Innovation Annual Summary

2023/24

ESO

Navigation

This version of the Innovation Annual Summary document has been optimised for printing out or viewing on a tablet.

Page navigation explained

Back a page

Forward a page

Return to contents

From here you can navigate to any part of the publication

Text Links

Click highlighted orange text to navigate to an external link.

Contents

Foreword

As the Electricity System Operator (ESO) for Great Britain, we are at the heart of the nation's energy system. We are responsible for operating the electricity network safely and efficiently, balancing electricity supply and demand second by second.

Later this year we will become the National Energy System Operator (NESO), an independent public organisation. We will be taking on new planning and advisory roles across the whole energy system, ensuring it remains secure, affordable and sustainable. As we move towards achieving net zero, innovation will play a critical role in exploring new technologies and solutions to meet the challenges of this transition and help shape the energy system of the future.

Shubhi Rajnish
Chief Information Officer,
Electricity System Operator (ESO)

During 2023/24 our innovation activities underwent significant changes. As we progress through our RIIO-2 funding period, our portfolio of projects has become more mature, with a greater emphasis on development and demonstration. With this maturity, we've started to adopt more innovative project outputs into our daily operations, including new methods of assessing system strength, the use of consumer archetypes in our Future Energy Scenarios and the development of short-term stability markets. This year we've added a section exploring 'What Happened Next?', showcasing former and mature innovation projects, such as those mentioned above, that have gone on to shape our operations and the wider industry, while creating better value for consumers.

One of our key demonstration projects is CrowdFlex, which has successfully progressed to the full-scale demonstrator phase of Ofgem's Strategic Innovation Fund (SIF). The project secured a further £21m of funding to continue exploring how domestic flexibility can be used in grid operations as we decarbonise the energy system. In this past year, we've also secured four more projects for SIF feasibility funding and successfully transitioned two of these into the proof-of-concept phase. In addition, we successfully operated 54 live projects through the Network Innovation Allowance (NIA) fund, a significant increase of 29 projects compared to two years ago.

Foreword

To support this expanding portfolio of activities, we have continued to enhance our capabilities and have expanded our team to ensure we have the necessary skills and expertise to maximise opportunities for collaboration. We worked with 74 different project partners over the year, including universities, small-medium enterprises, networks and government bodies, allowing us to expand and share our expertise across the wider energy industry. As part of our growing capabilities, we've created a dedicated Innovation Strategy and Insights team to focus our efforts in the most effective areas to achieve net zero. As part of these efforts, we have refreshed our Innovation Strategy for 2024/25, outlining our priorities for the year ahead and how through these we will continue to deliver benefits for our organisation, wider energy system and consumers.

One of our key innovation priorities is Digital, AI and Data. As our energy system continues to transition to net zero and becomes more complex, we must be able to make faster and better-informed decisions. As NESO we will become a Digital Leader, leveraging the power of Artificial Intelligence and Machine Learning (ML) to drive the transformation to a fully integrated and secure whole energy system. We've already started to trial ML in the control room through our Dynamic Reserve Setting project to provide better forecasting for balancing activities. During its first trial, it saved us from buying 1GW of unnecessary excess reserve within just 2 hours, reducing costs to operate the system and therefore consumer bills.

Our growth and accomplishments over the past year serve as a solid foundation for our future innovation activities. As we transition to NESO, innovation will remain a crucial component in shaping a sustainable energy future. We will continue to transform innovative ideas into operational activities, paving the way for net zero and establishing a whole energy system that is affordable, reliable and secure for both consumers and the wider industry.

Portfolio Overview

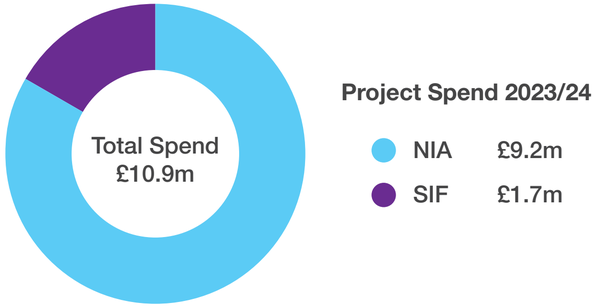
Projects

Innovation funding is essential for the transition towards a sustainable energy system, enabling us to execute ambitious projects and drive collaboration across the whole energy sector.

Our portfolio has experienced rapid growth, increasing from 55 projects live in 2022/23 to 75 projects in 2023/24. This includes 21 Strategic Innovation Fund (SIF) projects (an increase of 7) and 54 Network Innovation Allowance (NIA) projects (an increase of 13).

By addressing Ofgem's key challenge areas, we have continued to secure SIF funding for both new and ongoing projects to drive the energy transition. Our projects range from the Discovery to the Alpha and Beta stages. Collaboration is vital to innovation and successfully addressing the challenges of a decarbonised energy system, which is why we've partnered on a further fourteen SIF projects.

Driven by our Innovation Strategy, our NIA portfolio has continued to grow and mature. These projects focus on longer-term challenges that are higher risk than our everyday activities. Our portfolio aims to create significant value for the ESO, consumers and the wider energy system.



Our scorecard on the following page showcases our NIA and SIF activities from the past 12 months. It provides insight into the culture of innovation at ESO, our successes and areas for improvement.

Our Year in Numbers

NIA Projects

54 Projects Live in 2023/24	**21** Projects Registered
33 Projects continued from previous year	**25** Projects Completed

SIF Projects

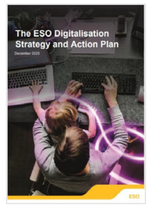
04 Lead Discovery Projects	**02** Lead Alpha Projects	**01** Lead Beta Project
08 Partner Discovery Projects	**04** Partner Alpha Projects	**02** Partner Beta Projects

Innovation Scorecard

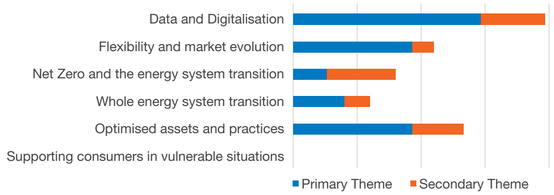
Strategy & Vision

Strategies:

- Innovation Strategy 24/25
- ESO Digitalisation Strategy and Action Plan
- Energy Networks Innovation Strategy 2024



Spread of projects across ENA themes



Organisation & Culture

144

Innovation ideas generated

TRL Map	% No. Projects	% Spend
TRL 2	2%	0%
TRL 3	28%	15%
TRL 4	19%	10%
TRL 5	25%	64%
TRL 6	11%	5%
TRL 7	9%	4%
TRL 8	5%	2%

8.63

Average Stakeholder & Customer Satisfaction Score

Capabilities & Collaboration

118

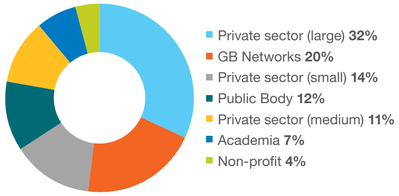
3rd party Big Ideas received

16

3rd party Big Ideas approved

74

Project Partners



Results & Outcomes

33%

Ideas approved at Big Idea stage

40

Big Ideas being developed into projects

34 days

Average length of time from Big Idea submission to initial decision

Innovation Scorecard

Below we provide details for our 2023/24 activities, with insights into how our portfolio has changed from previous years and our expectations for the future.

Our Big Ideas Process

We received 144 ideas (what we call ‘Big Ideas’) in 2023/24, the largest amount we’ve ever received. 82% of these were submitted by third parties, with the remainder coming from ESO colleagues, demonstrating our dedication to generating new ideas with the wider energy sector.

When we receive a new Big Idea, we follow a set process. Among other considerations, the idea is evaluated against our strategy, available resources, duplication of existing work and funding eligibility. This relies on input from internal colleagues who are subject matter experts and deeply understand the needs and challenges of the energy system. The most suitable projects are then refined and optimised to ensure they meet all the criteria before a final approval pitch.

Although we’ve seen an increase in 3rd party ideas the number of projects, we are taking forward has remained steady. This reflects that while we are reaching a wider range of stakeholders our portfolio has also become more focused as we increase our efforts on developing long-term projects and progressing them to subsequent stages.

The average time taken from ‘Big Ideas’ submission to decision has decreased from 75 days in 2022/23 to 34 days. This reflects our expanded capabilities within our team and more expert resources being available following a challenging winter in 2022.

