in our 2023/24 Innovation Strategy.

1 Zero Carbon Transition

2 Digital & Data Transformation

3 Whole Energy System

4 Future Markets



5 Constraint Management

6 System Stability & Resilience

Case Study: Carbon Intensity Modelling

Having more accurate data of how much carbon dioxide is released for every kilowatt hour of electricity produced will ensure we operate the network in the cleanest way possible, as we strive to meet our net zero operation targets.

Zero Carbon Transition

Project overview

Carbon intensity data tells us how much carbon dioxide (CO_2) is released for every kilowatt hour (kWh) of power that is produced, so we can measure and monitor how clean the GB electricity system is. Renewable generation, such as wind and solar, has a much lower carbon intensity than fossil-fuelled power plants, and we need to operate the electricity system with more low carbon options to decarbonise the grid so it's an important metric.

The data we have at the moment gives us a single value for carbon intensity. This isn't wholly accurate as it doesn't tell us how operating a power plant in different states might impact its emissions. For example, CO_2 emissions from a fossil-fuelled generator running at part capacity or intermittently may vary significantly from one operating at a steady rate at full capacity.

If we are to make balancing and optimisation decisions based on carbon intensity – rather than cost – in the future, we need to ensure the Control Room has the most accurate data to hand.

This project seeks to improve the modelling data we have for carbon intensity using data science research and analysis to provide more granular data sets which could potentially be developed into a tool for the Control Room in the future.

To see the greenest times of day to use electricity and real time information on how our electricity is being produced download the ESO Carbon Intensity app - available for free on Google Play Store and The App Store.

Project Lead / Scrum Master

(Rapid Development team)

Name: Devi Tatineni

About: After studying Computer Science and Engineering at university, I spent 16 years working in IT across various industries including healthcare, automotive and utilities. Having worked for two energy supply companies, it was a natural step to join the ESO four years ago. The main focus of my role in the ESO's Rapid Development team is governance and the replacement and transfer of legacy applications.

> *Carbon intensity is increasingly important and there is a lot of interest within the ESO to know more about it, to improve our data and to see how we can make better use of the information. Through the work we are doing with this innovation project, we are establishing a solid base to start from to see what is possible and how far we can go with it."*

Case Study: Carbon Intensity Modelling

Having more accurate data of how much carbon dioxide is released for every kilowatt hour of electricity produced will ensure we operate the network in the cleanest way possible, as we strive to meet our net zero operation targets.

Results

Working in partnership with Hartree, we started the 12-month project with an analysis of the correlation between fuel and power in fossil-fuelled power stations based on real world operating scenarios. The findings of this research will help us understand the true carbon intensity of the balancing and optimisation actions currently taken by the Control Room.

When we have fully investigated the data, we will use our learnings to develop a working carbon intensity model which can more accurately calculate emissions for power plants in different states of use.

Case Study: Carbon Intensity Modelling

Having more accurate data of how much carbon dioxide is released for every kilowatt hour of electricity produced will ensure we operate the network in the cleanest way possible, as we strive to meet our net zero operation targets.

Zero Carbon Transition

Benefits

With a deeper understanding of the complexities of carbon intensity, the ESO can find more efficient ways to operate the grid – in particular, by decarbonising balancing and optimisation actions. A more accurate carbon intensity model will also contribute to our digital twin systems, to further support the ESO's ambition of net zero operation.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO027	Carbon Intensity Modelling	In progress

Project Partners
UKRI - The Hartree Centre

Registered Value	Start TRL	End TRL
£205,000	2	5

Case Study: Co-optimisation of Energy and Frequency-containment services (COEF)

This project seeks to co-optimise the energy balancing with frequency response actions taken by the Control Room by using automation and advanced modelling to cut overall cost of energy balancing and frequency response services to the end consumer.

Zero Carbon Transition

Project overview

Changes to the way power is generated and consumed is making the GB electricity system more complicated to operate. This brings new challenges for the Control Room which is responsible for running the grid within set parameters to keep it stable.

One of the stability parameters is frequency, which must be kept at 50hz. To do this, supply and demand must be closely matched. When there are events on the system which affect frequency – such as a drop in generation or a spike in demand – the Control Room must use 'frequency containment' actions to address the imbalance.

'Frequency containment' encompasses a number of different ways to restore frequency including dynamic containment, increasing inertia levels and minimising generation/ demand losses. Currently these actions are taken in sequential way in the day ahead stage, which may not be optimal.

The Co-optimisation of Energy & Frequency Containment project is looking at building a co-optimisation prototype that finds the optimal combination of despatched units and services to solve both the energy balancing and frequency containment problems, simultaneously. Co-optimising solutions to these two problems may result in significant savings to our daily balancing cost.

Energy and Innovation System Matter Expert

Name: Colin Webb

About: I joined the electrical industry straight from school as an apprentice and have gained a wealth of experience in the sector, having worked for generators, energy suppliers and now the ESO. In nearly 20 years working for National Grid I have worked across a variety of roles including scheduling, energy strategy and operations as part of the Control Room team. In my current role in the Balancing Transformation team, I am helping to bring forward the tools needed to support Control Room operations in the future.

> *Over the years, I have worked on a number of innovation projects. I find them really exciting as you might find new ways of doing things that transform operations at the ESO. I believe Artificial Intelligence and Machine Learning will be increasingly important to innovation in the future, helping improve our outputs."*

Case Study: Co-optimisation of Energy and Frequency-containment services (COEF)

This project seeks to co-optimise the energy balancing with frequency response actions taken by the Control Room by using automation and advanced modelling to cut overall cost of energy balancing and frequency response services to the end consumer.

Zero Carbon Transition

Results

Working with Imperial College London, we are using mathematical modelling to investigate the possibility of co-optimising energy balancing and frequency containment. The modelling will tell us what works, what doesn't and what conditions may need to change for it to work.

If the research shows advanced modelling can improve and potentially replace the process we use at the moment, we will move to a new phase to develop and test a Control Room tool ready for use in 'Business as Usual'. If not, the findings may give us other considerations to explore in future innovation projects.

Case Study: Co-optimisation of Energy and Frequency-containment services (COEF)

This project seeks to co-optimise the energy balancing with frequency response actions taken by the Control Room by using automation and advanced modelling to cut overall cost of energy balancing and frequency response services to the end consumer.

Zero Carbon Transition

Benefits

In an increasingly complex energy landscape, we need to phase out legacy systems and replace them with advanced, supported tools to address the complexities of maintaining vital services such as frequency containment as we move to a net zero future. Co-optimising Control Room functions such as frequency containment and energy balancing will create efficiencies to help lower carbon emissions, reduce costs and help the ESO progress its digitalisation goals to operate a connected, intelligent electricity network.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO033	Co-optimisation of Energy and Frequency-containment services (COEF)	In progress

Project Partners
Imperial Consultants (ICON)

Registered Value	Start TRL	End TRL
£469,000	3	6

Case Study: Peak Demand Forecasting

With a more accurate model to forecast peak demand, the ESO can ensure generation better matches demand during the winter months to maintain a reliable supply to consumers.

Zero Carbon Transition

Project overview

Consumer demand for electricity varies seasonally, with peak demand usually coming in the winter when people spend more time indoors and the need for lighting, space heating and hot water is higher. Being able to forecast in advance how high that winter peak is going to be ensures we have enough generation on the system to meet consumer demand.

The Peak Demand Forecasting model we use to calculate this figure is more than a decade old, and when it was created there was much less data available. Consumer demand has changed a lot during this time, so peak demand is now affected by different factors such as the electrification of domestic heating, the uplift in electric vehicle charging, the improved efficiency of appliances and people changing the way they consume energy. There are also more weather dependent technologies on the electricity system which can impact the forecast's accuracy.

This project is reviewing the Peak Demand Forecasting model to aid rebuilding it from the bottom up using the latest research and available data on consumer energy use to improve the accuracy of the peak forecast.

Data Analyst

Name: Robbie Mulvany

About: I have a PhD in energy modelling for automotive manufacturing, and before joining the ESO three years ago, I worked as a simulation consultant in the manufacturing sector. My current role with National Grid focuses on delivering energy insights for the Future Energy Scenarios (FES) team.

> *There's a real excitement for me in research-based projects, particularly when you can see it all the way through to application which is what we have been able to do with the Peak Demand Forecasting project. It was a dynamic project and there was a lot of support from within the ESO for it as so many teams can benefit from our research findings and our innovative modelling which puts us ahead of the curve."*

Case Study: Peak Demand Forecasting

With a more accurate model to forecast peak demand, the ESO can ensure generation better matches demand during the winter months to maintain a reliable supply to consumers.

