Network Innovation Allowance

Annual Summary 2021/22

nationalgridESO

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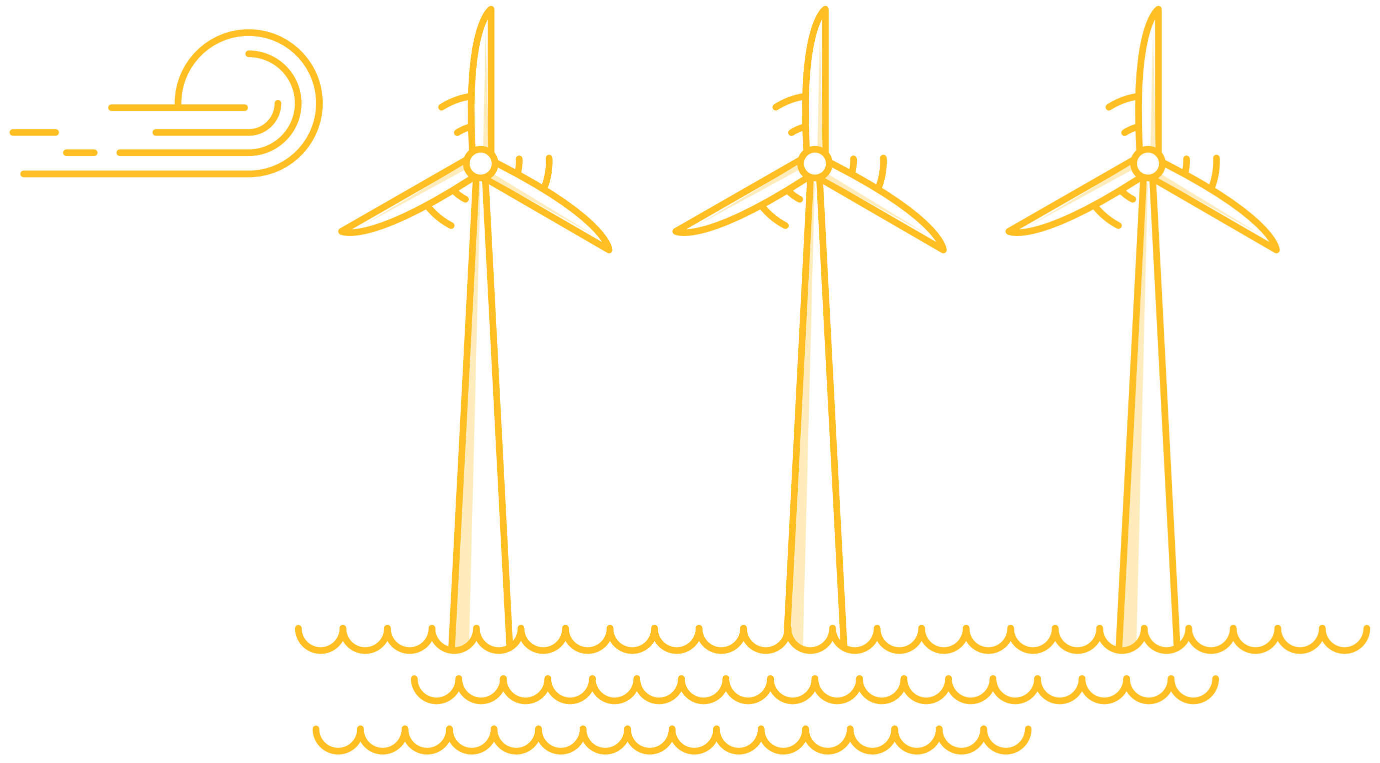


Foreward

As the Electricity System Operator for Great Britain, we are responsible for operating the electricity network safely and efficiently, supplying homes, businesses, and industry with the power they need, when they need it. Our position at the heart of the electricity system means we are playing a central role in delivering the UK's Net Zero target by 2050. As we transition to become the Future System Operator (FSO), innovation will become even more critical to achieving this target, allowing us to explore ground-breaking solutions and technologies across the whole energy system.

The FSO will include all the Electricity System Operator's existing roles, expanding over time to look at the whole energy system, with a focus on net zero, security of supply and ensuring an efficient and coordinated system. Becoming the FSO is a crucial step to help deliver a reliable and clean energy transition for all. We will be right at the heart of the energy system, addressing challenges with a whole-systems approach, providing independent advice and technical input to the government and Ofgem to inform strategic policy decisions.

Fintan Slye
Executive Director,
Electricity System Operator (ESO)

To achieve these key transformations, we must accelerate the rate of innovation and work together as an industry. In our first year under the RIIO-2 price control, we have looked to grow our innovation team, expanding our skills and expertise to maximise opportunities for innovation and collaboration. We have intensified our engagement throughout industry and the ESO, developing exciting partnerships and rapidly expanding our portfolio of projects. A perfect example of this is our Virtual Energy System (VirtualES) project. This project is a world first, a real-time replica of the entire energy landscape that works alongside the physical system. Whilst driven by the ESO, VirtualES is an industry-wide effort to improve simulation and forecasting abilities to facilitate a zero-carbon energy system by leveraging data and driving open innovation.

2021/22 also saw the introduction of the Strategic Innovation Fund (SIF) aimed at funding ambitious, innovative projects with the potential to accelerate the transition to net zero. Collaboration is at the core of SIF and we were delighted to work with 33 project partners on SIF Discovery projects in the last 12 months, leading two projects (CrowdFlex and VirtualES) and supporting eight projects led by other networks. This whole-systems approach is central to the net zero transition and our ambition for 2022/23 is to expand the number of SIF projects we lead and partner on. We will once again be hosting live Open Innovation Events (suspended during the pandemic), the first of which will take place in July 2022, to engage partners from the energy industry and beyond, to co-create innovative solutions to our energy system challenges.

Additional highlights in 2021/22 include the publication of our updated '**Innovating with the Electricity System Operator**' report which explains our process in detail to support partners, and potential partners, to innovate with us. We also refreshed our '**ESO Innovation Strategy**' and, following extensive stakeholder engagement, a new strategic priority was added for 2022/23, Zero Carbon Transition. The need to rapidly decarbonise our energy system is only becoming greater and, while this net zero ambition already underpins all ESO activities, we believe innovation will accelerate this process.