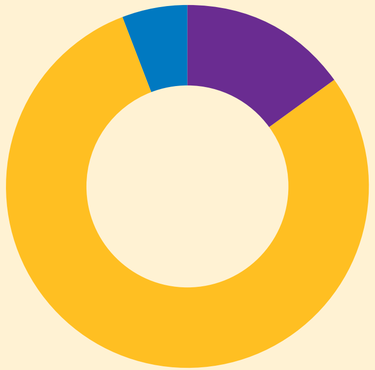
Technology Readiness Level

We measure project maturity through Technology Readiness Levels (TRL), classed under either Research, Development or Demonstration. Last year over half of our projects were classed as research, this has decreased to 30% with increases in all subsequent TRL levels. Our previous work building a robust pipeline of ideas and Research projects has now transformed into a strong portfolio of Development projects, which are generating and testing solutions to the biggest energy system challenges.

As we move forward with RIIO-2 and our portfolio continues to mature, we expect to see a further increase in Development and Demonstration projects. Our goal is to advance these projects to a stage where they can be tested on the network to create commercially viable options or transitioned into business as usual activities to deliver benefits to consumers and the energy system.

Innovation Scorecard

On the previous page, you can see from our TRL heat map that 64% of our spend is in TRL 5, classed as ‘Development’. This is due to £21 million of SIF funding for the CrowdFlex Beta project. As the project progresses, we anticipate that this TRL will reach a demonstration level once its initial testing trials are completed in 2025. Even without considering the additional £21 million, our development funding has still increased by nearly £12 million.



TRL Spending Split 2023/24

Research	£6.8m
Development	£35.5m
Demonstration	£2.5m

Performance Against Our Innovation Strategy

To monitor our progress, we track alignment of the innovation portfolio against our innovation priorities.

Figure 1 shows how we have performed against our 2023/24 innovation priorities, demonstrating the focus of our efforts (indicated by Number of Projects) and funding (Sanctioned value for NIA and SIF projects live in 23/24) over the last year. Although many of our projects will address multiple challenges, we have mapped them to one innovation priority based on the primary challenge that the project addresses to help us better track our progress.

The number of projects addressing Driving the zero-carbon transition may be lower than expected. We received feedback that this innovation priority needed to be more focused, to clearly communicate the type of projects we are looking to develop in this area. To address this, we modified the priority and mapped live projects in 23/24 to specific areas such as Better forecasting for integration of renewables, Reducing balancing costs and Improved Carbon Monitoring. However, all our projects contribute to the zero-carbon transition.

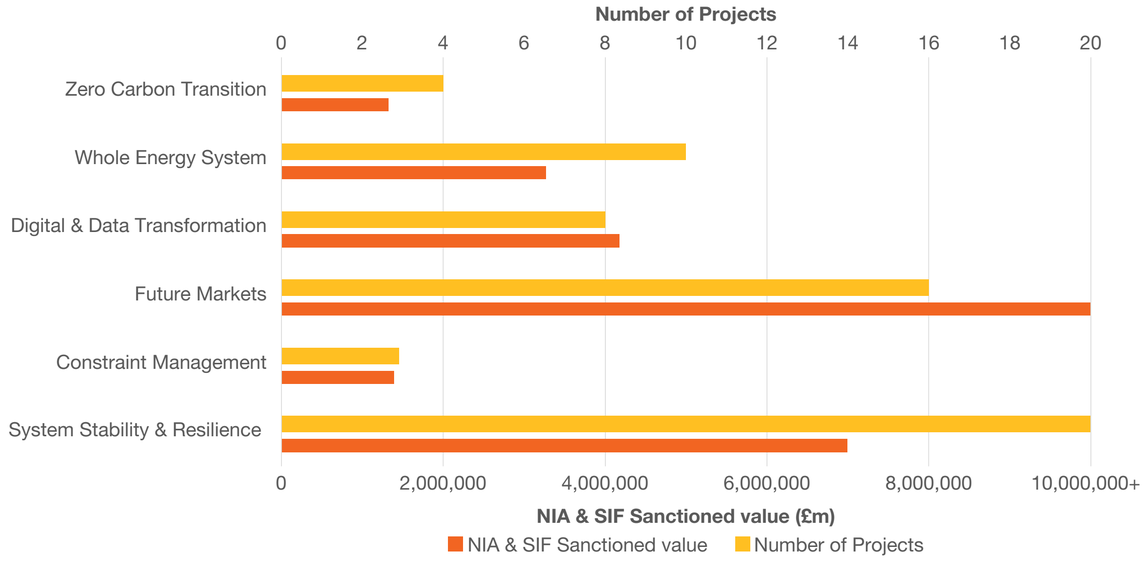
Digitalisation remains a key enabler of the transition to a zero-carbon energy system. A large number of the projects previously mapped to this priority have been realigned to others e.g. System Stability & Resilience. This is because projects have been mapped to the innovation priority that covers the primary challenge they are addressing; however, our projects always have a Digital, AI and Data element.

The number of projects addressing System Stability & Resilience is higher due to projects being mapped to just one innovation priority. It may also have increased as we look to better understand how and why the system may be impacted by different factors and how to mitigate against them e.g. more extreme weather events.

The number of projects addressing Whole Energy System has steadily increased as we transition to National Energy System Operator. Similarly, as we continue to drive competition across industry and explore how markets evolve, the number of projects addressing Future Markets has increased.

Like last year, the number of projects addressing Constraint Management may be lower than expected. This is due to the main activity addressing this priority being done following the Constraint Management Pathfinders, innovation projects support this where possible.

Figure 1. 2023/24 Portfolio Analysis: Number of projects linked to the 6 priority areas and sanctioned value for NIA and SIF projects live last year linked to the 6 priority areas.



Our Updated Strategic Priorities

Our Innovation Strategy has been refreshed for 2024/25, outlining how we need to innovate in the year ahead and where to focus our efforts to drive the decarbonisation agenda for Great Britain as we transform to NESO.

The innovation priorities included in our strategy have been developed using feedback from across industry and ESO subject matter experts. They are also informed by other ESO strategies such as the ESO Digitalisation Strategy & Action Plan and Operability Strategy, as well as changing energy system dynamics from the macro trends of Decarbonisation, Decentralisation, Digitalisation and Democratisation.

We have made our innovation priorities more focused by outlining key opportunities to explore. These will help innovators to better understand how we can work together to transform our energy system. To help prioritise and focus our projects, we've also developed a success statement for each innovation priority.

This report contains case studies illustrating how our priorities are being addressed through our collaborative work with our partners.

View our 2024/25 Innovation Strategy.

Driving the zero-carbon transition

Digital, AI and Data

Constraint Management

Driving the zero-carbon transition

We must enable new research and technology, developing and testing the solutions necessary to ensure the zero-carbon transition is delivered by the ESO and wider energy system in a timely, responsible way, for the benefit of all consumers.

Digital, AI and Data

Digital, AI and Data underpins the success of the ESO tackling almost all of its ambitions while leading the energy transition. The scale of the challenge, both internally and across the industry, is great.

Constraint Management

Building new transmission and distribution network capacity to meet peak flows on the system is not always the lowest cost solution for consumers, or the best for the environment, so we need to test a variety of innovative market-led solutions and technologies in this area.

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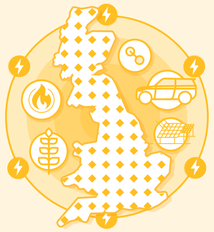

Whole Energy System

Future Markets

System Stability & Resilience

Whole Energy System

As our energy system changes, we will take a leading role and deliver a holistic approach. With our unique position in the industry, we'll invest significant effort to encourage collaboration and find efficiencies, particularly within hydrogen, transport, heating and smart technologies.

Future Markets

Designing markets that are fit for purpose underpins the ESO ambitions of 'competition everywhere' and zero-carbon operation. We need to understand the long-term options for market design, and work with our customers and stakeholders to find the best whole-system solutions.

System Stability & Resilience

Significant progress has been made on System Stability across the ESO, but there is still more to be done. As we transform to a zero-carbon electricity system, it will remain a key area of investment.

Case Study: 3MD (Market Monitoring Model Development)

Identifying suspicious trading activities using advanced machine learning techniques will help ensure the GB energy market remains fair and competitive for market participants, while delivering best value for consumers.

Future Markets

Project overview

The energy market should be operated in a fair and transparent way, to ensure a competitive marketplace for power providers and a secure energy supply at the best price for consumers.

To make sure this happens, a market monitoring team was set up by ESO to review and investigate potential suspicious transactions across all balancing services which could indicate a breach of energy market rules, market manipulation or insider training.

The market monitoring team has created automated alerting tools to screen transactions in the balancing market, however the team wanted to explore and create more sophisticated anomaly-based detection tools to extend the team's capabilities to spot different types of patterns and suspicious behaviours.