Results

With a broad scope of interest, the project started with research into the latest hypotheses and findings on peak demand and the factors which affect it. This included everything from appliance efficiencies, seasonal effects, socioeconomic factors (which links to another ESONIA project on consumer archetypes) and the impact of incentives and restrictions on consumer demand.

Using this research alongside historical and correlation data, we worked with Aurora Energy Research to test new stochastic modelling methods to forecast peak demand more accurately.

The project completed in July 2022. The new peak demand forecasting methodology we created is now being incorporated into new model developments, with its outcomes informing the capacity market.

Case Study: Peak Demand Forecasting

With a more accurate model to forecast peak demand, the ESO can ensure generation better matches demand during the winter months to maintain a reliable supply to consumers.

Zero Carbon Transition

Benefits

The ability to forecast peak demand more accurately with new data and methodologies is helping the ESO maintain a stable and reliable electricity supply, as the GB energy landscape continues to change. Our better understanding of the rationale behind peak consumer demand is also helping to de-risk operations and set the groundwork for other legacy models used by the demand team to be updated in the future.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO019	Peak Demand Forecasting	Complete

Project Partners
Aurora Energy Research

Registered Value	Start TRL	End TRL
£250,000	3	5

Case Study: STARTZ (Stability Requirements Calculation Toward Net-Zero)

This project will review how we calculate the balancing services we need to keep the electricity system stable, and look for ways to improve our calculations by using new methodologies, automation and machine learning.

Digital & Data Transformation

Project overview

Decarbonisation is reducing the stability of the GB network, as we now have less inertia and short circuit levels on the electricity system than before. Traditionally, these stability services were provided by conventional power stations, as a by-product of burning gas or coal. As the older coal and gas plants come off the electricity system, we need to procure replacement balancing services from other sources.

To decide what services we need to procure and how much is required to maintain stability, we have to have accurate calculation methods. If we overestimate our needs, we will spend money on services we don't use which isn't a cost efficient way to operate the network. If we underestimate our calculations, there is a risk to stability and the potential for blackout events.

Our current stability calculation methods use a number of assumptions and approximations and there may be room to make the process more accurate. This project reviews the ESO's stability requirement calculations and explores the potential for new methodologies, machine learning and automation to enhance accuracy and efficiency to inform procurement market activities and future network planning.

Power Systems Engineer

Name: Tatiana Assis

About: My background is in academia, having spent 15 years as a university professor specialising in power system dynamics. I joined the ESO two years ago and the focus of my role is on operability products and how these can be used in business as usual. This is my first innovation project as lead.

> *Innovation is key for the business. The system is changing fast and there are so many problems and challenges that require new solutions and ideas. The innovations we are working on might not be ready to be applied but they are a great starting point that we can build on, investigate and develop – we don't know what's going to happen or where it will take us! That's exciting."*

Case Study: STARTZ (Stability Requirements Calculation Toward Net-Zero)

This project will review how we calculate the balancing services we need to keep the electricity system stable, and look for ways to improve our calculations by using new methodologies, automation and machine learning.

Digital & Data Transformation

Results

Working in partnership with TNEI, we are reviewing the existing calculation methods used by the ESO to track the network's stability needs and identifying where improvements can be made. Our suggested improvements to the methodology will be tested and validated against detailed system modelling.

Next, we will be looking at how digital tools might be used to improve calculations. Running manual simulations is time consuming, so we are investigating whether automation could be used to run thousands of future energy scenarios at once. We are also looking at whether machine learning techniques could be applied to speed up calculations.

Case Study: STARTZ (Stability Requirements Calculation Toward Net-Zero)

This project will review how we calculate the balancing services we need to keep the electricity system stable, and look for ways to improve our calculations by using new methodologies, automation and machine learning.

Digital & Data Transformation

Benefits

This project will support the energy transition by ensuring the grid remains stable while more renewable generation is integrated into the network. It will provide value for money for consumers, as there is less variance in our estimates so the balancing services required will be more accurately predicted and procured. The potential to use automation and machine learning to calculate stability needs will make the process more efficient and reduce the risk of human error which could affect the results.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO046	STARTZ (Stability Requirements Calculation Toward Net-Zero)	In progress

Project Partners
TNEI

Registered Value	Start TRL	End TRL
£400,000	3	5

Case Study: Dynamic Reserve Setting

The Dynamic Reserve Setting project will help us more accurately forecast the levels of back-up power needed to maintain grid stability, while reducing operating costs and carbon emissions.

Digital & Data Transformation

Project overview

To keep the GB electricity network stable, the ESO Control Room must maintain a balance between supply and demand at all times. One of the ways the team does this is by utilising reserves of power, which are procured in advance and remain on standby until needed. Power reserves may provide extra power (headroom) or take power off the system (foot room).

Minimum and maximum limits for back-up power are set twice a year (for summer and winter) and within this, levels of reserve power are set for different times and days of the week. Reserve power levels are based on statistical analysis of past consumer behaviour and energy generation. They usually err on the side of caution, so often we procure more reserves than we need, which costs more money and it generates more carbon emissions (power reserves are usually provided by fossil-fuelled generators).

Now in phase two, the Dynamic Reserve Setting project will deliver a working demonstration of a new tool for the Control Room which will more accurately predict what reserve power is needed and when by helping us better understand the uncertainties in our demand forecasting. Once tested, this tool could help us move to a more dynamic way of procuring reserve power (day ahead) in the future.

Data Scientist

Name: Joshua Brooke

About: I joined National Grid in 2019 on the graduate scheme, after finishing my degree in electronic engineering. As part of my placement, I gained experience in a number of different departments including network access planning, National Grid ventures and ESO Labs. Now, I work within the Frequency risk and modelling team.

> *I enjoy working in energy, as it's a purpose driven sector where you can really make a difference, especially through the innovation projects. It's like – here's a problem, now go solve it! It's interesting being part of the process and to be able to work with external partners. There's more to come on this project and the potential to solve other problems for ESO."*

Case Study: Dynamic Reserve Setting

The Dynamic Reserve Setting project will help us more accurately forecast the levels of back-up power needed to maintain grid stability, while reducing operating costs and carbon emissions.

Results

Proof of concept for the dynamic reserve setting tool was delivered in phase one of the project, so phase two is improving on those initial designs and ensuring it works in practice.

Working alongside the Smith Institute, the previous model is being shaped into a form that can be used by the Control Room with features such as a review dashboard, and new functionalities are being considered – such as the removal of trips from reserve requirement calculations.

Before it transitions into ‘Business as Usual’, the demonstration tool will run in parallel with the Control Room’s existing reserve power recommendation tools for up to a year to ensure it is accurate. Preliminary results show that using the Dynamic Reserve Setting tool recommends 380MW less reserve per settlement period.

Case Study: Dynamic Reserve Setting

The Dynamic Reserve Setting project will help us more accurately forecast the levels of back-up power needed to maintain grid stability, while reducing operating costs and carbon emissions.

Digital & Data Transformation

Benefits

By more closely matching power reserves to the power requirements of the grid, the Dynamic Reserve Setting project can reduce the ESO's operating costs and deliver value for money for consumers. Reducing our power reserves will help the ESO reach zero carbon targets as we will be less reliant on fossil-fuelled generation to provide headroom, and we can better manage foot room requirements (taking power off the grid) without curtailing renewable energy generation.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO003	Probabilistic Machine Learning Solution for Dynamic Reserve Setting	Complete

Project Partners
Smith Institute

Registered Value	Start TRL	End TRL
£400,000	2	5

Case Study: Course-correction Dispatch Instructor

This project will help automate the rapidly increasing number of real time calculations and balancing actions the Control Room engineers must make to maintain frequency levels and the stability of the electricity system.

Digital & Data Transformation

Project overview

Balancing the electricity network and keeping it running at a steady frequency of 50hz is an increasingly complex task for the Control Room's national dispatch engineers.

In the past, fossil-fuelled generators provided a reasonably steady supply of power and the main challenge for the engineers was fluctuating consumer demand. Now, with more weather-dependent generation on the system and changing consumer behaviours, generation and demand are both increasingly volatile, and engineers must take additional actions in real time to course correct and maintain frequency levels.

Every course correction action has to be calculated and instructed manually and the methodology used is largely based on the engineers' judgement and experience.