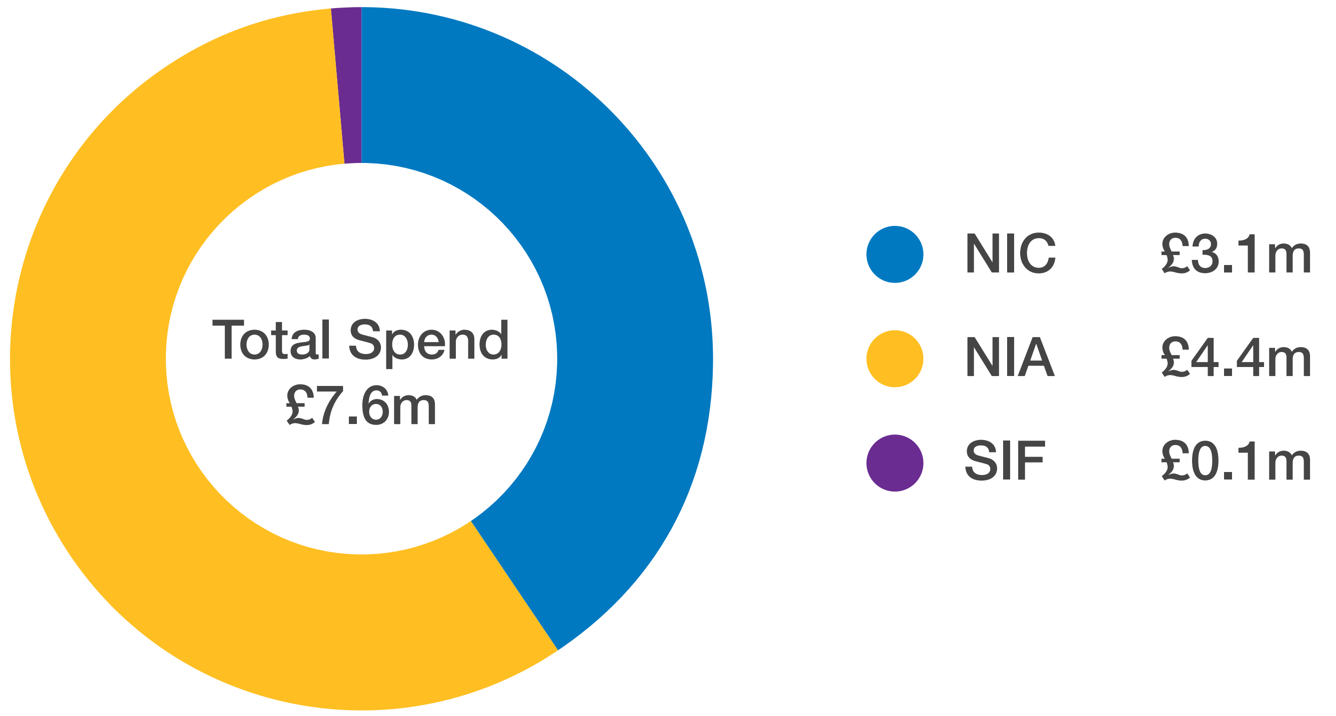
Innovation Strategy / Foreward 04

Portfolio Overview

Projects

Our innovation funding allows us to build a cutting edge and robust innovation portfolio, delivering new tools and technologies that will shape the System Operator of the future.

In our first year of RIIO-2 we have also benefitted from the introduction of the Strategic Innovation Fund (SIF), a new funding mechanism to deliver ambitious, innovative projects with the potential to accelerate the transition to net zero. With collaboration at it's core, we are delighted to lead two SIF Discovery projects and partner on eight SIF Discovery projects working with a range of energy networks, suppliers, and organisations. With our Innovation Strategy providing a clear route, we are innovating in a targeted way, using funding efficiently, to maximise potential benefits for energy consumers.



Our Year in Numbers

NIA Projects

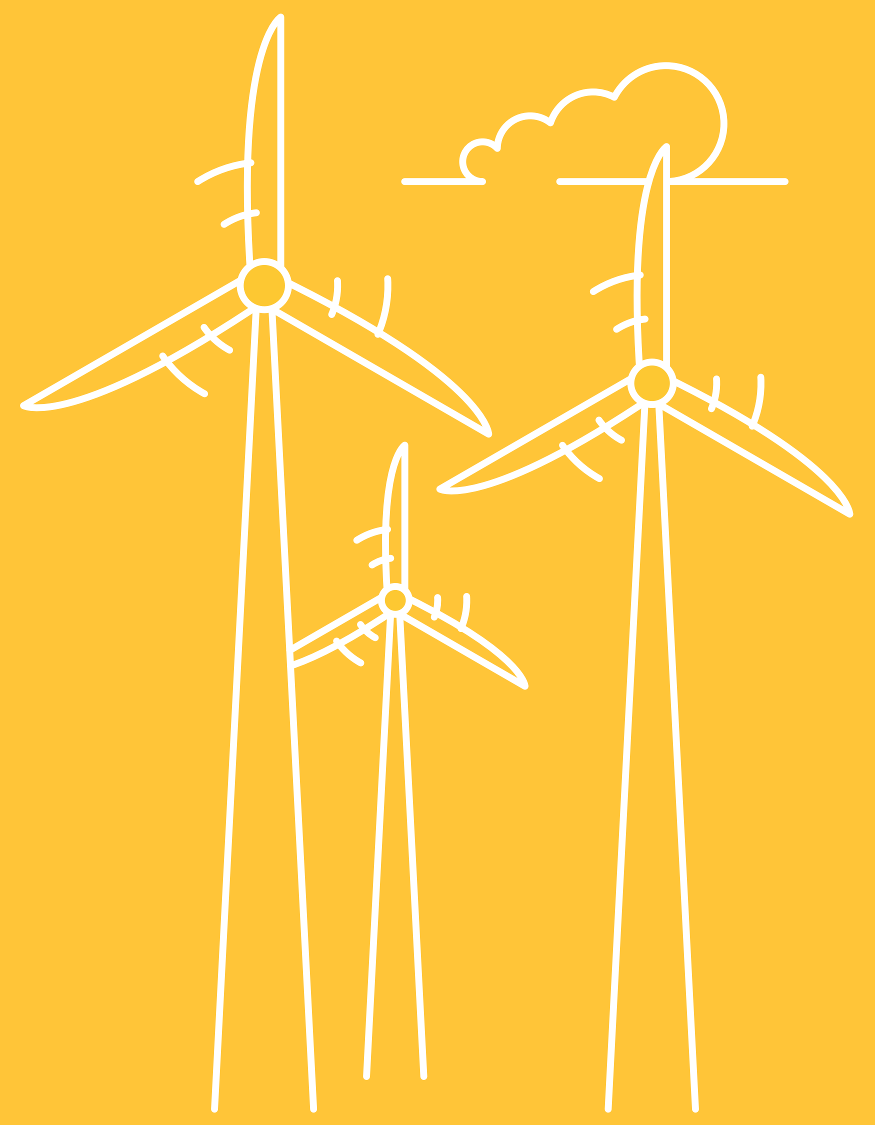
24 Projects Live in 2021/22	**14** RIIO-2 Projects Registered	**10** RIIO-1 Projects Carried Over	**13** Projects Completed