This 12-month project was established to create an advanced monitoring tool using machine learning (ML) to identify a range of anomalies in energy market data. The information gathered using the ML-powered model will be analysed alongside existing data reports and used as the basis for internal investigations into potential breaches of fair-trading practices.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: 3MD (Market Monitoring Model Development)

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Future Markets

Results

The project started with an exploration phase, where we worked in partnership with Hartree Innovation Centre to see what ML techniques existed to filter, test and run statistical analysis on our balancing and operational data.

The next two stages looked at how we could apply these techniques and model behaviours for pricing (evaluating high offer pricing) and physical notifications (what a unit is intending to generate). These models have already been incorporated into our market monitoring processes. This includes creating a process for reviewing activity against Ofgem's new Inflexible Offer Licence Condition (IOLC), which will ensure that generators don't receive excessive benefits from inflexible offers when participating in the balancing mechanism.

The remaining work packages looked at constraints and the technical driven dynamic parameters submitted from generators. The subsequent models and tools which arose from our exploration of these topics will be implemented into our processes in the next financial year.

Benefits

This project has delivered sophisticated alert systems which has resulted in identified cases of suspicious transactions being escalated to Ofgem. This supports ESO to manage balancing costs which will be reflected in better value for consumers. The project will also have benefits for the whole energy system as it ensures the GB market remains fair and competitive for market participants, which encourages further engagement with ESO in providing balancing and response services.

Our Partners:

UKRI Science and Technology Facilities Council
Hartree Centre

Case Study: 3MD (Market Monitoring Model Development)

Identifying suspicious trading activities using advanced machine learning techniques will help ensure the GB energy market remains fair and competitive for market participants, while delivering best value for consumers.

Future Markets

Innovation culture

Samuel Kintoff
Senior Market Monitoring Analyst

About: I joined National Grid Group in 2017 on a graduate scheme and worked in a variety of placements across the organisation including roles in IT, IT commercial and gas strategy, where I worked on a really exciting hydrogen project. In 2021 I joined the ESO's Market Monitoring team. My main responsibilities are to review alerts, liaise with trading and Control Room teams, carry out investigations and create Suspicious Transaction Reports for issue to OFGEM. This is the first innovation project I have been the lead for.

> *This project has been so good to work on as the innovations being delivered actually have a direct impact on our team and our daily work. I'm in a position where I can influence the project's output and that's been really rewarding. I've also learned a lot from the partner consultants we've worked with, as it's allowed me to explore how we can use different models and tools to great effect."*

Case Study: Demand Flexibility Service Evaluation

The evaluation of GB's first national flexibility service to use households and businesses to reduce demand at peak times will help shape the design of future demand response services.

Future Markets

Project overview

This project was created to evaluate the Demand Flexibility Service (DFS). The scope included analysing the motivating factors for consumer participation, barriers or challenges encountered, and how the DFS could be improved to make it more cost efficient and encourage further engagement in the future.

The Demand Flexibility Service was designed by the ESO to incentivise households and businesses to reduce or shift their electricity use during peak times. The service first ran from November 2022 – March 2023, with 20 test events and two live events held during in this time.

ESO guaranteed DFS providers a minimum price of flexibility of £3/kWh and provided a standardised baselining methodology to determine kWhs shifted. DFS providers used the method to determine each household's kWh savings relative to a household's specific baseline for that day. An 'in-day adjustment window (IDA) was used to adjust average demand. DFS Providers determined their own incentive schemes for customers some using points, cash back or prize draws. In total, 31 providers signed up (14 domestic only, 10 non-domestic only, and seven both domestic and non-domestic). Providers were able to sign up at any point in the 5-month period, which meant their customers were offered different numbers of events.

The DFS is the largest demand response scheme to have taken place in the UK to date, with participation from 1.6 million households and businesses. Together participants delivered a total reduction of electricity use of 3,300MWh at key times, which is roughly the amount of electricity that 9.9 million households would use at peak times across a single hour.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Demand Flexibility Service Evaluation

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Future Markets

Results

Working in partnership with the Centre for Sustainable Energy, we ran a consumer survey in conjunction with selected energy providers whose customers took part in the DFS. We analysed 23,500 consumer responses alongside diary entries and qualitative interviews to give a full picture of people's motivations, experiences and capabilities to respond in demand-side flexibility services. Our initial findings were presented in June 2023, and used to inform the design of the winter 2023/24 DFS to ensure it was fair and cost-effective.

The second phase of the project will evaluate smart meter data alongside the social data from surveys of both domestic and non-domestic DFS participants. This will allow us to run layers of analysis, comparing consumer answers (perceptions) to existing data (reality).

Once completed, the full DFS evaluation will be used to support ESO's Consumer Building Blocks project to identify different consumer archetypes, their capabilities, and the incentives required for them to participate in future flexibility services.

Benefits

Understanding how consumers and businesses can actively contribute to the balancing of the grid is an essential part of the transition to net zero. The evaluation data provided by this project informs ESO about the potential opportunities and challenges for consumers to deliver market services, and provides valuable insight for future energy scenario models to enable more accurate network planning in the future.

Our Partners:

centre for sustainable energy

ERM

Case Study: Demand Flexibility Service Evaluation

The evaluation of GB's first national flexibility service to use households and businesses to reduce demand at peak times will help shape the design of future demand response services.

Future Markets

Innovation culture

James Kerr
Power Responsive Engagement Lead

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, before building the Consumer Strategy team on my return. In July 2023, I moved into the Power Responsive team, focusing on how we encourage more households and businesses to take part in demand-side response and analysing the opportunities and barriers to wider participation in flexibility services.

> *The big question for me is how we unlock consumer potential to help transform the energy system. Consumer behaviour is still a relatively unknown in the energy transition, but through innovation projects such as this one, we can find out more about what we don't know. And that knowledge is what's going to help us get to net zero."*

Case Study: Exploring the Economic Benefits of Co-optimising Procurement of Energy, Response and Reserve

This project explores the benefits of agreeing to buy power from generators to meet everyday demand, response and reserve services at the same time to maximise resources and lower operating costs.

Future Markets

Project overview

To decarbonise the electricity grid by 2035, we need to review our market structure to ensure it is fair and accessible to all participants and that it delivers the power required, when needed, at the right price.

Currently the wholesale market procures generation to meet everyday demand separately from the ESO procurement of reserve and response services, which are used to help counter any peaks in demand and keep the grid balanced. These different energy trades are done sequentially – so a generator decides how much power they want to offer for wholesale, and then bid again to offer capacity for ancillary services.

As the energy landscape is changing to include more renewable energy resources, sequential procurement may not be the most effective way to buy or dispatch power, and this could be leading to higher operating costs and resources not being fully optimised.

ESO's Net Zero Market Reform team was created to review how the market structure would need to evolve to meet the demands of a net zero grid. In this 12-month innovation project, the team is using academic-based research and modelling to explore the quantifiable benefits of co-optimising procurement of energy, reserve and response services, and how this could be implemented in practice.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Exploring the Economic Benefits of Co-optimising Procurement of Energy, Response and Reserve

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Future Markets

Results

Working in partnership with consultants FTI, we investigated the economic benefits of a co-optimised market in GB, both now and in the future. Using 2022 as a base year and then modelling market behaviour in the short and medium term (up to 2035), the study investigates asset behaviour and market outcomes between co-optimised and non-co-optimised market simulations in a national market. It also looks at how a zonal price structure would affect the behaviours in a co-optimised regime.

A second work package, led by consultants N-SIDE, focused on the delivery of a supporting research report to explore the key areas of consideration for implementing co-optimisation, drawing on examples of co-optimised procurement around the world, analysing the strengths and weaknesses of different approaches. The research found like-for-like comparisons challenging, as other countries don't have the same penetration of wind generation and battery storage as the GB network, but draws from a wealth of relevant market design experience.

The final findings of the co-optimised procurement study will be shared with the industry and will feed into the Department for Energy Security & Net Zero to inform its decision-making process in the ongoing Review of Electricity Market Arrangements (REMA), which will be used to create a market framework for the future.

Benefits

A co-optimised market for energy and ancillary services can lower operating costs across the whole energy market and ensure the efficient allocation of resources. This makes better use of the assets of the future like limited duration energy storage and renewable generation, therefore aiding the transition to net zero operation. In addition, a co-optimised structure will encourage more market participation in the future as it simplifies the procurement process for smaller generators, and it also has benefits for future investment, as the more predictable price signals encourage power providers to invest in long term projects for the GB network.