To make the whole process more efficient and responsive, the Course Correction project is investigating whether a Control Room tool could be developed to predict movements in frequency ahead of time and to automatically calculate balancing action targets for engineers, which can then be manually reviewed and instructed.

Energy and Innovation System Matter Expert

Name: Colin Webb

About: I joined the electrical industry straight from school as an apprentice and have gained a wealth of experience in the sector, having worked for generators, energy suppliers and now the ESO. In nearly 20 years working for National Grid I have worked across a variety of roles including scheduling, energy strategy and operations as part of the Control Room team. In my current role in the Balancing Transformation team, I am helping to bring forward the tools needed to support Control Room operations in the future.

> *Over the years, I have worked on a number of innovation projects. I find them really exciting as you might find new ways of doing things that transform operations at the ESO. I believe Artificial Intelligence and Machine Learning will be increasingly important to innovation in the future, helping improve our outputs."*

Case Study: Course-correction Dispatch Instructor

This project will help automate the rapidly increasing number of real time calculations and balancing actions the Control Room engineers must make to maintain frequency levels and the stability of the electricity system.

Digital & Data Transformation

Results

Working with Strathclyde University, the starting point for the 12-month project was to use mathematic modelling techniques to analyse existing system data to better understand frequency movement and the course corrections required to stabilise it, such as increasing inertia levels or changes in demand.

Next, the mathematical models created will be used to develop proof of concept for a tool which can calculate course correction actions to be communicated to a dispatch optimiser using real world examples.

If successful, future steps could include looking at how the models can be applied to long- and short-term dispatch and how they could be integrated into the Control Room's multi-instructor platform.

Case Study: Course-correction Dispatch Instructor

This project will help automate the rapidly increasing number of real time calculations and balancing actions the Control Room engineers must make to maintain frequency levels and the stability of the electricity system.

Digital & Data Transformation

Benefits

The increased automation of Control Room tasks will allow the ESO to anticipate and react faster to changes in frequency to maintain grid stability when consumer demand and generation are more unpredictable. While full automation of the Control Room is a long way off, the Course Correction tool is a big step towards new methods of optimisation which will help the ESO keep pace with the challenges of running a net zero electricity system.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO032	Course-correction Dispatch Instructor	In progress

Project Partners
University of Strathclyde

Registered Value	Start TRL	End TRL
£1,700,000 (incl. Phase 2)	2	3

Case Study: Consumer Building Blocks

Understanding how different consumer groups might change the way they use energy in the future can help us plan how the electricity and gas networks may need to evolve to meet the future needs of domestic, commercial and industrial users.

Whole Energy System

Project overview

How consumers will behave in the future is an important - yet unknown - factor in the energy transition and how we meet our net zero emission targets by 2050. We want to understand to a greater extent which consumers will adopt new technologies, such as solar panels, smart controls, electric vehicles, heat pumps and hydrogen boilers, how they will use energy differently in the future or how they might participate in new markets or services designed to support the operation of a zero carbon system.

With a more detailed understanding of the different types of residential, commercial and industrial consumers we have in GB and how they use energy now, we can use models and statistical analysis to help us forecast their future demand. This information can then be used to plan the future development of the electricity and gas networks to better meet consumer needs.

The Consumer Building Blocks project will enable this work by developing a series of standard archetypes for domestic, industrial and commercial users. These archetypes will become a common language available for use by the electricity and gas network operators and our partners, to help us more accurately model consumer energy use scenarios and plan a future-ready energy system.

Regional Strategy & Engagement Manager

Name: James Whiteford

About: I joined National Grid in 2010, starting out my career in gas network development before moving to the ESO in 2015 where I specialised in electricity network planning. My current role is focused on supply modelling to 2050 to support the decarbonisation of the electricity system, and exploring how we can transition towards providing more regional insights and data to enhance the planning process.

> *We can't face the challenges we have as an ESO or FSO without innovation. It's not enough to reinvent the wheel, we need to try things that haven't been done before and accept that sometimes they won't work. Innovation requires persistence, and also collaboration, to succeed."*

Case Study: Consumer Building Blocks

Understanding how different consumer groups might change the way they use energy in the future can help us plan how the electricity and gas networks may need to evolve to meet the future needs of domestic, commercial and industrial users.

Whole Energy System

Consumer Strategy Lead

Name: James Kerr

About: I joined National Grid ESO in 2011 on the graduate development scheme. I spent time working in lots of different departments at first, which gave me a well-rounded view of the organisation, the network and the challenges we face. I spent 2.5 years on secondment with Citizen's Advice learning more about energy policy and the consumer role in the energy transition, and was given the task of building the Consumer Strategy Team on my return.

> *Consumer behaviour is an unknown in the energy transition, and innovation gives us a way to unlock what we don't know. We can take risks, fail quickly and learn from our mistakes. We understand what we need to do to get to net zero, and innovation gives us a vehicle to get there."*

Results

Working in partnership with Centre for Sustainable Energy (CSE), we studied residential consumer behaviour, and created archetype models using smart meter data from the Smart Energy Research Lab.

Alongside Element Energy we used stakeholder engagement to develop our industrial and commercial archetypes. We engaged with consumers and suppliers to investigate how their behaviour might change in the future, the potential benefits of decarbonisation incentives and new commercial offerings, and the impact high energy consumers could make.

Once tested, the final archetypes will be published and utilised in the ESO's Future Energy Scenarios (FES) work to provide consumer insights for the network planning process.

Case Study: Consumer Building Blocks

Understanding how different consumer groups might change the way they use energy in the future can help us plan how the electricity and gas networks may need to evolve to meet the future needs of domestic, commercial and industrial users.

Whole Energy System

Benefits

Understanding the consumer factor is an essential part of decarbonising the electricity network and achieving zero carbon operation by 2025. The archetypes this project develops will give the ESO, and its whole energy system partners, a common approach to modelling consumer behaviours, which will deliver value for money through a more consistent and informed approach to network planning now and in the future.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO026	Consumer Building Blocks	In progress

Project Partners
Centre for Sustainable Energy, Element Energy

Registered Value	Start TRL	End TRL
£300,000	3	5

Case Study: Service Provider Capability Mapping

This project will tell us more about GB's current and future low carbon and decentralised technology providers and provide insights into how we can improve and redesign our markets to encourage them to participate in flexibility services in the future.

Future Markets

Project overview

The electricity system is changing rapidly, as we move away from fossil-fuelled generation to new renewable and low carbon technologies, such as solar and wind farms, battery storage and hydrogen.

These new technologies could potentially offer balancing and operability services but recent market engagement suggests we don't know enough about them to fully understand how we could work together and what barriers are presented by our current market structures. For example, we don't yet know the extent to which they could provide active or reactive power, how quickly they can deliver those services and for how long, and what type of business models they are using.

The Service Provider Capability Mapping project seeks to enhance our understanding of the technical capabilities and commercial decision-making (both investment and operational) of existing and future flexibility providers. This information will help enable us to identify market reforms and unlock the potential of future flex providers, enabling them to maximise their value and contribution to the whole electricity system.

Markets Development Lead

Name: Thomas Pownall

About: I joined the ESO a year ago after completing a PhD in Electrical Market Design. I am part of the electricity market development team, which takes a strategic view of the markets, where they are going and how they can align to deliver maximum value for customers.

> *It's an exciting time to be working within this sector during the energy transition. New technologies are coming to the fore but while they are part of the solution, they also bring their own set of challenges. We need a new mindset to solve these problems and through innovation projects like this one we can do that, bringing together knowledge from academia and commercial companies with our own expertise."*

Case Study: Service Provider Capability Mapping

This project will tell us more about GB's current and future low carbon and decentralised technology providers and provide insights into how we can improve and redesign our markets to encourage them to participate in flexibility services in the future.

Future Markets

Results

Working in partnership with LCPDelta, we used qualitative and quantitative methodologies to explore and understand the needs of our low carbon and decentralised technology customers.

This included an academic study of current and future technology and its potential to provide flexibility services and stakeholder analysis to understand the commercial aspects of these technologies, such as their investment cases and why they participate in some markets over others.

We studied the lifecycle of assets from development to build/operation to settlement, to understand what pain points exist, particularly with regards to interactions with the ESO and wholesale energy markets.

We mapped what we'd learned against existing ESO markets to see how we could optimise our markets to enable greater participation in the future. We look forward to disseminating our findings in due course.