NIC Projects

02 Ongoing NIC Projects	**01** Completed NIC Project

SIF Projects

02 SIF Lead Discovery Projects	**08** SIF Partner Discovery Projects

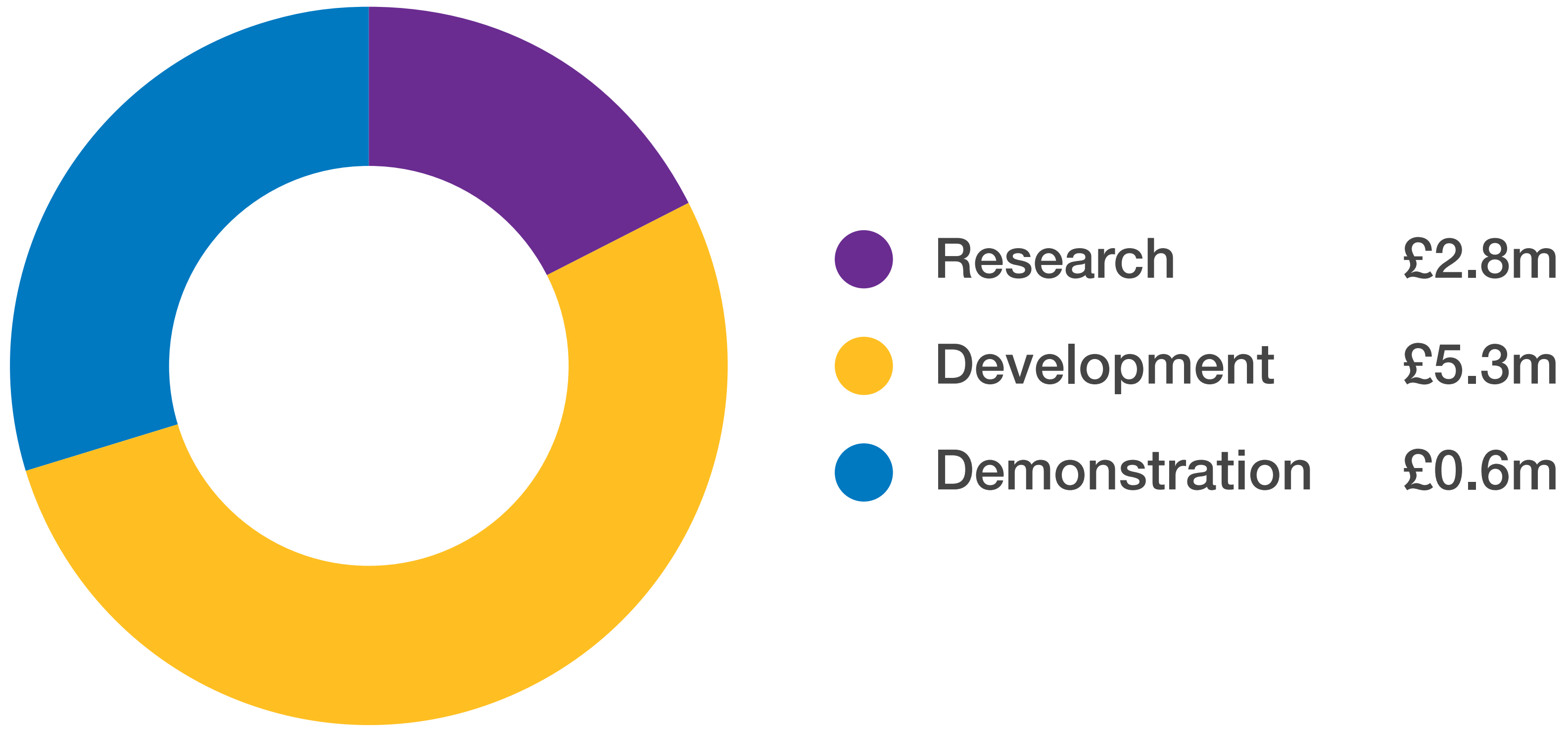


Innovation Strategy / Portfolio Overview 05

Portfolio Overview

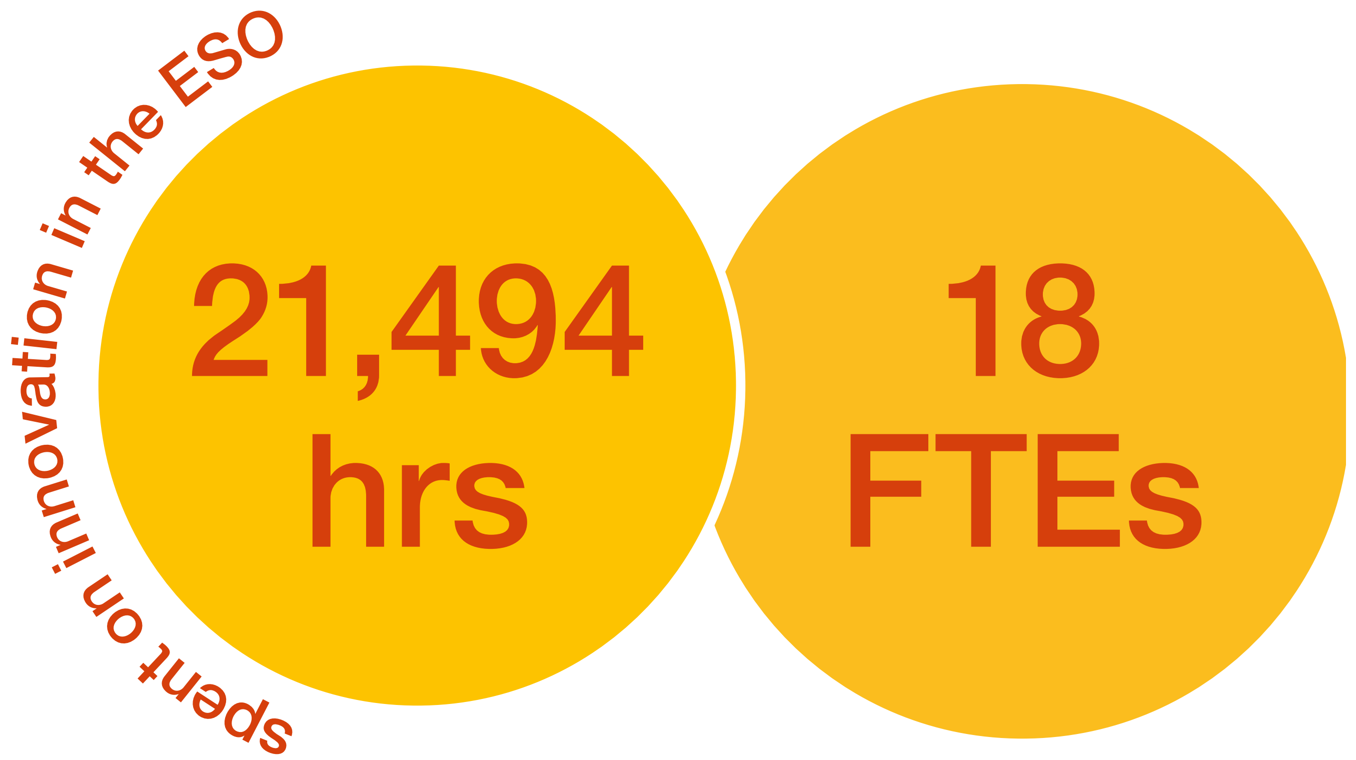
Technology Readiness Levels

We continually endeavour to build a broad portfolio of projects 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 projects in 2021/22 were largely focused on development activities, this reflects a number of projects carried over from RIIO-1 which have completed in the last 12 months.



People

Our highly-talented and dedicated team has grown substantially over the past 12 months to 18 FTEs. Increasing our team three-fold has allowed us to extend our reach throughout the ESO, engaging more employees in innovation projects, solving business challenges and identifying new opportunities for innovation. Our Business Partnering approach, underpinned by our Innovation Strategy, allows us to break down silos and ensure that the whole business is equipped with the opportunity, skills and support to innovate.



Innovation Strategy / Portfolio Overview 06

RIIO-2 NIA Scorecard

Our first year of RIIO-2 also saw the introduction of the Innovation Measurement Framework (IMF) developed by the energy networks to report on a range of innovation measures. These measures have been identified as key enablers of innovation, including collaboration and partnerships, the speed at which innovation is delivered and the benefits innovation has realised. It is one element in a set of activities developed collaboratively by the energy networks and also includes a balanced scorecard, which is a range of measures which demonstrates how innovation is performing in each network.

Our first RIIO-2 NIA Balanced Scorecard reflects the culture of innovation at the ESO, highlighting successes and opportunities for improvement.

Ideas

The ESO received over 100 innovation ideas in 2021/22, with just over 60% of ideas submitted by third parties and the remainder submitted by our colleagues internally. Our RIIO-2 NIA project portfolio is an even split between internal and external ideas, highlighting our openness to external ideas and recognition of the benefits of working with a range of innovators.