Our Partners:

FTI CONSULTING

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Future Markets

Innovation culture

Robert Westmancoat
Senior Market Strategy Lead

About: After gaining a degree in physics, I joined National Grid Group in 2010 on a graduate placement scheme. I started my career in a series of 6-month placements, including System Operations, Asset Management for high voltage DC links (interconnectors) and Regulation, where I focused on EU energy policy. My first full role was in the Operations Centre working on constraint management, before I moved into the trading team. From there, I went on to System Operability, addressing frequency management challenges, and then to the design and development of the response and reserve and the demand flex service. My current role is focused on the evolving needs of renewable markets.

> *I have worked across so many different teams at National Grid and what I've learned is that things can usually be done better – even if you think you are an expert, there is always more to know and things you may not have appreciated before. You have to be happy to admit that! The upside of innovation is that you can try new things and figure out what works and what doesn't. Projects evolve, and often you'll discover even more things that you didn't know before."*

Case Study: Forecasting the Risk of Congestion

This project will create a probabilistic forecasting tool to help the Control Room proactively manage congestion in the southeast of England where interconnectors from Europe and offshore wind generation all connect to the network.

Constraint Management

Project overview

Interconnectors are an important part of the GB power network, providing supplementary electricity supplies to and from Europe. The amount of power each interconnector provides is agreed in formal trading requests from our Control Room a day ahead.

Four interconnectors join the GB network in southeast England, where there is also a number of offshore wind farms. Having both interconnectors and windfarms adding power to the same part of the network can cause congestion, especially on days when there is a lot of wind and insufficient demand to use it all.

If this happens, the Control Room has to use costly or emergency actions – either curtailing output from the wind farms, which doesn't help us meet renewable energy targets, or by reducing the trades on the interconnectors.

Similarly, if there is a drop in wind generation and we haven't agreed a high enough amount of power from the interconnectors, we'll also need to take emergency actions to balance the system.

To help Control Room engineers reduce congestion on the network in southeast England and ensure there is a closer correlation between supply and demand, this two-year project seeks to build a probabilistic forecasting model to predict the flow of interconnector and renewable power in the region more accurately. The model will show the probability of the predicted flow a day ahead as well as the probability of it changing, so the Control Room can make more informed decisions with less need for balancing action in real time.

Find out more on this project on the ENA Smarter Networks Portal.

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Constraint Management

Results

Working in partnership with consultants N-SIDE, we have already completed the first two phases of this five-phase project. Using data mining and machine learning (ML), we have investigated the difference between the day-ahead flow expected from an interconnector and the actual energy flow, and generated scenarios to explore how interconnectors behave in different situations.

Using this improved understanding of how interconnectors interact with the GB network, we have developed a network model protype for the southeast region which we are now testing using historical interconnector data.

Next, we will continue to test and refine the prototype probabilistic forecasting tool before developing it further to include the impact of wind generation uncertainties, so that it can reliably forecast the probability of day ahead flow for the Control Room.

Benefits

This project will provide the Control Room with improved situational awareness and certainty about an area of the network which is at a high risk of congestion, giving them the tools to proactively and efficiently manage flow and ensure security of supply. With improved day-ahead forecasting, there is less need for ‘overtrading’ or wind curtailment, thereby reducing the cost of running the network, which provides better value to consumers, and ensuring more of the renewable power generated in GB is used to supply the network.

Our Partners:

N-SIDE

Case Study: Forecasting the Risk of Congestion

This project will create a probabilistic forecasting tool to help the Control Room proactively manage congestion in the southeast of England where interconnectors from Europe and offshore wind generation all connect to the network.

Constraint Management

Innovation culture

Colin Webb
Power System Transformation Manager

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 supplies and now ESO. In nearly 20 years 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.

> *Artificial Intelligence and Machine Learning are increasingly important tools to help guide innovation and improve our outputs. We are using those capabilities to great effect in our work monitoring and forecasting interconnector and renewable generation behaviour, and by harnessing the power of data that we get from it, we can develop ground-breaking and exciting Control Room tools to ensure the network of the future can be operated more efficiently."*

Case Study: Generative AI Discovery

This project is a deep dive into the potential benefits and risks of generative AI to the GB energy system, and an exploration of how the technology could be used in the future to improve ESO operations.

Digital, AI & Data

Project overview

Technology is advancing all the time, and it's important for ESO to understand how new developments could positively and negatively impact the operation of the power network.

To mitigate risk and explore opportunities, we are scanning the horizon for the next digital and energy innovations which could have the greatest effect on the energy transition in the short (next three years), mid (by 2035) and long term (by 2050). Over 70 relevant emerging technology topics have been identified, and of these, 24 have been selected for active monitoring with a subset of 6 for deeper exploration. Generative AI was selected for a deep dive in response to request from ESO leadership to understand the impact of the technology on our organisation.

Generative AI can create new data, such as text or code, based on the data it has been trained on, and it has rapidly grown in popularity in the last 12 months thanks to the launch of publicly available computer program such as ChatGPT. It has the potential to reshape how knowledge work is done in industries and business functions across the entire economy however it also comes with limitations and risks, so it is important to cut through the hype.

This project focuses on investigating the opportunities, limitations and threats of generative AI, exploring possible applications for it and sharing findings with teams across ESO.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Generative AI Discovery

This project is a deep dive into the potential benefits and risks of generative AI to the GB energy system, and an exploration of how the technology could be used in the future to improve ESO operations.

Digital, AI & Data

Results

The research project started by raising awareness of generative AI technologies within ESO. This was followed by a series of interviews with 17 internal teams to explore how they might adopt it (if at all) into their processes in the future.

Focusing on downstream applications in stakeholder engagement, knowledge management and customer operations, three priority use cases were shortlisted for lab testing: market reform consultations, Future Energy Scenario insights and horizon scanning. To mitigate against hallucinations – where factually incorrect information appears credible – the tests were run using a large language model with Retrieval-Augmented Generation (known as LLM + RAG). This ensured trusted sources of information were used to generate content to enhance accuracy.

The tests highlighted significant potential for productivity improvements and identified areas where the generative AI underperformed. The findings were discussed in internal forums, presentations and articles, and shared in a report published in March 2024.

Through the project, we also spoke to external experts from industry and academia, and made recommendations for potential partners and collaborators who could help ESO in adopting generative AI technologies in a safe and responsible manner.

Benefits

This deep dive into generative AI has highlighted where ESO processes could be improved by technology to maximise productivity and make operations more efficient. This includes Control Room applications where generative AI could alleviate cognitive overload by making it easier for engineers to find the knowledge they need to quickly make critical decisions that keep the lights on and the network running as efficiently and cost effectively as possible.

Our Partners:

ITC INFOTECH
Business-friendly Solutions

Case Study: Generative AI Discovery

This project is a deep dive into the potential benefits and risks of generative AI to the GB energy system, and an exploration of how the technology could be used in the future to improve ESO operations.

Digital, AI & Data

Innovation culture

Vikaran Khanna
Technology Insights Lead

About: I joined National Grid ESO in September 2022 as part of the Virtual Energy System team, to work on a programme to create an interconnected digital twin of the entire energy landscape. In July 2023, I moved into the Strategy & Insights team where the main focus of my work is technology horizon scanning. I am passionate about climate change and am excited that my work enables me to make a difference in this field. Before joining National Grid ESO, I was an experimental physicist.

> *The future of our energy system lies in widespread electrification but there is a lot of work to be done if we are to achieve this, particularly around the scaling up and commercialisation of new technologies. In my role I see those pivotal new technologies first hand and its awesome to be part of the team which is helping to identify them and bring them to the forefront of ESO operations. Innovation gives us space to be creative, to think outside of the box and engage with new and different players in the industry."*

Case Study: Powering Wales Renewably

This is the latest phase of a collaborative project with the Welsh Government, setting the groundwork for a digital twin of Wales's power network which will assist in the future planning and operation of a net zero carbon network.

Whole Energy System

Project overview

ESO is working in partnership with the Welsh Government to help deliver its net zero commitments by increasing the amount of renewable energy powering homes and businesses in the country.

To accelerate the transition to renewable energy in Wales, there are several key challenges which need to be addressed such as deciding where new assets are required, increasing the pace of new connections and deciding how flexibility on a national scale can help meet local needs.

To help resolve these challenges, ESO is seeking to create a digital twin which can be used for modelling and future planning. This project will set the groundwork for the development of the advanced digital tool, which will be a replica of the whole Welsh power network, including the complete transmission and distribution network and the current assets available.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Powering Wales Renewably

This is the latest phase of a collaborative project with the Welsh Government, setting the groundwork for a digital twin of Wales's power network which will assist in the future planning and operation of a net zero carbon network.