Case Study: Service Provider Capability Mapping

This project will tell us more about GB's current and future low carbon and decentralised technology providers and provide insights into how we can improve and redesign our markets to encourage them to participate in flexibility services in the future.

Future Markets

Benefits

The findings of this project will give us insights to make it easier for emerging low carbon service providers to join flexibility markets in the future. By enabling participation in future markets, we can encourage greater investment in clean technologies and distributed energy resources to further facilitate the energy transition and increase competition which will lower costs for consumers.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO031	Service Provider Capability Mapping	Complete

Project Partners
LCP

Registered Value	Start TRL	End TRL
£250,000	2	3

Case Study: REVEAL

REVEAL is delivering the new tools and processes needed to make it easier and faster for the ESO and its stakeholders to trial new capabilities, and to integrate them into 'Business as Usual'.

Future Markets

Project overview

The energy industry is evolving rapidly to meet national and international carbon emission reduction targets. New developments in technology, services and markets are being devised all the time to help us decarbonise the GB network to meet those targets, but before we can use them, we need to ensure they can be safely integrated without causing any adverse impacts to grid stability.

At the moment, the speed with which we can test new capabilities and launch them onto the live network is not as quick as we, or our partners, need it to be to match the pace of change required to meet net zero targets.

The REVEAL project is looking at how we can accelerate the trial phase, while still offering the Control Room assurances and certainty about the performance of new products and services. The project has created pilot designs for new tools to improve our trialling capabilities and assess their feasibility, while engaging with market participants and industry stakeholders to ensure the 'sandbox' test environments and streamlined processes match their needs.

Innovation Business Partner (Strategy & Regulation)

Name: Caroline Rose-Newport

About: I have been working in the Innovation team for National Grid for two years and bring to my role a vast knowledge of product and business development which I gained working in the consumer finance sector. I also have a wealth of experience in stakeholder engagement thanks to my time spent managing the Government's GREAT inward investment campaign across the central Europe region. As an Innovation Business Partner for ESO, my focus is on understanding the business's key challenges and working with stakeholders to develop innovation funded projects to resolve these challenges.

> *The best thing about my job is that every day is different. Everything we do through innovation projects hasn't been done before – it's fascinating to be part of it and to be able to really help other teams within ESO and external stakeholders to find solutions to their challenges."*

Case Study: REVEAL

REVEAL is delivering the new tools and processes needed to make it easier and faster for the ESO and its stakeholders to trial new capabilities, and to integrate them into ‘Business as Usual’.

Future Markets

Results

Working with Capgemini, we identified a small number of prospective trial and collaboration tools to develop and assess. These include a live test environment which is ringfenced from the rest of the grid to offer ‘real world’ trial conditions to external stakeholders.

Engagement has been a key part of REVEAL to establish what internal and external partners need from the trial process. To date, we have carried out workshops with teams across the ESO and interviews with all the DNOs, a transmission operator, multiple market participants and technology providers as well as engaging with Ofgem to understand the current derogation process and how we could make it more efficient.

Through our engagement work, we have also identified 42 business use cases, of which 15 have been taken forward to the design phase.

Our findings will be published in the summer, and these will be used to make the business case for developing a proof of concept.

Case Study: REVEAL

REVEAL is delivering the new tools and processes needed to make it easier and faster for the ESO and its stakeholders to trial new capabilities, and to integrate them into ‘Business as Usual’.

Future Markets

Benefits

Accelerating the rate with which new technologies and ways of operating the network more efficiently become ‘business as usual’ will help the ESO achieve its net zero targets, and wider ambitions, sooner, and improve grid stability and resilience in the future as we operate with more renewable energy generators on the network. The collaborative pilot platforms identified by REVEAL could open the trial process to more participants which will increase innovation, competition and ultimately reduce costs for the consumer.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO024	REVEAL	In progress

Project Partners
Capgemini

Registered Value	Start TRL	End TRL
£400,000	1	3

Case Study: Stability Market Design

Establishing a fit-for-purpose stability market is essential to ensure the ESO is able to procure long and short-term stability services from existing and new providers as the electricity network transitions to zero carbon operation.

Future Markets

Project overview

Synchronous generators – such as gas and coal fired power stations – have traditionally provided a range of services, such as inertia and Short Circuit Level, which help us to manage the stability of the electricity network. But while they are responsive and reliable, they can also be an expensive and sometimes carbon-intensive way to balance the grid.

As we move towards operating the system with less fossil-fuelled generators and more renewables on the transmission network, we need to ensure the tools to source the balancing services we require from different providers are sufficient.

The Stability Market project is exploring how short, mid and long-term markets for stability will work in practice. A similar project is also looking at voltage (reactive power). These projects are exploring who might be eligible to participate and the best way to design the markets to encourage competition and future investment.

Senior Market Development Lead

Name: Ed Farley

About: I joined the ESO two years ago after completing a graduate programme with one of the UK's 'big 6' energy suppliers. While on the graduate scheme I gained experience in flexibility services and participating in markets on behalf of large I&C consumers. This has been invaluable in my current role working on new market designs for the ESO, with a focus on medium to long term markets and ancillary services. I have previously worked on an innovation project exploring the use of offshore wind for stability, but Stability Markets is the first project where I have been the designated lead.

> *The stability challenge is not widely known or understood in the industry, but we need stability to become a mainstream service if we are to operate a zero carbon network. Innovation - in the form of novel technologies, new services and markets – is crucial if we are to deliver something tangible to resolve our stability issues in the future."*

Case Study: Stability Market Design

Establishing a fit-for-purpose stability market is essential to ensure the ESO is able to procure long and short-term stability services from existing and new providers as the electricity network transitions to zero carbon operation.

Results

Working with consultants, AFRY, we split the project into three work packages. Firstly, we looked at eligibility, analysing what types of generators and technologies could potentially participate in stability markets, the role of the Transmission Operator (TO) and how we could introduce fair competition rules to encourage participation.

Next was a granular study of contracts. We will need a mix of contracts to manage stability services in the future including long-term (10-15 year pathfinder-style contracts), mid-term (one year) and short-term (four hour blocks throughout the day).

The last work package addresses questions around procurement strategy such as how to pay for stability service provision (availability and service provision) and whether providers would be able to stack their services, by participating in multiple energy and balancing markets.

Later this year, we will use our findings to launch the first live market for stability, starting with mid-term contract procurement.

Case Study: Stability Market Design

Establishing a fit-for-purpose stability market is essential to ensure the ESO is able to procure long and short-term stability services from existing and new providers as the electricity network transitions to zero carbon operation.

Future Markets

Benefits

The Stability Market project will help the ESO use more renewable and alternative technologies to provide stability services, which aims to reduce the cost of operating the system and accelerate the transition to a net zero system. The establishment of long-term markets will send signals to the market to encourage future investment in new solutions, including grid-forming capability for otherwise non-synchronous technologies (e.g., wind, solar and battery storage), which will further aid the energy transition.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO005	Stability Market Design	In progress

Project Partners
AFRY

Registered Value	Start TRL	End TRL
£300,000	2	4

Case Study: Future of Transmission Network Charging

This project was created as part of the ESO's role in an industry-wide taskforce set up to address how to make Transmission Network Use of System (TNUoS) charges more predictable, cost reflective and fairer for all.

Future Markets

Project overview

It costs around £4.4 billion a year to build, maintain and upgrade/expand the transmission network. The cost of this is recouped by Transmission Network Use of System (TNUoS) charges which are levied on generators (circa £944m) and demand users (circa £3.47bn) and fed through to consumer bills.

The methodology used to calculate who pays what TNUoS charges was last reviewed some 10 years ago and may no longer reflect the reality of the transmission network or the complexities of today's energy system. As a result, charges for users can fluctuate significantly year-on-year, which increases uncertainty and discourages investment.

In 2021, Ofgem issued a Call for Evidence to ask for industry views in respect of electricity transmission charges. The general feedback indicated a review would be beneficial, so an industry taskforce was created by the ESO, bringing together a range of expertise, and varying depths of knowledge, that represented a broad range of business models and network users including TNUoS experts, consumer advice groups, high energy users, Distribution Network Operators, Transmission Owners, generators and supply businesses.

As part of our role within the taskforce, we established the Future of Transmission Network Charging research project to investigate options for change to the methodologies to calculate TNUoS charges, with the aim of improving predictability and cost reflectivity of charges and addressing the wider concerns of the industry.