'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 NIA eligibility. This initial review determines 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 to optimise the benefit to the energy system and consumers. 51 'Big Ideas' were approved in 2021/22, 12 of which have been registered as projects (2 additional projects were registered from ideas received in RIIO-1) and 39 are currently in the 'Plan and Refine' stage. In the last 12 months the Innovation Team has grown three-fold and a Business Partnering approach has been established in order to accelerate the approval and project development process going forward.

TRL

The TRL Heatmap demonstrates that the majority of our NIA projects fall into the research or early development stage with 86% of projects TRL 4 and below. This reflects 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 and therefore is not a business-as-usual activity. As the innovation portfolio is predominantly focused at low TRL, and it is the first year of RIIO-2, no benefits from our innovation projects have been realised to date. Where successful, we expect research projects to lead to further work to demonstrate the effectiveness of the solution and where proven, be embedded into business-as-usual and the benefits to the consumer and the energy system to be realised.

Project Partners

We have continued to expand our network of project partners in the last twelve months working with partners from academia, energy networks, non-profit organisations and private companies. 41% of the suppliers we partnered with on our NIA portfolio are Small and Medium Enterprises (SMEs). Collaborating with SMEs is crucial to access new ideas, fresh thinking and more agile ways of working to facilitate the energy transition.

RIIO-2 NIA Scorecard

Higher level enablers of innovation

	Initiation & Evaluation	Demonstration, Iteration & Learning	Deployment & Optimisation

Strategy & Vision

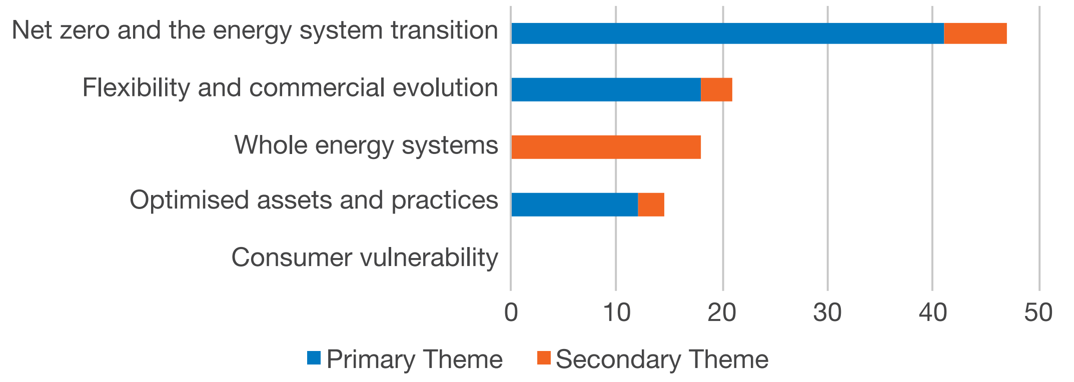
Strategies:

- ESO Innovation Strategy 2022/23
- Electricity Networks Innovation Strategy

8

Average Stakeholder & Customer Satisfaction Score

Spread of projects across ENA themes



Organisation & Culture

102

Innovation ideas generated

TRL Map	% No. Projects	% Spend
TRL 2	14%	9%
TRL 3	36%	40%
TRL 4	36%	38%
TRL 5	14%	12%
TRL 6	0%	0%
TRL 7	0%	0%
TRL 8	0%	0%

14

Projects registered

Capabilities & Technology

60

3rd party Big Ideas received

25

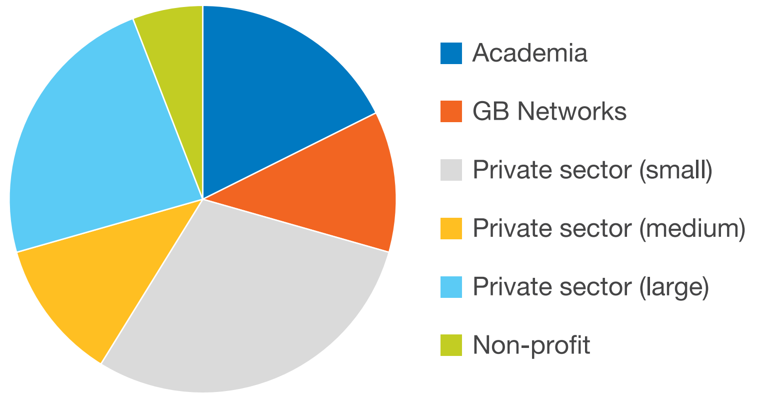
3rd party Big Ideas approved

50%

Total number of registered projects from 3rd party ideas

17

Project Partners



Results & Outcomes

51

Ideas approved at Big Idea stage

39

Big Ideas being developed into projects

45 days

Average length of time from Big Idea submission to initial decision

Innovation Strategy / RIIO-2 NIA Scorecard 08

Performance Against Our Innovation Strategy

Our Innovation Strategy determines our priority areas for the year ahead, providing a clear roadmap against which to focus our activities and develop a portfolio of projects that will accelerate the transition to a net zero energy system.

Figure 1 demonstrates how we performed against these priorities, reflecting how our funding (NIA spend) and efforts (number of projects) were focused over the past 12 months. As our projects typically address more than one priority area, Figure 1 shows how our innovation activities tackle the priorities across the entire portfolio.

Our top priority for 2021/22, Digital Transformation, was reflected in our portfolio, with the highest number of projects focussed primarily on this priority. Digitalisation is a key enabler of the energy system transition and will underpin many of the solutions that address our other priority areas. In 2021/22 we have launched several ambitious digitalisation projects including Virtual Energy System, an industry-wide collaboration led by the ESO to create a digital replica of the entire energy system in Great Britain.

One significant outlier is that we invested more heavily on System Stability than would be expected based on our strategic priorities. The global energy landscape has changed dramatically, even in the short period of time since our Innovation Strategy was published and, as such, System Stability will remain 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 projects addressing Future Markets and Constraint Management, number two and three in our top priorities, also broadly follow this order with the third and fourth highest number of projects in our portfolio respectively.