Whole Energy System

Results

Working alongside consultants CGI, the project brought together collaborating partners in the ESO, the Transmission System Operator (TSO) and the Distribution Network Operators (DNOs) in Wales. Each stakeholder holds their own asset and network information and sharing this data onto a single open platform is fundamental to the development of the digital twin.

To foster a collaborative approach, workshops were held to demonstrate the capabilities a digital twin would offer to partners. After these discussions, possible use cases were identified and deep dives were conducted on the potential for network modelling, flexibility and co-ordination, multi-vector integrated planning gap analysis and energy transition system planning.

With a deeper understanding of what stakeholders want from a digital twin, the challenges of integrating multiple network and asset models into a single digital replica and the costs to achieve these goals, an application has now been made to fund the next stage of the project to build the digital twin.

Benefits

The creation of a digital twin on this scale is an industry first, and it will become a blueprint for other regions. It will offer unprecedented situational awareness for the Control Room and allow ESO to manage more renewable energy connections on the system in Wales. The digital twin will also boost long-term regional planning capabilities and connect new renewable energy units faster to accelerate the transition to a decarbonised network by 2035.

Our Partners:

Llywodraeth Cymru Welsh Government · nationalgrid · nationalgrid Electricity Distribution · SP ENERGY NETWORKS · CENIN · CGI

Case Study: Powering Wales Renewably

This is the latest phase of a collaborative project with the Welsh Government, setting the groundwork for a digital twin of Wales's power network which will assist in the future planning and operation of a net zero carbon network.

Whole Energy System

Innovation culture

Bridget Hartley
Head of Regional Strategic Planning

About: Bridget is leading the setting up of a Regional Energy Strategic Planner capability for GB; a new role recently given to the ESO. In this role Bridget is creating a team with a whole system, stakeholder led approach to strategic energy planning at the distribution network level.

Bridget is a chartered gas engineer with over 25 years leadership experience in gas transmission and distribution. This has covered a wide number of strategic, regulatory, asset management, stakeholder and operational leadership roles. Bridget is also a member of IGEM and has recently served on the IGEM Executive and Council.

> *This project is pioneering the use of digital twin technology to enhance visibility & transparency of energy data for Wales. This should enhance understanding of cross-energy vector and transmission/distribution network interactions leading to better investment decisions."*

Case Study: RealSim

To fully understand how the GB power network is affected by rapid changes in supply caused by the high penetration of renewable energy generation and the fast-switching characteristics of power electronic devices, such as interconnectors, the ESO needs to develop more sophisticated methods to assess the stability of the Great Britain National Electricity Transmission System (GB NETS).

Project overview

To maintain stability and ensure the lights stay on, the grid must operate within several parameters – including set frequency and voltage levels – but these can be adversely affected by fluctuations in supply and demand. The grid's ability to recover from these fluctuations is its stability.

As there are now more renewable energy generators and fast switching power electronic devices on the network, the amount of power flowing through the grid can change very quickly in a short space of time. This has a notable impact on the grid's stability and could impact key operational parameters. We don't fully know how sensitive the grid is to these behaviours as our analytical tools were created to assess a predominantly fossil-fuelled power network with relatively low amounts of renewable energy generation.

This project was set up to assess the stability of a more complex GB power system (i.e. with more renewables, less fossil-fuelled generation and more fast switching power electronic devices) using a new analytical method – electromagnetic transient (EMT) analysis.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: RealSim

To fully understand how the GB power network is affected by rapid changes in supply caused by the high penetration of renewable energy generation and the fast-switching characteristics of power electronic devices, such as interconnectors, the ESO needs to develop more sophisticated methods to assess the stability of the Great Britain National Electricity Transmission System (GB NETS).

System Stability & Resilience

Results

Working in partnership with University of Warwick, we first explored how we could model the GB network in the level of detail needed for EMT analysis. We started with our existing analytical model for stability analysis and added layers of complexity to make it EMT compatible. This was done on an offline model version of the south coast of England, as our test area.

Having found that it was possible to capture EMT data in this way without affecting the original south coast network data, we entered phase two of the project to develop our model further and validate its findings.

Next, we will be exploring the challenges and opportunities of using our model to create a tool to measure stability in real time – to for example help us understand what kind of computational power would be required, whether it could be used effectively for regional grid level stability analysis, and if we could calculate EMT information quickly enough for the Control Room to use it for critical network analysis.

The last part of the project will be to develop a framework and standards for EMT analysis of stability, which will set the groundwork for the future development of a tool to provide real time EMT analysis and reporting.

Benefits

This project has the potential to provide ESO planning and operations engineers with advance warning of stability issues on the network, to allow for course correction if required. As well as enhancing ESO's ability to maintain stability and keep the lights on, real time EMT analysis could in the future help the Control Room to better manage the impact of high levels of renewable energy generation and fast switching power electronics, so that more clean energy units can come online in the future to help meet net zero targets.

Our Partners:

WARWICK
THE UNIVERSITY OF WARWICK

Case Study: RealSim

To fully understand how the GB power network is affected by rapid changes in supply caused by the high penetration of renewable energy generation and the fast-switching characteristics of power electronic devices, such as interconnectors, the ESO needs to develop more sophisticated methods to assess the stability of the Great Britain National Electricity Transmission System (GB NETS).

System Stability & Resilience

Innovation culture

Chomba Tumelo-Chakonta
Power System Engineer

About: After completing a PhD in electrical and electronic engineering at the University of Manchester, I joined National Grid Group in 2016 in the System Operator directorate, which later became the ESO. I have worked in long term planning and forecasting roles, but my job now is centred around developing advanced analytic tools which are fit for purpose and able to support the operation of our evolving power network.

> *I joined National Grid with a research background, so I very much enjoy being at the forefront of knowledge and innovation in my role. We need to completely change our approach to operate a decarbonised network and innovation is what is going to narrow the gap between the demands of the energy transition and how we reach it as Business As Usual. We are constantly learning new things and pushing the boundaries and I'm very happy to be part of that ongoing process."*

Case Study: Scenarios for Extreme Events

This project is developing a tool which can simulate the impact of extreme events on the electricity and gas networks, and quantify how this will affect homes, businesses and vital services, to inform future planning and investment decisions.

System Stability & Resilience

Project overview

Extreme events are classed as high-impact, low-probability events. These could include weather-related occurrences such as floods, major storms and extremes of heat, which are becoming more frequent, as well as other incidents like malicious attacks, cyberattacks, industrial action and supply chain disruption.

When an extreme event occurs it can have a direct or indirect impact on the national power network and as part of ESO's resilience planning, these risks need to be fully analysed and quantified.

In 2024, National Grid ESO will transition to National Energy System Operator (NESO), becoming wholly government-owned and independent from National Grid. There are some new responsibilities that will come with this change, one of which is to produce a report assessing risks to the whole energy system (electricity and gas). This report will be subjective, based on insight from across the energy industry expert opinion but there is a need to illustrate the potential impact of extreme events on society numerically – for example, estimating the number of people who will be without power for a given time frame or the disruption caused to vital services like transport, water supplies or communications.

This project was established to develop a prototype tool which could simulate extreme events, quantify the risks to the whole energy system and society, and highlight any vulnerabilities to inform future decisions around resilience planning and investment.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Scenarios for Extreme Events

This project is developing a tool which can simulate the impact of extreme events on the electricity and gas networks, and quantify how this will affect homes, businesses and vital services, to inform future planning and investment decisions.

System Stability & Resilience

Results

Working in partnership with distribution and transmission partners from across electricity and gas networks and supported by the Frazer-Nash Consultancy, the project has already delivered a framework for an extreme events simulation tool and agreed new resilience metrics which focus on consumer and societal impact.

Next, the project team – which included the Met Office and University of Strathclyde – defined and explored different test scenarios to be run on the prototype tool. These included a weather and a non-weather scenario.

Results showed the tool had the ability to cascade the direct and indirect impact of the two extreme events on consumers and it was able to track the correlation between disruption to gas and electricity networks in each of the different scenarios. The prototype model can run scenarios quickly and may be developed further to run multiple scenarios at once.

A cost-benefit analysis of the extreme events tool has been completed with a view to securing funding to build the tool in the future.

Benefits

The tool being developed has the potential to analyse the full impact of extreme events on the whole energy system (gas and electricity) and wider society, and to highlight where future resilience planning and investments are required to address vulnerabilities on the network. As well as informing investment planning and making the whole energy system more resilient by recognising interdependencies, and increased risks in the future as the energy landscape and society changes over time.