Transmission Charging Strategy Manager

Name: James Stone

About: I have been working in the energy industry for 23 years, having started my career at an energy supplier. While there I spent several years in the operations side of the business, gaining a broad understanding across the domestic and commercial sectors including the forecasting of non-energy costs, pricing as well as the roll out of EV infrastructure. I have been at the ESO for three years, working in the Commercial Codes team looking at the industry codes which are the contracts which underpin the operational and commercial relationships in the GB energy industry. Charging methodologies is currently my main focus, and my work also incorporates wider industry reforms specifically looking at the required changes to the methodologies to facilitate the connection of future offshore wind projects.

> *"We are bringing together various industry parties including conventional and renewables generators as well as considering new technologies such as energy storage in a way that's not been done before to aid investment decisions and make costs fairer and truly reflective of the GB energy landscape now and in the future."*

Case Study: Future of Transmission Network Charging

This project was created as part of the ESO's role in an industry-wide taskforce set up to address how to make Transmission Network Use of System (TNUoS) charges more predictable, cost reflective and fairer for all.

Future Markets

Results

Initially, there were more than 50 potential areas for review or specific defects within the current TNUoS charging methodology that the taskforce collated, which were collectively grouped and prioritised. Some of the big-ticket items were shared with our partners Frontier and LCP Economics for progression. They used conceptual analysis to develop an understanding of the suitability of the current regime in the context of the current and future energy system and then explored improvements to the methodology and whether the underlying principles could be changed and then provided impact analysis of the various options for change.

Some of the priority considerations researched included whether any data inputs into the calculations caused volatility, measures to improve predictability and assessment of the impact of possible alternative approaches to the reference node (the cost split between generators and demand). Our initial quantitative analysis was presented to the taskforce for discussion.

Using taskforce feedback, we will be identifying any gaps in this analysis and considering further options for changes to the charging methodology. If the taskforce can collectively agree, these changes will then be raised as modification proposals through the 'Business as Usual' industry governance route. We will also be investigating other aspects of the TNUoS methodology such as demand charging i.e., considering the impact of changing consumer behaviours in the future and the principles of demand charging and its design.

Case Study: Future of Transmission Network Charging

This project was created as part of the ESO's role in an industry-wide taskforce set up to address how to make Transmission Network Use of System (TNUoS) charges more predictable, cost reflective and fairer for all.

Future Markets

Benefits

This project will deliver a fit-for-purpose TNUoS charging structure which gives existing users, clean energy generators and new technology owners predictability and cost reflective charges that will give them confidence to invest in the GB electricity system, helping us meet our net zero targets. A revised charging structure will encourage more connections in the right place for optimum grid operability, helping us to lower balancing and constraint costs, therefore lowering bills for consumers.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO039	Future of the Transmission Network Charging Methodology	Complete

Project Partners
Frontier Economics

Registered Value	Start TRL	End TRL
£500,000	2	3

Case Study: Inertia Measurement Method Optimisation

Establishing a standard way of measuring inertia for the whole energy industry will help us more accurately measure how much inertia is available on the GB electricity system, where it is located and how much more we need to respond to frequency changes as we transition to a zero carbon future.

System Stability and Resilience

Project overview

Inertia is required to keep the electricity grid stable, as it helps balance frequency levels. Traditionally, inertia was provided by synchronous generators (such as coal and gas power stations) but as these are being taken offline to make way for more renewable forms of energy generation, our inertia levels are decreasing.

As an industry, we don't currently have a standard way to measure inertia, making it more challenging for the Control Room and our operational teams to understand how much inertia is still available for frequency balancing and reactive power. Traditional methods estimate inertia based on the volume of synchronous generation running and the level of demand. We also have limited visibility of where inertia is located on the GB network, as it can vary regionally.

We have invested in two "first-of-their-kind" commercial tools to help us better calculate our inertia needs but before they can be implemented, we need to calibrate them and understand how accurate they are against our current estimates.

This two-year project will establish a standard measurement of inertia to test our commercial systems before they are introduced to the Control Room and to map inertia levels across the GB network which together will help us run the grid more efficiently now and in the future. The inertia measurement standard will be shared with our partners and stakeholders to improve and simplify operations across the industry.

Product Manager (Inertia & Frequency)

Name: Anna Blackwell

About: I have worked in a variety of roles and capacities for National Grid over the past 20 years, including working as a contracted researcher, within the transmission team and latterly with the ESO within the Network Access Planning department.

In my current role as product manager, I oversee the introduction of new tools into the Control Room, ensuring they are fit for purpose, they work well with existing tools and systems and that teams are trained to use them correctly. I've been involved with a number of innovation projects in the past, and am working on two at the moment including the inertia measurement project, with a couple more in development.

> *Working together is key to innovation. The energy industry is moving and evolving so fast that we don't want off the shelf products anymore – we need solutions which are flexible to our changing needs. By working in partnership with our stakeholders, suppliers and customers, we innovate together and deliver new tools, solutions and technologies faster."*

Case Study: Inertia Measurement Method Optimisation

Establishing a standard way of measuring inertia for the whole energy industry will help us more accurately measure how much inertia is available on the GB electricity system, where it is located and how much more we need to respond to frequency changes as we transition to a zero carbon future.

System Stability and Resilience

Results

Working in partnership with National Physical Laboratory (NPL), we are comparing data from our new inertia measuring tools with different generation types. We found a good correlation and a high level of accuracy between the data sets, as well as a few areas requiring further investigation.

Regional differences in inertia are being modelled, looking at how these might be affected by local changes in frequency, the rate of change of frequency (RoCoF) for the GB network and sudden loss of power events.

Next, NPL will be developing a framework for the standard measurement of inertia and engaging with industry partners for feedback before developing the final technical specification for inertia measurement instruments.

Case Study: Inertia Measurement Method Optimisation

Establishing a standard way of measuring inertia for the whole energy industry will help us more accurately measure how much inertia is available on the GB electricity system, where it is located and how much more we need to respond to frequency changes as we transition to a zero carbon future.

System Stability and Resilience

Benefits

Being able to accurately measure inertia will improve the ESO's situational awareness and reduce the risk to stability of the GB network operating with less synchronous generators. Measuring and managing inertia levels is critical to the ESO reaching its zero carbon ambitions by 2025. The findings of this project will also assist with the establishment of a future stability market which will lower our operational costs, encourage smaller players and new technologies to participate in delivering grid balancing services and help address regional variances in inertia levels.

Further innovation work is being done in this area with the Stability Market Design project (NIA1_NGESO005) which is considering current stability arrangements and investigating the best option for an end-to-end stability market.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO023	Inertia Measurement Method Optimisation	In progress

Project Partners
National Physical Laboratory (NPL)
SP Energy Networks (SPEN)

Registered Value	Start TRL	End TRL
£371,000	2	5

Case Study: FIC (Future of Interconnectors)

This project looks at the opportunities and challenges that an increase in interconnectors presents to the ESO as we move towards a net zero electricity system.

System Stability and Resilience

Project overview

The GB network is linked to networks in several other countries including France, Norway, Netherlands, Belgium and Ireland via interconnectors which allow electricity to be traded and shared. These interconnectors have a total capacity of 8.4GW and more are being built, potentially adding 16GW more capacity by 2035.

Interconnectors could have an important role to play in the import and export of electricity to help us manage the peaks and troughs in our renewable energy generation now and in the future, but we don't yet have the necessary insight into the technical and commercial issues that more interconnectors on the network might cause.

The 12-month Future of Interconnectors project will analyse the current impact of interconnectors on the GB electricity system and explore the possible opportunities and challenges of adding more interconnectors in the future in terms of adequacy (security of supply), flexibility (balancing) and operability (ancillary services).

Senior Development Lead

Name: Magdalena Morenes

About: I joined National Grid ESO in September 2021, after gaining a wealth of energy industry experience at National Grid Gas, as a procurement buyer. Future of Interconnectors was my first project in my role at ESO and it touches on many aspects of the energy system, from GB to the wider EU energy market.

> *Interconnectors is such a wide topic and there are lots of unknowns. Through this project, we have had the freedom to learn and to discover more about them and their potential future role. Innovation gives us the opportunity to try different things, never knowing what we will find or what new questions we will seek to answer."*

Case Study: FIC (Future of Interconnectors)

This project looks at the opportunities and challenges that an increase in interconnectors presents to the ESO as we move towards a net zero electricity system.