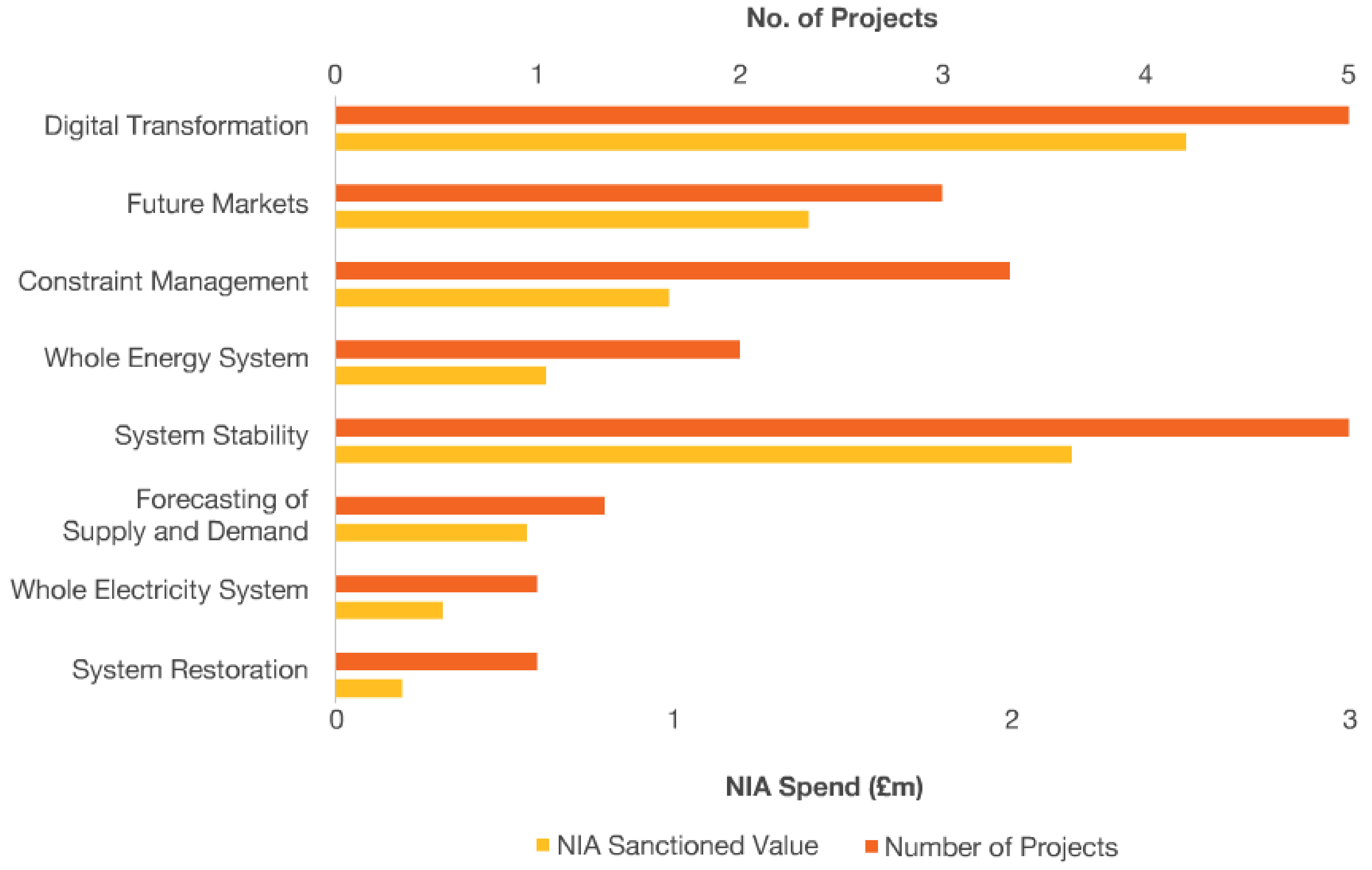


Figure 1. Number of projects linked to our strategic priorities (live projects in 2021/22) and committed NIA spend per strategic priority.

Innovation Strategy / Performance Against Our Innovation Strategy 09

Our Strategic Priorities

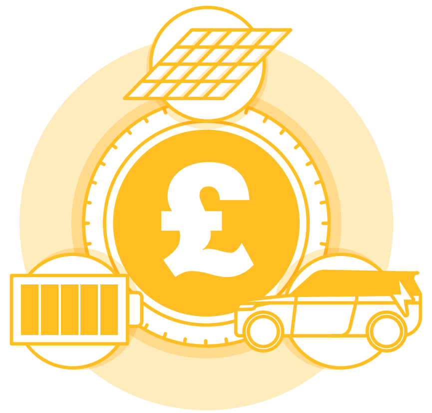
Our Innovation priorities have been refreshed for 2022/23 in consultation with industry and informed by an evolved understanding of the issues from our project portfolio and our Bridging the Gap work. It sets out where to focus our efforts going forward to set us on the right path for 2025 and beyond.

The following section contains case studies illustrating how our priorities are being addressed through innovation projects we are delivering with our partners.

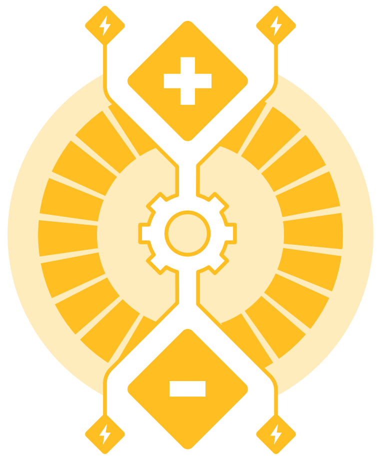
Find out more about our strategic priorities in our 2022/23 Innovation Strategy

1 Zero Carbon Transition

2 Digital & Data Transformation

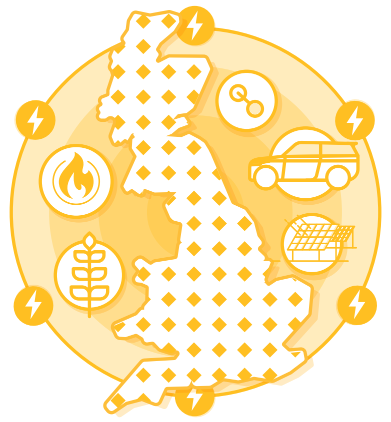


3 Future Markets

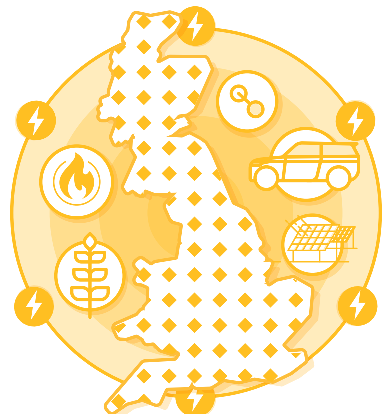


4 Constraint Management

5 System Stability



6 Whole Energy System



7 Whole Electricity System

Innovation Strategy / Our Strategic Priorities 10

Case Study: Optimal Outage Planning System

This project seeks to improve the way maintenance and construction work on the electricity network is planned, and to better estimate the risks of planned outages to the electricity system.

Digital & Data Transformation

Project Overview

Outage planning is a necessary part of maintaining the GB electricity system, as the operator is required to assess distribution and transmission partners' requests to take equipment offline and carry out essential works.

The outage planning process is done manually, and completing the assessment of outage requests relies on the experience of the outage planners.

As we move towards an electricity system with more interconnectors and more renewable energy resources, it's harder to predict the risk of taking parts of the network offline. As such, a lot of time is currently spent on reacting and re-planning.

This project was established to optimise outage planning by creating a tool to automate the process, while adding in more information and risk analysis so that planners can make more accurate assessments.

Outage Planner

Name: Rachael Eynon

About: I started in 2019 as an engineering graduate and have worked across different departments to build up my experience and knowledge of the ESO. I am currently working as an Outage Planner in the Network Assessment Planning department, so the work I am doing on this project is very relevant to my day job.

> *"I've been able to contribute a lot of my own experience of outage planning to this innovation project, ensuring that the outcome will accurately represent the network and the work our department does. The thing I like most about being part of this project is that it will make outage planning quicker and more streamlined, freeing up people's time so they can do more proactive work, and crack on with different issues."*

Innovation Strategy / Case study: Optimal Outage Planning System 11

Case Study: Optimal Outage Planning System

Digital & Data Transformation

This project seeks to improve the way maintenance and construction work on the electricity network is planned, and to better estimate the risks of planned outages to the electricity system.

Results

The first step in the project was to create a simplified network model which could run simple, optimal power flow computations. Four optimisation models were then designed to run on this power model.