Our Partners:

Frazer-Nash Consultancy – A KBR Company; University of Strathclyde Glasgow; Met Office; Scottish & Southern Electricity Networks Transmission; national gas; Cadent Your Gas Network

Case Study: Scenarios for Extreme Events

This project is developing a tool which can simulate the impact of extreme events on the electricity and gas networks, and quantify how this will affect homes, businesses and vital services, to inform future planning and investment decisions.

System Stability & Resilience

Innovation culture

Jenna Macgregor
Resilience Engineer

About: I am part of the new generation of resilience engineers who are bringing different industry experience to the ESO resilience team. After studying meteorology and oceanography at university, I joined the Met Office as a forecaster. I then applied those skills in the water industry, where I was an adverse weather strategist. In that role, part of my remit was to investigate the inter-reliance between the water and power industries. I joined National Grid in January.

> *This innovation project is a fantastic collaboration between different partners, all with their own viewpoint, experience and knowledge to bring to the problem we are trying to solve. Everyone has something unique to add, including myself who is advocating for the water industry and our wider communities as well as the electricity network. It's exciting to be part of delivering this innovative new tool, especially when I'll have first-hand experience of using it to support my work."*

Case Study: Solar PV Nowcasting

This project has used machine learning to build a tool for the ESO control room which can predict short-term solar generation more accurately, up to 36 hours ahead.

Project overview

As penetration of solar generation on the GB electricity network continues to increase, it brings with it a number of issues for the ESO – firstly, solar is embedded generation so it is invisible to the grid operators. Secondly, existing weather data doesn't give enough information to allow operators to accurately predict generation from known solar resources, like large scale solar farms.

As a result of this uncertainty, the ESO Control Room must keep power in reserve to make up any shortfalls in solar generation caused by cloud cover or unexpected changes in the weather, particularly in the 'shoulder months' of April/May and September/October when the weather is more unpredictable.

This project was created to improve short term solar forecasting by using machine learning techniques to build a tool which could give the Control Room more accurate short-term solar forecasts as well as longer range probabilistic forecasts.

Find out more on this project on the ENA Smarter Networks Portal.

Case Study: Solar PV Nowcasting

This project has used machine learning to build a tool for the ESO control room which can predict short-term solar generation more accurately, up to 36 hours ahead.

Results

Working in partnership with Open Climate Fix, a working tool has been created which brings together numerical weather prediction data, real PV data outputs and satellite images and uses these to run algorithms which can more accurately predict solar generation patterns.

The user interface is being tested by Control Room operatives, who are giving feedback to the project team to help them further improve the usability and accuracy of the tool.

The tool is still being fine-tuned and developed using different technologies and data sets, but in its current form it is 40 per cent more accurate than the ESO's previous solar forecasting methods. The tool can now run forecasts up to 36 hours ahead and also provide probabilistic modelling to vastly improve the control room's situational awareness.

Benefits

Reducing the margin for errors in demand by improving accuracy of solar predictions up to 36 hours ahead, the ESO can reduce its power reserves significantly. This will make the network more cost effective to run, and it will also reduce the ESO's carbon impact as power reserves are usually drawn from 'spinning' fossil-fuelled generators.

As more of the world moves to a renewable energy future, the Solar Nowcasting tool has the potential to be a globally significant innovation, which can be adopted by ESOs in other countries, positioning GB as a global leader in the energy transition.

Our Partners:

OPEN CLIMATE FIX

Case Study: Solar PV Nowcasting

This project has used machine learning to build a tool for the ESO control room which can predict short-term solar generation more accurately, up to 36 hours ahead.

Innovation culture

Lyndon Ruff
AI Centre of Excellence Manager

About: I first joined National Grid ten years ago. My specialist field is machine learning and artificial intelligence, and how these can be applied to solve business issues. That's why I was appointed to set up and lead ESO's AI Centre of Excellence, sharing ML/AI best practice across the business and integrating managed ML models in house to improve operations.

> *Given the pivotal role that AI and ML plays in innovation, I am involved in a number of projects for ESO. I enjoy this side of my role as I like being able to apply what I know to influence climate change for the good, making both a societal impact and a direct impact on ESO and GB's carbon emissions targets.*
>
> *One of the other innovation projects I'm leading on currently is the Data Scientist Fellowship which is essential to the future of innovation, as it seeks to address the digital skills gap and attract an increasing number of talented data scientists into the energy industry."*

What Happened Next?

Below we discuss some of our previous and current innovation projects that are shaping our operations and the wider industry.

Dynamic Reserve Setting

Using AI and machine learning to set reserve levels dynamically, at the day ahead stage.

Following the extension of the original project to allow the development of a proof-of-concept model, the project has now been delivered and is being trialled in the control room. During its initial trial, it saved us from buying an additional 1GW of unnecessary reserve within just 2 hours. In the future it is expected to be fully implemented in our control room operations. Additionally, we are exploring the development of a regionalised reserve model to further reduce waste and lower overall reserve requirements by offsetting reserves in neighbouring regions.

Find out more about this project on the ENA Smarter Networks Portal.

Consumer Building Blocks

A set of industry-standard consumer archetypes created in partnership with the other energy network organisations.

The project produced a set of industry-standard consumer archetypes that are currently being used as part of the Future Energy Scenarios modelling process. The archetypes have helped us understand the different types of consumers and the characteristics that drive their behaviour, as well as what this means for their consumption, willingness to change, adoption rates of technology and ability to engage with time of use tariffs. Additionally, relevant stakeholders and project partners from external organisations have received training on how to interpret and apply the archetypes, as well as how to keep them up to date. Our next step involves improving the archetypes by incorporating further data from the first Demand Flexibility Service.

Find out more about this project on the ENA Smarter Networks Portal.

What Happened Next?

Below we discuss some of our previous and current innovation projects that are shaping our operations and the wider industry.

D3 - Data Driven Power System Model Development for Control Interaction Studies

Developed new ‘black box’ models which can be shared with external companies without revealing confidential system data.

This work is particularly valuable for future projects that examine how different parts of a power system interact and how to keep the system stable. It provides insights into several key areas, including ensuring the power network functions as it should, evaluating how new customers can connect to the network, investigating issues that occur, and assisting with the planning and design of the network. This project has produced several tools and methods, including a testing system and models in the PSCAD/EMTDC environment, a module for testing and measuring harmonics, and a toolbox for analysing stability based on impedance, which helps identify potential risks of interaction between different parts of the system. Additionally, it developed a technique for simplifying models, making it easier to balance the system's accuracy with the need for efficient data processing.

Find out more about this project on the ENA Smarter Networks Portal.

Strength to Connect

A new method to measure grid strength as an alternative to short circuit level.

The project's initial phase involved a comprehensive review and reclassification of system strength metrics into two categories: small-signal and large-signal. These categories were based on their distinct behaviours. The newly defined metric classifications provide a method for evaluating the resilience of the system's voltage to different types of disturbances: minor ones that can lead to voltage fluctuations, harmonic interactions (small signal), and major ones (large signal) that can result in voltage drops and protection maloperation. This differentiation allows us to more accurately determine if the integration of new devices might compromise system stability or pinpoint vulnerabilities within the system. The project has already helped several academics and industry professionals gain a deeper understanding of how to assess system strength effectively. The second phase of the project focuses on developing a metric to gauge system strength in scenarios of significant disturbances and assessing the best ways to apply these new metrics.

Find out more about this project on the ENA Smarter Networks Portal.

What Happened Next?

Below we discuss some of our previous and current innovation projects that are shaping our operations and the wider industry.

Stability Market Design

Analysis and delivery of a short-term stability market for the UK.

The project recommended 3 discrete markets – Long-term (Y-4), Mid-term (Y-1), and Short-term (D-1) – to procure stability services effectively, with the recommendation to launch the Y-1 Mid-term market as a priority. Plans for this have been set out in the 2023 Markets Roadmap and has accepted bids for the first delivery year. We're currently completing further process mapping and system impact assessments to establish plans for developing the short-term stability market and a regular framework for initiating new-build procurement in the long-term.

Find out more about this project on the ENA Smarter Networks Portal and on our website.

Key Project Updates

Find out about how our larger programmes and projects have progressed over the past year.

Virtual Energy System (VirtualES)

The Virtual Energy System (VirtualES) Programme, launched in 2021 by the ESO, will enable the creation of an ecosystem of connected digital twins of the entire energy system of Great Britain which will operate in synchronisation to the physical system. Facilitating the secure and resilient sharing of data across organisational boundaries, it will provide the ability to model complex real-world scenarios and generate insights to cut carbon emissions and accelerate the transition to net zero.