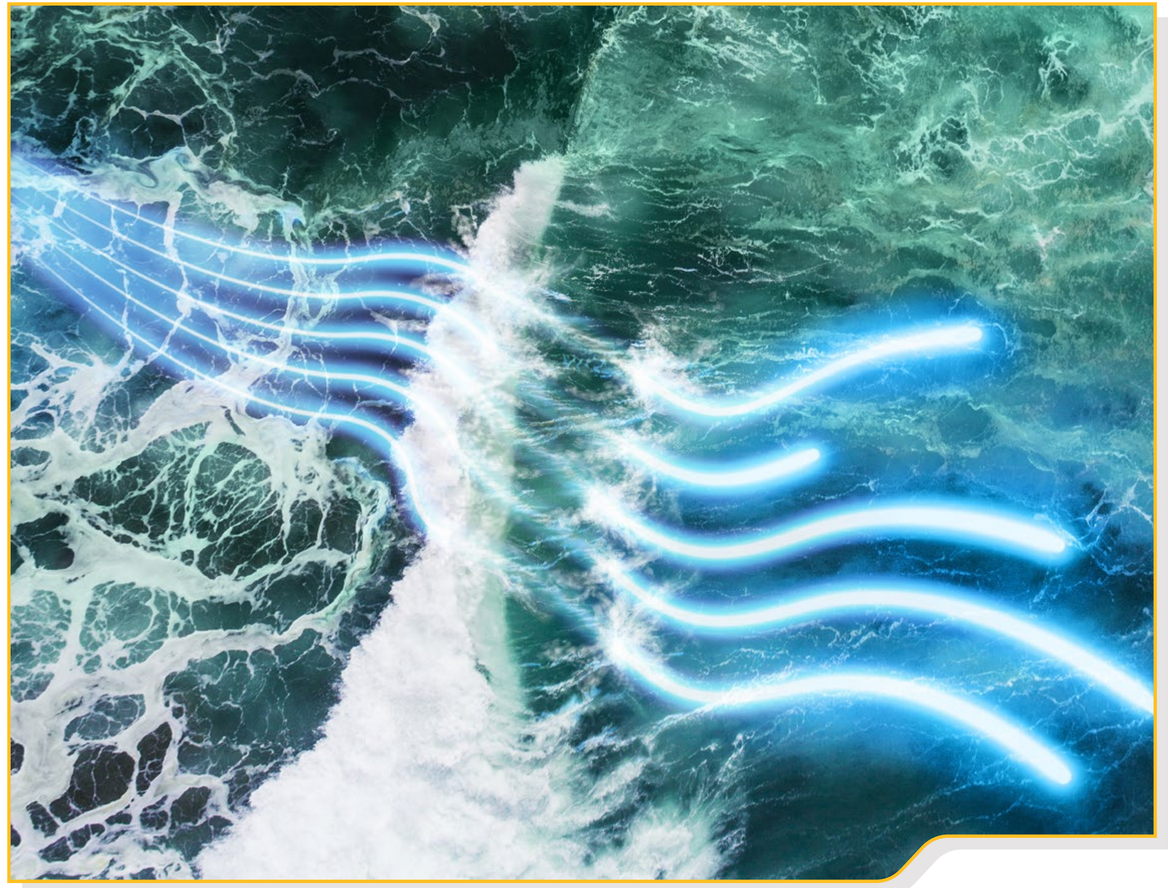
System Stability and Resilience

Results

Working alongside consultants from AFRY, we started with an investigation into the status quo, looking at interconnectors on the system now, current market arrangements, the wider European energy landscape and how Brexit has impacted electricity trading. We then carried out future modelling, using the four FES scenarios as the baseline, to analyse how the role of interconnectors might change in 2025, 2030 and 2035.

Our modelling data was used for a deep dive into how the different interconnector future scenarios might impact adequacy, operability and flexibility, using qualitative and quantitative analysis to investigate the risks, opportunities, blockers and enablers. We also explored the impact of potential sensitivities such as zonal pricing and multipurpose interconnectors.

Using our analysis, we are now putting together a list of options and actions which could be used to more effectively manage the grid with more interconnectors in the future.



Case Study: FIC (Future of Interconnectors)

This project looks at the opportunities and challenges that an increase in interconnectors presents to the ESO as we move towards a net zero electricity system.

System Stability and Resilience

Benefits

This project is improving the ESO's knowledge and understanding of interconnectors and how they can be used in future network and service planning to establish a more stable network as we move to zero carbon operation. Interconnectors have the potential to facilitate the energy transition by allowing us to move surplus renewable electricity from where it is produced to where it is needed most. For example when weather conditions mean that supplies from UK wind farms and solar are lower, we can draw on carbon-free sources of electricity through the interconnectors. On windy or very sunny days in Britain, excess renewable energy can be sent via an interconnector to neighbouring countries. By connecting Great Britain to broader and more diverse sources of energy, interconnectors can help overcome operability issues, which will lower costs to consumers.

Project information

NIA Reference	Project Name	Status
NIA2_NGESO015	FIC (Future of Interconnectors)	In progress

Project Partners
AFRY

Registered Value	Start TRL	End TRL
£400,000	2	3

Delivering Value through Collaboration

From project webinars to industry conferences and events, in 2022/23 we aspired to reach a wider audience to share our learnings and challenges. We held a number of events including the VirtualES Conference, our Open Innovation Event and a series of webinars both internal and external. Members of the Innovation Team also presented at 17 external events and conferences, including:

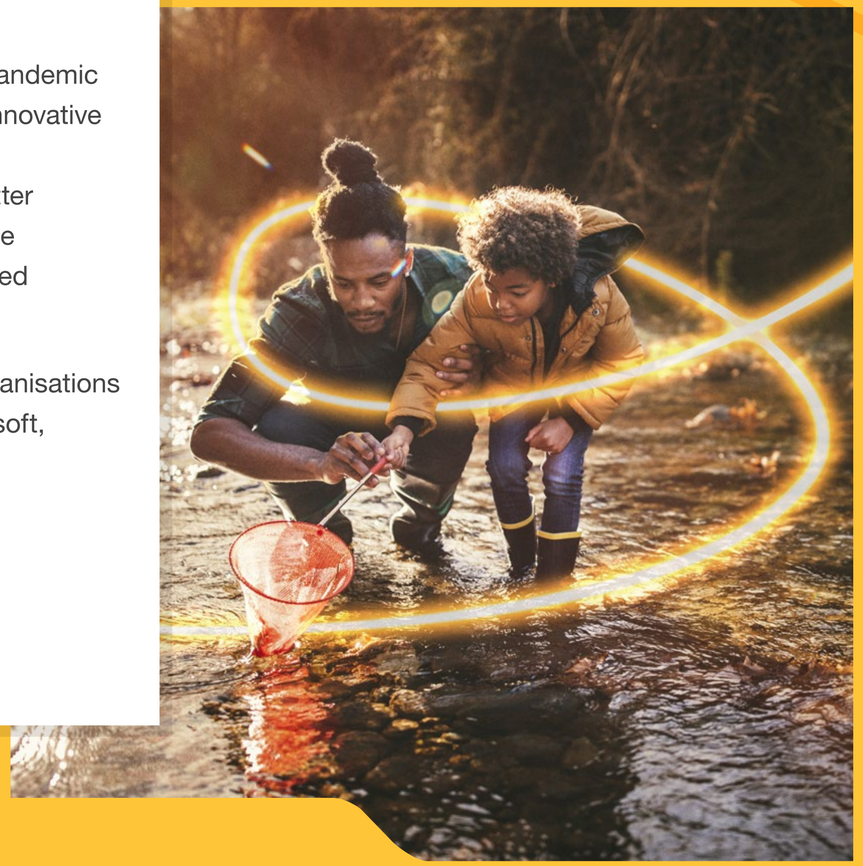
- **Utility Week Live**
- **Parliament Festival of Energy Digitalisation**
- **CIGRE Conference**
- **Financial Times Energy Transition Summit**
- **Future of Utilities Summit**
- **Ernst & Young Digitalisation of Energy event**

Open Innovation Event 2022

Our first in-person Open Innovation Event since the pandemic was held in July 2022. Starting with an open call for innovative new proposals, to help address industry challenges, we selected 5 finalists to join us and ESO subject matter experts at a collaborative 2-day event to develop these proposals further. On the second day the teams pitched their proposals to an industry panel of judges.

Over 60 stakeholders attended the event, from 10 organisations across the industry (including Octopus Energy, Microsoft, Energy Systems Catapult, Citizens Advice and more).