The first optimisation model looks at decision-making. It suggests whether a single outage can be added to the outage plan and when this should happen. The decision-making model uses lots of different data including historic scenarios, weather and demand forecasts.

The second model looks at recovery. It works out what should happen if there is a fault when a part of the network is offline due to a planned outage. The model assesses different options to get power back online, including actions planners may not have considered before. The third model calculates the risk to the system of the planned outage, and the fourth looks at the associated costs of the outage.

Early versions of all four optimisation models have been delivered, and can calculate one scenario at a time. The next stage of the project will be to add more data into the models so the tool can process multiple scenarios at once.

Innovation Strategy / Case study: Optimal Outage Planning System 12

Case Study: Optimal Outage Planning System

Digital & Data Transformation

This project seeks to improve the way maintenance and construction work on the electricity network is planned, and to better estimate the risks of planned outages to the electricity system.

Benefits

This project will streamline outage planning, and optimise future outages to ensure they are always the most cost effective, helping to reduce the cost of operating the network and ultimately the cost to consumers. An important benefit to the ESO is the enhanced risk monitoring the tool will deliver, ensuring that planned outages do not affect grid stability or reliability as we transition to net zero operation.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO011	Optimal Outage Planning System	In progress

Project Partners
The University of Edinburgh

Registered Value	Start TRL	End TRL
£385,000	3	5

Innovation Strategy / Case study: Optimal Outage Planning System 13

Case Study: VirtualES Common Framework

The development of a Common Framework is an essential building block for the ESO's Virtual Energy System (VirtualES) project, which is bringing different data and models together to create a digital replica of the complete GB energy system.

Digital & Data Transformation

Project overview

Our energy landscape is becoming increasingly complex as we move towards operating a low-carbon energy system. To navigate this complexity and to ensure we continue to operate the electricity system in the most clean and cost effective way, dynamic data-driven decision making is essential.

The VirtualES project aims to create a digital twin of the whole GB energy system, mapping out the entire network's assets (such as generators, substations, homes etc) with data about each to help the ESO optimise dispatch decisions, better understand the impact of new technologies such as EVs, heat pumps and battery storage, and to support system stability.

At the moment this information is 'siloed', recorded in different places by different stakeholders. So, before we can bring it all together to build the VirtualES, we need a Common Framework so each stakeholder can contribute their data and information in such a way that the data sets can be connected together to create a virtual energy ecosystem.

The Common Framework project is a feasibility study which looks at what is needed to make this collaboration a reality.

Workstream Lead - Virtual Energy System

Name: Jonathan Barcroft

About: I am the lead for the Common Frameworks project, and this is my third innovation project. Each one has been linked as they often tackle silo thinking and applied AI and machine learning to create solutions.

> *"The energy transition is always top of mind, and what we are doing with these innovation projects could have a wide-reaching impact both inside and outside of the ESO. What I've particularly enjoyed about this project is the broad range of stakeholder interaction, as it's highlighting where else we should be collaborating to make even bigger changes."*

Case Study: VirtualES Common Framework

The development of a Common Framework is an essential building block for the ESO's Virtual Energy System (VirtualES) project, which is bringing different data and models together to create a digital replica of the complete GB energy system.

Digital & Data Transformation

Results

Working in partnership with consultancies ARUP, Energy Systems Catapult and IcebreakerOne, the project started by exploring existing best practice examples from around the world and in different industries where cross-sector organisations have brought together assets, systems and digital twins. This gave us an insight into what elements we should be replicating, and help us to understand the scope of the project.

With the benchmarking complete, we mapped out the key elements we would need for the Common Framework and looked at the industry standards which would be needed to roll it out in the future.

At each step in the project, we have engaged stakeholders from industry, academia, research and local government, holding regular open 'show and tell' calls to share our latest findings and to seek feedback.

Innovation Strategy / Case Study: VirtualES Common Framework 15

Case Study: VirtualES Common Framework

Digital & Data Transformation

The development of a Common Framework is an essential building block for the ESO's Virtual Energy System (VirtualES) project, which is bringing different data and models together to create a digital replica of the complete GB energy system.

Benefits

The ESO will be able to use data-driven decision-making to operate the network more efficiently, and to optimise operations to achieve net zero targets. Generating cost savings for the ESO, the connected digital twins and ultimately the end consumers. The Common Framework and the subsequent VirtualES will become a valuable asset which can evolve and grow with the ESO, as the repeatable interfaces can be added to or used for other projects to increase the pace of future innovation projects.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO0014	A Common Framework for a Virtual Energy System	In progress

Project Partners

ARUP, Energy Systems Catapult and IcebreakerOne

Registered Value	Start TRL	End TRL
£350,000	2	3

Innovation Strategy / Case Study: VirtualES Common Framework 16

Case Study: Advanced Dispatch Optimisation

This project is exploring the feasibility of creating an advanced dispatch optimisation tool to help the ESO control room keep the grid balanced in a rapidly changing energy landscape.

Digital & Data Transformation

Project overview

The ESO control room uses Balancing Mechanism tools to keep the network perfectly balanced. But the GB energy system is changing, and we are seeing more renewable generation and battery storage on the grid as well as different demands from consumers, with the increasing electrification of transport and heat. This means there are more variables for the control room engineers to consider and more uncertainty for them to factor into their calculations.

With limited data sets available and a reliance on manual processes and engineer knowledge, the control room needs better tools to manage the additional variables and uncertainty the energy transition is creating.

This project will use desk research and data analysis to look at whether it is feasible to create an advanced dispatch optimisation tool for the system operators, studying examples of best practice around the world and setting out a roadmap of how the tool could be developed.

Innovation SIF Manager

Name: Rhiannon Calado

About: I am working as a project leader for SIF innovation projects, and I bring to that a variety of experience from across the industry having started out in project design and commissioning on the generation side, before moving into commercial procurement and then to ESO. At ESO, I've worked in data and digitalisation roles, energy trading and control system support. I bring this wealth of knowledge to the innovation projects I lead on.

> *"It's a privilege to be working in innovation at this moment in time, where I can bridge the gap between where we are and where we need to be and contribute to the solution. I am motivated by the purpose of delivering a net zero future – without it, we won't have a planet."*

Innovation Strategy / Case study: Advanced Dispatch Optimisation 17

Case Study: Advanced Dispatch Optimisation

This project is exploring the feasibility of creating an advanced dispatch optimisation tool to help the ESO control room keep the grid balanced in a rapidly changing energy landscape.