The programme focuses on:

1. **Stakeholder Engagement:** The energy industry, regulator and government will be impacted by the Virtual Energy System and so must be involved in its development.
2. **Common Framework:** It's vital that there's a framework established setting out technical standards and engagement principles which stakeholders can follow to collaborate and build an interoperable VirtualES.
3. **Value driven development through Use Cases:** The development and build sequence of the VirtualES is organised to respond to real-world needs; its scale and complexity will grow iteratively over time based on requirements of Use Cases it will be called to serve and stakeholders' feedback. We are working with stakeholders to agree which Use Cases to build and how to prioritise them to deliver whole system value.

Key Project Updates

Key developments over the past year include:

Memorandum of Understanding with the National Digital Twin Programme

In November 2023, the Virtual Energy System Programme and the National Digital Twin Programme, led by the UK Government's Department for Business and Trade, signed a Memorandum of Understanding to collaborate on developing an energy system Data Sharing Infrastructure.

This collaboration furthers the aspirations for sector-wide secure and resilient data sharing outlined by the Energy Digitalisation Taskforce, Ofgem's Future Systems and Network Regulation (FSNR) decision, and the recommendations set out in the Department for Energy Security and Net Zero's recent Transmission Acceleration Action Plan.

The agreement supports developing an integrated high-level technical design and architecture, which identifies the interfaces between components of the energy system Data Sharing Infrastructure to be implemented. It further covers scoping the technical, process, and policy requirements for achieving an integrated minimum viable product that both programmes can use to practically demonstrate the concept of connected digital twins.

> We are excited to sign this Memorandum of Understanding with the National Digital Twin Programme, led by the Department for Business and Trade, to look at the components for developing an energy sector data sharing infrastructure. This collaboration is a significant step for energy digitalisation and the goal of enabling secure and resilient exchange of data across the sector, to support the delivery of a zero-carbon energy system in Great Britain by 2035."
>
> ***Shubhi Rajnish, Chief Information Officer at the ESO***

Key Project Updates

Published six priority factors for development of the VirtualES

The creation of the VirtualES is a socio-technical challenge, requiring a collaborative and principled approach. The programme has identified 14 socio-technical factors that create a clear path forward to collaboratively build the VirtualES. Extensive research took place over the last year on the six priority factors below, its outcomes were consolidated and published in a series of reports.

1. Raising awareness and fostering culture
2. Engaging stakeholders
3. Creating a Governance framework
4. Aligning models and taxonomies
5. Increasing visibility and enabling sharing
6. Creating an interoperable tech stack

To validate the outcomes of this research with industry, the programme formed advisory groups.
These groups span both gas and electricity vectors with representatives from industry bodies, networks, generators, suppliers, academia, and technology.

Visit the Virtual Energy System webpage to view reports on the six priority factors.

Scoping and design for a VirtualES pilot

Having converged on the proposed functional specification of a data sharing infrastructure based on desktop research, the next key undertaking of the programme will be to trial and validate its proposals in practice. A round of design and planning has been completed for the implementation of a pilot, in consultation with networks who have expressed interest in participating as partners.

The pilot is shaped to trial how the VirtualES can be formed and used to support business processes for coordination of running arrangements in the context of operational planning as a foundational VirtualES use case. It will mark the beginning of the VirtualES build process with the first instance of the underlying technology being deployed in a virtual lab environment. It will allow the testing, elaboration, and prioritisation of functional and non-functional requirements alongside the development and refinement of the architecture. It will enable gaining feedback from users for future development and building support based on the tangible demonstration of ways the VirtualES is set to bring benefit.

Key Project Updates

Volta

The **Volta** programme is focused on utilising machine learning and AI in the control room to optimise forecasting and dispatch decisions, by leveraging cutting edge technologies and flexible demand and storage technologies. The aim is ultimately to reduce balancing mechanism costs and help achieve a net zero electricity grid.

By unlocking the capability to deliver a control room of the future, Volta gives operators the ability to assess multiple scenarios, providing informed risk profiles and the ability to make strategic operational decisions. The system utilises adaptive input models and machine learning to improve performance monitoring, evaluation and feedback of the system, and the benefit of enhanced operator visualisation.

Over the past year, we have achieved several key milestones:

- Production of a data model report detailing the type, source and quality of data required to run the Adaptive Input Models.
- Capability framework and gap analysis of projects addressing the Volta scope.
- An architectural view and agile plan; a roadmap for delivering Volta in an integrated way with BAU and business plans, including high-level costings and potential supplier list.

Josh Visser, Innovation Incubation Portfolio Senior Manager commented on achievements in the last year:

> It's really exciting to see the significant progress the Volta programme has made over the last year and to have further explored the potential that Volta can offer the future control room, enabling engineers to make better informed decisions, optimising planning and balancing actions to reduce costs."

The next steps for the Volta programme are to decide on the approach to progress the proposed programme of works by prioritising work packages, and by considering funding, timelines and partner options.

Find out more about this Volta project, completed in the last year and registered as Dispatch Optimiser Transformation, on the ENA Smarter Networks Portal.

Key Project Updates

CrowdFlex

The **CrowdFlex** project – now in its two and a half year Beta phase – will run a series of live trials to gather data which will demonstrate the potential of consumer flexibility as a reliable balancing mechanism resource for the Control Room. The information from the trials will be used to develop forecasting models and a better understanding of consumer behaviours, which will inform future market strategies.

It is an industry-wide collaboration, bringing in expertise and knowledge from across the sector (including transmission and distribution partners, big tech and consultants) to operate, refine and analyse a series of live consumer flexibility trials.

Summer and Winter Trials

Participants for the summer trial (May – July 2024) and winter trial (September 2024 – March 2025) will be joining through energy suppliers Octopus Energy and OVO Energy, and EV charger operator Ohme. Participating Octopus and OVO customers will be given Utilisation Payments to increase or decrease their power consumption when required. Ohme customer participants will be given fixed Availability Payments to make their smart assets available at regular times.

The data from the trials will be used to refine the parameters for future trials, improve the effectiveness of communication and engagement with consumers and further develop the forecasting and flexibility models being delivered by the Smith Institute.

Benefits

The CrowdFlex project will demonstrate the potential and reliability of domestic demand-side flexibility services and how these can help ESO to keep the grid balanced with greater penetration of renewable generation. This approach could save the ESO up to £232 million in balancing costs per year, and reduce the need for additional capacity or network reinforcement works by more than £60 million, to considerably lower operating costs and therefore bills for consumers.

Introducing our **Project Lead for CrowdFlex, Sanna Atherton**

> I love working on big, complex innovation projects where you start with a seed of an idea and make it a reality. It's exciting, always new and collaboration is key to making those ambitions a reality. I believe that innovation should help people, and with CrowdFlex we can save consumers money on their energy bills so it will have a positive impact on people's lives."

Find out more about this project on the ENA Smarter Networks Portal.

Projects Live In 2023/24

Project Reference	Project Name	Status	Project Partners
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_NGESO004	Trial on Implementation of Wide Area Monitoring and Control System (WAMCS)	In progress	SP Energy Networks, GE Digital
NIA2_NGESO005	Stability Market Design	Complete	Afry
NIA2_NGESO008	Reactive Power Market Design	In progress	Afry
NIA2_NGESO009	'D3' - Data-driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind	Complete	University of Birmingham
NIA2_NGESO012	COMMANDER – Coordinated Operational Methodology for Managing and Accessing Network Distributed Energy Resources	In progress	National Grid Electricity Distribution, WSP
NIA2_NGESO015	FIC (Future of Interconnectors)	Complete	Afry
NIA2_NGESO018	Automated Identification of Sub-Synchronous Oscillations (SSO) Events	In progress	TNEI Services
NIA2_NGESO020	Strength to Connect	In progress	Imperial Consultants (ICON)
NIA2_NGESO0021	AI Centre of Excellence	Complete	Capgemini
NIA2_NGESO022	BC Forecasting	Complete	UKRI (Hartree Centre)
NIA2_NGESO023	Inertia Measurement Method Optimisation	In progress	National Physical Laboratory (NPL)