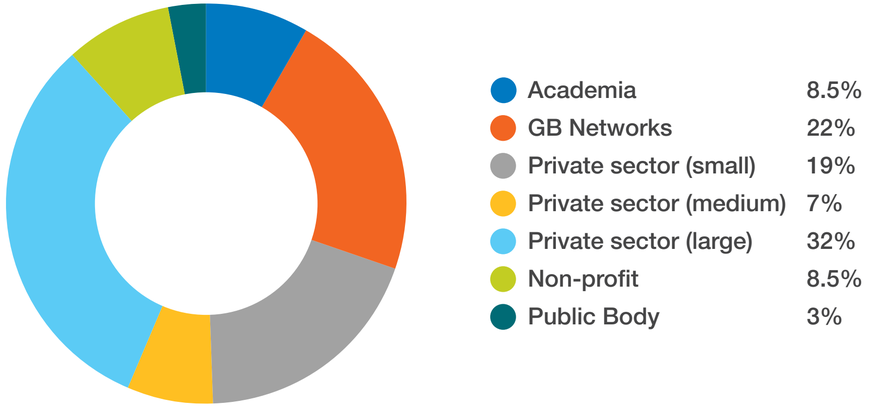
View the Open Innovation Event's highlights video



Delivering Value through Collaboration

Growing our Partner Network

Being open to ideas from a broad and diverse range of partners is crucial to developing the pioneering innovation projects needed to deliver the energy system transition at the lowest cost to consumers. Through our open calls for proposals over the last twelve months, over 80% of ideas were submitted by third parties. We worked with 59 different partners on our NIA & SIF innovation projects from across industry including academia, energy networks, non-profit organisations and a range of small, medium and large companies.



We are continually looking to work with new organisations and innovators; to achieve this we have begun developing ideas for a Technology Partner Network. Our ambition is to create a platform for building relationships and maintaining communications with a wide range of existing and potential technology partners including academics, start-ups, SMEs and incubators. Events held as part of the partner network could help partners to better understand the ESO's innovation needs and create opportunities for the ESO to understand the potential of emerging technologies and solutions.

Innovation in Action: experts from across the ESO gather to hone their Probabilistic Forecasting skills

Our 2-day Probabilistic Forecasting Teach-in brought together over 30 experts from across the ESO in October 2022 to understand how Probabilistic Forecasting could improve forecasting accuracy.

Control REACT, a recently completed innovation project, refined a Probabilistic Forecasting approach and developed a Proof-of-Concept tool for Control Room Engineers to view forecast uncertainty in real-time, enabling more economic and secure balancing decisions to be made.

The Teach-in, led by our project partners, TNEI and the University of Glasgow, provided an opportunity for teams from across the ESO to try it for themselves – spreading the knowledge and results throughout the business to ensure benefits are delivered efficiently and effectively.

Delivering Value through Collaboration

Working with Industry

We were delighted to work with Ofgem, the ENA, Innovate UK and all the GB electricity and gas networks to deliver the first Energy Innovation Basecamp in February 2023. Together we shared some of our most pressing challenges to an audience of ambitious innovators from industry, government, suppliers, generators, aggregators, large energy users and consumer representative groups from across energy, utilities and beyond. We look forward to exploring and developing these ideas with innovators to deliver some trail-blazing projects in the coming months.

Several of our NIA projects also presented at the 2022 Energy Innovation Summit, the UK's flagship dissemination event for the electricity and gas network operators. Previously known as the Energy Networks Innovation Conference (ENIC), 2022's event was rebranded to The Summit as part of a new collaboration with the ENA, BEIS, Innovate UK, Ofgem and Regen, opening the event up to wider industry. Over 1,000 people attended the event in Glasgow, with 60 innovation projects sharing their insights and experiences from across the energy sector.

Virtual Energy System

As we progress towards net zero emissions, we are driving ahead with our initiative to develop an ecosystem of connected digital twins of Great Britain's energy system through the Virtual Energy System (VirtualES) programme.

Our ambitious, industry-wide mission to digitise Britain's energy system could provide the ability to generate insights, and model solutions to cut real-world carbon emissions, accelerating the transition to net zero.

Projects

Having launched the VirtualES in late 2021, the past year saw completion of the project's Discovery phase through the Strategic Innovation Fund. During Discovery we worked to evaluate key factors setting the scope of the Common Framework, testing against real-world scenarios. We are now stress-testing the standards and governance framework that will soon facilitate collaboration and compatibility across the energy industry as we move to turn the VirtualES into a reality.

In 2022 we were awarded funding to progress CrowdFlex, a VirtualES use case project that explores the role of domestic flexibility in grid management, to the Alpha phase of the Strategic Innovation Fund. The Alpha phase focused on gaining a better understanding of the system challenges and potential solutions using domestic assets.

We are also developing innovative use cases for the future digital twin. The Advanced Dispatch Optimiser (ADO), once operational, will rapidly analyse data from the VirtualES, helping grid operators plan for a range of potential system scenarios, and improve dispatch decisions within our transforming energy system.

The more data provided within the Common Framework, the more powerful the VirtualES becomes and the more accurately tools like the ADO will be able to analyse the system.

Visit our website to find out more or contact us.
Join our mailing list to stay updated on the latest VirtualES news and events.

Virtual Energy System

Advisory Groups

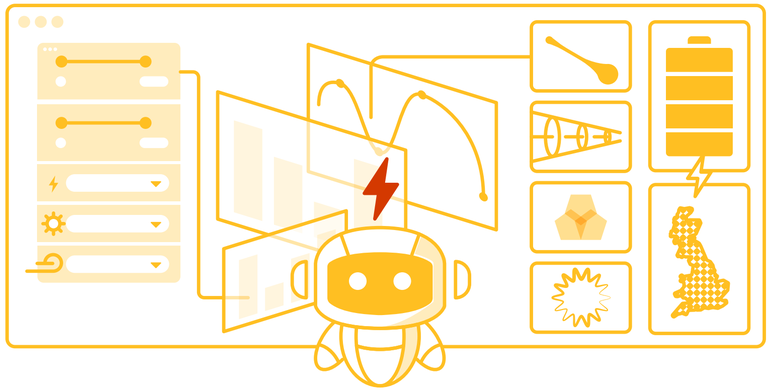
Three industry Advisory Groups have been established to facilitate expert input, support, and overview of the Virtual Energy System programme:

- Data & Technology – connecting physical infrastructure, enhancing modelling & analysis and creating an interoperable technology stack
- People & Process - building capabilities & skills, engaging stakeholders, and creating a governance framework
- Use Cases – Providing expert input and insights, enabling ESO to make informed decisions regarding prioritisation and development of use cases for the VirtualES

Seats are held by senior representatives from industry and academia, with the first advisory group meetings taken place in the first half of 2023.

Next Steps

We are excited to be announcing the next major step for the VirtualES project this summer, when we will sharing the principles for the Common Framework to industry. The principles will enable industry players, with support from the project advisory groups, to prepare to share data through the VirtualES and build out longer-term roadmaps of use cases.



Projects Live In 2022/23

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO001	CrowdFlex	Complete	Ohme, Octopus Energy, Scottish & Southern Electricity Networks
NIA2_NGESO002	Solar PV Nowcasting	In progress	Open Climate Fix
NIA2_NGESO003	Probabilistic Machine Learning Solution for Dynamic Reserve Setting	In progress	The Smith Institute
NIA2_NGESO005	Stability Market Design	In progress	Afry
NIA2_NGESO006	Resilient Electric Vehicle charging (REV)	Complete	Sygensys
NIA2_NGESO008	Reactive Power Market Design	In progress	Afry
NIA2_NGESO009	Data-Driven Power System Model Development for Control Interaction Studies (D3)	In progress	The University Of Birmingham
NIA2_NGESO010	The Role for Hydrogen as an Electricity System Asset	Complete	Delta-EE
NIA2_NGESO0011	Optimal Outage Planning System	In progress	The University of Edinburgh
NIA2_NGESO012	COMMANDER - Efficient ESO-DSO Coordination to Access DERs via National-Local Markets	In progress	WSP, National Grid Electricity Distribution
NIA2_NGESO013	Advanced Dispatch Optimisation	Complete	Google X
NIA2_NGESO014	A Common Framework for a Virtual Energy System	Complete	Ove Arup And Partners
NIA2_NGESO015	FIC (Future of Interconnectors)	In progress	Afry
NIA2_NGESO018	Automated Identification of Sub-Synchronous Oscillations (SSO) Events	In progress	Tnei Services
NIA2_NGESO019	Peak Demand Forecasting	Complete	Aurora Energy Research