Projects Live In 2023/24

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO024	REVEAL	In progress	Capgemini
NIA2_NGESO025	3MD (Market Monitoring Model Development)	Complete	UKRI (Hartree Centre)
NIA2_NGESO026	Consumer Building Blocks	Complete	ERM, Centre for Sustainable Energy
NIA2_NGESO027	Carbon Intensity Modelling	In progress	UKRI (Hartree Centre)
NIA2_NGESO028	Virtual Energy System – Common Framework Demonstrator	Complete	National Gas Transmission, Arup
NIA2_NGESO029	DER Visibility	Complete	UKRI (Hartree Centre)
NIA2_NGESO030	Enduring Cross-Border Balancing	Complete	Compass Lexecon
NIA2_NGESO031	Service Provider Capability Mapping	Complete	LCP Delta
NIA2_NGESO032	Course-correction Dispatch Instructor	In progress	University of Strathclyde
NIA2_NGESO033	Co-optimisation of Energy and Frequency-containment Services	In progress	Imperial Consultants (ICON)
NIA2_NGESO035	Practical Transition into wider EMT GB Modelling	In progress	Manitoba Hydro International
NIA2_NGESO036	Hydrogen Production for Thermal Electricity Constraints Management	In progress	Arup, National Gas Transmission
NIA2_NGESO037	Forecasting the Risk of Congestion	In progress	N-SIDE
NIA2_NGESO038	Whole Energy System Network Planning Review	Complete	DNV
NIA2_NGESO039	Future of the Transmission Network Charging Methodology	In progress	Frontier Economics

Projects Live In 2023/24

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO040	DETECTS II	Complete	Transmission Excellence
NIA2_NGESO041	Model-driven Strategy for Balancing Optimisation (MSBO)	In progress	The Smith Institute
NIA2_NGES042	Revamp Interconnector Ramping Arrangements (RIRA)	Complete	Baringa
NIA2_NGESO043	Demand Flexibility Service Evaluation	In progress	Centre For Sustainable Energy, ERM
NIA2_NGESO044	Dispatch Optimiser Transformation (DOT)	Complete	IBM
NIA2_NGESO045	RealSim: Real-Time Phasor-EMT Simulations	In progress	University of Warwick
NIA2_NGESO046	STARTZ (Stability Requirements Calculation Toward Net-Zero)	In progress	TNEI Services
NIA2_NGESO047	Distributed ReStart – Redhouse Live Trial	Complete	SP Energy Networks, TNEI Services
NIA2_NGESO048	GB Inertia Forecasting with Regional Extrapolation	In progress	General Electric
NIA2_NGESO049	Data-Driven Online Monitoring and Early Warning for GB System Stability (DOME)	In progress	Imperial Consultants (ICON), University of Bath
NIA2_NGESO050	Enhanced RMS (e-RMS) models for stability assurance	In progress	Imperial Consultants (ICON)
NIA2_NGESO051	MinGFM	In progress	University of Birmingham
NIA2_NGESO053	Exploring the Economic Benefits of Co-optimising Procurement of Energy, Response and Reserve	In progress	FTI Consulting LLP
NIA2_NGESO055	QWID FLEXER	Complete	TNEI Services

Projects Live In 2023/24

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO057	Alternative Metering (Baselines)	In progress	The Smith Institute
NIA2_NGESO058	InterCast	Complete	Faculty AI
NIA2_NGESO060	FastOut	Complete	Faculty AI
NIA2_NGESO061	VoltaVisor	Complete	Faculty AI
NIA2_NGESO064	Generative AI Discovery	Complete	ITC Infotech
NIA2_NGESO065	Virtual Energy System: Common Socio-technical Framework Development	In progress	Arup
NIA2_NGESO071	AI Centre of Excellence – GB Energy Industry Data Science Fellowship	In progress	Arup
NIA_WPD_071	ANM Balancing Services co-ordination demonstration (ABCD)	Complete	WSP, National Grid Electricity Distribution, Smarter Grid Solutions
NIA_SHET_0035	TOTEM (Transmission Owner Tools for EMT Modelling) Extension	Complete	Scottish and Southern Electricity Networks Transmission, National Grid Electricity Transmission, SP Transmission, Scottish Hydro Electric Transmission
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 future scenarios based on strategic transport and energy demand modelling STATUS	Complete	National Grid Electricity Transmission
NIA2_NGET0020	Co-Simulation	In progress	National Grid Electricity Transmission, Scottish and Southern Electricity Networks, SP Energy Networks

Projects Live In 2023/24

Project Reference	Project Name	Status	Project Partners
10060460	Scenarios for Extreme Events Discovery	Complete	National Grid Electricity Distribution, Scottish and Southern Electricity Networks, National Gas Transmission, Cadent, Lloyd's of London, University of Strathclyde, Met Office, Frazer-Nash
10060474	Powering Wales Renewably Discovery	Complete	National Grid Electricity Distribution, National Grid Electricity Transmission, Welsh Government, CGI
10070764	CrowdFlex Beta	In progress	Octopus Energy, OVO, Ohme, Centre for Net Zero, Element Energy, The Smith Institute, Scottish and Southern Electricity Networks Distribution, National Grid Electricity Distribution, Centre for Sustainable Energy, Amazon Web Services
10078787	Scenarios for Extreme Events Alpha	In progress	Scottish and Southern Electricity Networks Transmission, National Gas Transmission, Cadent, University of Strathclyde, Met Office, Frazer-Nash
10078792	Powering Wales Renewably Alpha	In progress	National Grid Electricity Distribution, National Grid Electricity Transmission, Welsh Government, CGI, CENIN Renewables, SP Energy Networks
10103996	Network Security in a Quantum Future	In progress	Cambridge Consultants, University of Warwick, University of Edinburgh
10104062	Probabilistic Pathways for Energy System Planning	In progress	National Grid Electricity Transmission, Frazer-Nash

Delivering Value through Collaboration

To achieve net zero in the most efficient and effective way, it is crucial to share our knowledge and work together with a broad range of partners. This year, we have encouraged collaboration and grown our network through various events and opportunities.

Stay informed about the latest news and opportunities by signing up for our mailing list.

Our 2023/24 Partner Network

- Private sector (large) **32%**
- GB Networks **20%**
- Private sector (small) **14%**
- Public Body **12%**
- Private sector (medium) **11%**
- Academia **7%**
- Non-profit **4%**

74
Project partners

Delivering Value through Collaboration

SIF Open Call

In September we invited industry to collaborate with us on developing project proposals for Round 3 of the Strategic Innovation Fund (SIF). Following Ofgem's release of their next round of Innovation Challenges, we worked with subject matter experts across the ESO to identify our focus areas before inviting academics, industry and other innovators to apply with project proposals or as potential project partners. We organised several webinars and drop-in sessions to facilitate applications and meet prospective partners to answer questions. We received over 80 project ideas and 24 expressions of interest to partner.

We worked with our subject matter experts to thoroughly assess each project idea. After narrowing it down to two ideas, we developed them through workshops and stakeholder collaboration into full project proposals ready for submission. The two selected projects, Network Security in a Quantum Future and Probabilistic Pathways for Energy System Planning successfully secured funding and have completed their initial phase. Both projects are now applying for further funding to continue their development and drive the transformation towards a zero-carbon future.

Battery Storage Hackathon

Last year we organised an industry-first hackathon to challenge data scientists to integrate battery forecasting into our balancing activities using open data. The capacity of batteries in GB is growing steadily and we wanted to explore various datasets to understand how batteries can support demand on the network, forecast their impact and see how they can be used to make real-time decisions to balance the system. We received over 500 submissions from participants from across the globe, including Brazil, Switzerland, Taiwan, UAE, Norway, Egypt, India and Thailand.

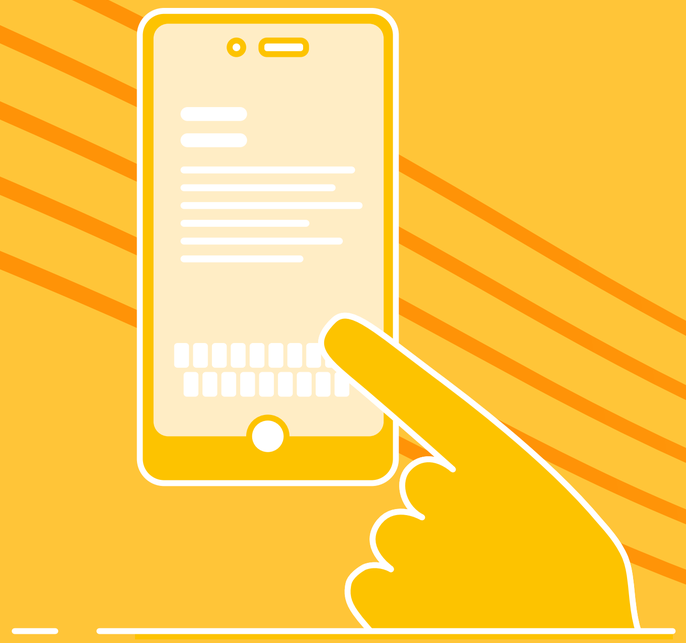
Get in Touch

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

Contact the team: Innovation@nationalgrideso.com

Media enquiries: PressOffice@nationalgrideso.com

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



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