Projects Live In 2022/23

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO020	Strength to Connect	In progress	Imperial College
NIA2_NGESO021	AI Centre of Excellence	In progress	Capgemini
NIA2_NGESO022	Balancing Costs Forecast (BC Forecasting)	In progress	UKRI (Hartree Centre)
NIA2_NGESO023	Inertia Measurement Method Optimisation	In progress	National Physical Laboratory (NPL)
NIA2_NGESO024	REVEAL	In progress	Capgemini
NIA2_NGESO025	3MD (Market Monitoring Model Development)	Complete	UKRI (Hartree Centre)
NIA2_NGESO026	Consumer Building Blocks	In progress	Element Energy Limited, Centre For Sustainable Energy
NIA2_NGESO027	Carbon Intensity Modelling	In progress	UKRI (Hartree Centre)
NIA2_NGESO028	Virtual Energy System: Common Framework Demonstrator (NIA)	In progress	Ove Arup And Partners, National Gas Transmission
NIA2_NGESO029	DER Visibility and Probabilistic Modelling	In progress	UKRI (Hartree Centre)
NIA2_NGESO030	Enduring Cross Border Balancing	Complete	Compass Lexecon
NIA2_NGESO031	Service Provider Capability Mapping	In progress	Lane Clark & Peacock (LCP)
NIA2_NGESO032	Course-correction Dispatch Instructor	In progress	The University of Edinburgh, University Of Strathclyde
NIA2_NGESO033	Co-optimisation of Energy and Frequency-containment Services	In progress	Imperial College

Projects Live In 2022/23

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO036	Hydrogen Production for Thermal Electricity Constraints Management	In progress	Ove Arup And Partners, National Gas Transmission
NIA2_NGESO038	Whole Energy System Network Planning Review	In progress	DNV
NIA2_NGESO039	Future of the Transmission Network Charging Methodology	In progress	Frontier Economics
NIA2_NGESO040	DETECTS II	In progress	
NIA2_NGESO042	Revamp Interconnector Ramping Arrangements	In progress	Baringa
NIA2_NGESO046	STARTZ (Stability Requirements Calculation Towards Net Zero)	In progress	Tnei Services
NIA2_NGESO047	Distributed ReStart - Redhouse Live Trial	In progress	Tnei Services, SP Energy Networks
NIA2_NGET0002	Role and value of electrolysers in low-carbon GB energy system	Complete	National Grid Electricity Transmission, National Gas Transmission
NIA2_NGET0017	System value from V2G peak reduction	In progress	National Grid Electricity Transmission
NIA_NGGT0184	Gas and Electricity Transmission Infrastructure Outlook	Complete	Guidehouse Europe, National Gas Transmission
NIA_SHET_0035	TOTEM 2	In progress	Scottish Hydro Electric Transmission, SP Transmission, National Grid Electricity Transmission
NIA_WPD_071	ANM Balancing Services co-ordination demonstration (ABCD)	In progress	WSP, Smarter Grid Solutions (SGS), National Grid Electricity Distribution

Meet the Team

We're always on the look-out for new project ideas and collaboration opportunities. Whether you are interested to find out more about our innovation process and portfolio or one of our flagship programmes, there is a team in ESO Innovation who can help.

Anna Carolina Tortora,
Head of Digital Transformation and Innovation Strategy

I have the coolest job in the world. My job is to learn new things, imagine possible scenarios, and then finance solutions.

"Climate change is the challenge of the age and being a part of the solution truly drives me. I have a toddler son and like all parents I must live with the responsibility of knowing the kind of planet my generation is going to leave behind and the fact that he won't be able to experience it as I did. Unlike other parents however I can do something big about it. Every action I take, every meeting, every email, every hour spent reviewing a paper allows me to give a piece of myself to my son's future."

Innovation Delivery

Our purpose it to build a robust pipeline of innovation projects to deliver the energy transition. We engage with ESO subject matter experts and external partners to support and deliver these projects.

Geoff Down
Innovation Manager

Charlotte Horne
Innovation Business Partner – National Control

Caroline Rose-Newport
Innovation Business Partner – Markets

Alex Hurley
Innovation Business Partner – Networks

Alison Dineley
Senior Innovation Analyst

Samantha Williams
Project Manager

Meet the Team

Strategy & Stakeholder

Our purpose is to support innovation across the business, through close engagement and communication to ensure stakeholders are aware of the Innovation team's activities and how they can get involved. We also lead on developing the Innovation Strategy to help innovation funding to be focused on the right priorities each year to deliver the energy transition.

Joshua Visser
Innovation Manager

Isla Martin-Abel
Stakeholder Engagement Lead

Abigail Mills
Innovation Analyst

Arwen Seymour
Team Assistant

Technology Insights

Our purpose is to drive open innovation with technology experts and innovators. We aim to achieve this through raising our colleagues' awareness of relevant technology developments, facilitating networking and ideating with external organisations, and centralising the knowledge created by the ESO's various strands of technology research.

Alexi Reynolds
Technology Insights Manager

Vikaran Khanna
Technology Insights Lead

Strategic Innovation Fund (SIF)

Our purpose is to seek large-scale project opportunities for application to the Strategic Innovation Fund (SIF). We ensure projects support network innovation to contribute to the achievement of net zero, while delivering net benefits to energy consumers.

Claudia Centazzo
SIF Innovation Manager

Lauren Cooper
SIF Business Partner

AI Centre of Excellence

Our purpose is to unify and grow a collective AI workforce in the energy industry; creating a collaborative space where people can use their skills to help decarbonise the whole energy system and discover, learn and contribute positively towards improving society and saving our planet.

Lyndon Ruff
AI Centre of Excellence Manager

Darya Nizhnikova
Customer and Technology Innovation Business Partner

Rend Nawari
Customer and Technology Innovation Business Partner

Meet the Team

Virtual Energy System

The Virtual Energy System is an ambitious, industry-wide mission to digitise Britain's energy system. Our dedicated Stakeholder, Common Framework and Use Case teams are progressing the three workstreams of the programme.

Stakeholder Engagement

James Edward-Tombs
Stakeholder Engagement Manager

Anca Marinescu
Stakeholder Engagement Lead

Divya Mahalingam
Stakeholder Engagement Lead – Common Framework

Jo Webb
Stakeholder Engagement Lead – Use Cases

Common Framework

Jonathan Barcroft
Workstream Manager

Sooraj Soman
Process Manager

Siva Kaviya
Common Framework Specialist

Use Cases

Dozie Nnabuife
Use Cases Manager

Mark Sunderland
Use Cases Project Lead

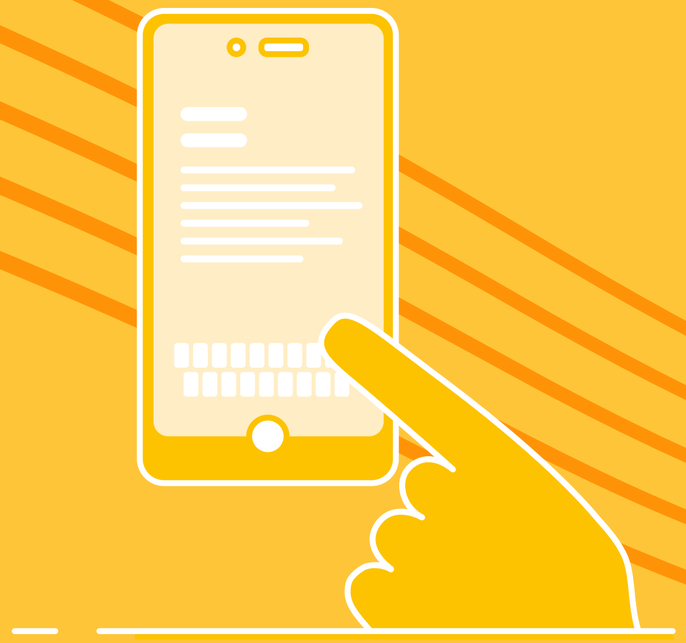
Shaun Clohessy
Business Change Project Manager

Get in Touch

Visit our website or contact us to learn more about the new ESO innovation process, our priorities, and the NIA and SIF funding available.

Contact the team: Innovation@nationalgrideso.com

Visit our website: nationalgrideso.com/future-energy/innovation



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