Results

Working in partnership with Google X and involving ESO personnel including control room operatives, the project researched what could be possible with existing or new data and optimisation techniques and what the priorities were for an advanced dispatch optimisation tool.

The first work package focused on what was already in existence, studying the dispatch optimisation of system operators around the world. GB has unique challenges, but we can learn lessons from other operators with similar challenges. A report of findings will be published in the summer.

The second work package is exploring different types of models, such as probabilistic models, and the potential for machine learning to be utilised. Different approaches to developing a tool are also being analysed, such as creating it in smaller sections to ensure it stays relevant to current system requirements, and the possibility of extending its remit to include carbon emissions data in the future.

Innovation Strategy / Case study: Advanced Dispatch Optimisation 18

Case Study: Advanced Dispatch Optimisation

This project is exploring the feasibility of creating an advanced dispatch optimisation tool to help the ESO control room keep the grid balanced in a rapidly changing energy landscape.

Digital & Data Transformation

Benefits

If an advanced dispatch optimisation platform can be created for the control room it will streamline balancing processes, improve the control room's situational awareness, and give them more options so they can operate the network more cost efficiently – meaning lower bills for the consumer. The project is progressing the ESO's digitalisation ambitions; a key enabler for net zero operations.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO0013	Advanced Dispatch Optimisation	Complete

Project Partners
Google X

Registered Value	Start TRL	End TRL
£750,000	2	3

Innovation Strategy / Case study: Advanced Dispatch Optimisation 19

Case Study: CrowdFlex Discovery

Future Markets

Domestic consumers could help the ESO to manage the grid in the future, by being flexible about when they use their electric vehicle (EV) chargers, heat pumps and white goods on the electricity system.

Project overview

One of the ESO's key challenges is how to balance supply and demand when there is more renewable energy generation on the network – which is not able to flex up and down as required to meet peaks and troughs in demand – especially when there is rapidly growing electricity demand from consumers from their electric vehicle chargers and heat pumps.

One solution is to shift flexibility from being a service delivered on the supply-side (generators) to something delivered on the demand-side (consumers) to help keep the network balanced. For example, asking consumers to charge their EVs when wind generation is high, rather than turning off wind turbines because they are making more power than we need.

The CrowdFlex project looks at the opportunity to create a smart and reliable energy system by using domestic assets as a flexibility resource. It looks at the technologies that could be used to provide flexibility, how to design markets for small assets which will encourage consumer participation, how to conduct a trial to test the delivery of domestic flexibility and how demand-side flexibility services could be forecast in the future.

Innovation Technical Manager

Name: Dr Nina Klein

About: My role is to deliver innovation projects, ensuring they are technically sound and meet the ESO's strategic objectives and deliver value for money. I am on secondment from BEIS, where I provide technical advice to policy makers.

> *"Innovation is important because all the climate change reports are telling us that we must up the pace of energy system transformation. We can't keep taking little steps, we need innovation and the bigger jumps it allows to hit our net zero carbon targets."*

Innovation Strategy / Case study: CrowdFlex Discovery 20

Case Study: CrowdFlex Discovery

Future Markets

Domestic consumers could help the ESO to manage the grid in the future, by being flexible about when they use their electric vehicle (EV) chargers, heat pumps and white goods on the electricity system.

Results

A feasibility study was conducted to understand what services domestic flexibility could provide to the ESO and Distribution Network Operators (DNOs). With the exception of rapid response services, stakeholder engagement highlighted a number of suitable areas for further exploration including energy market flexibility and system operation services.

To understand how these balancing services could be tested in a real-world trial, the study considered the capability of domestic assets - such as electric vehicle chargers, heat pumps and even dishwashers and tumble dryers – and also consumer behaviour to determine key aspects to test in a trial.

The third element of the feasibility study was scoping statistical modelling for domestic demand and flexibility services, which could aid the future development of an accurate and reliable forecasting tool for control room operators.

Innovation Strategy / Case study: CrowdFlex Discovery 21

Case Study: CrowdFlex Discovery

Domestic consumers could help the ESO to manage the grid in the future, by being flexible about when they use their electric vehicle (EV) chargers, heat pumps and white goods on the electricity system.

Future Markets

Benefits

The CrowdFlex project is demonstrating how the ESO may be able to turn the challenge of additional EV chargers and heat pumps into demand-side services that will support greater penetration of renewable generation and the delivery of a low carbon energy system.

This approach could reduce the cost of operating the system through more small assets competing in energy markets to lower costs. These system savings will be passed onto consumers through lower energy bills and consumers participating in flexibility services will receive financial rewards.

Project Information

SIF Reference	Project Name	Status
10027180	Crowdflex: Discovery	Complete

Project Partners

Octopus Energy, Ohme, Element Energy, Western Power Distribution, SSEN Distribution

Registered Value

£206,830

Innovation Strategy / Case study: CrowdFlex Discovery 22

Case Study: Stability Market Design

This project is exploring potential enduring and optimal market design options to procure stability services. The primary objective of our stability market is to ensure cost-efficient provision of services needed to maintain system stability and security in the interests of consumers.

Future Markets

Project overview

We have an ambition to operate a zero carbon grid as well as ensuring the operability of the electricity system based on our Security and Quality of Supply Standard (SQSS). This includes the need to manage system stability, including inertia, short circuit level (SCL), and dynamic voltage support. Traditionally, system stability has been inherently provided by synchronous generators as a by-product of the delivery of energy, as well as by synchronous elements of demand (e.g., motors). As non-synchronous generation in Great Britain (GB) grows and displaces synchronous machines, managing system stability is becoming increasingly challenging.

Today we manage stability through various market arrangements. ESO's long-term stability services are currently provided by pathfinder contracts. The number of these contracts is increasing but our stability requirements will continue to grow in the future as the energy transition gathers pace. At the moment, short-term stability services are procured through the Balancing Mechanism (BM) and energy trades, but these can be expensive and carbon intensive.

This innovation project has explored a potential enduring market design for the procurement of stability services to deliver a stable and secure system.

Innovation culture

Name: Amir Alikhanzadeh

About: I have been with ESO for almost five years and have spent the last 18 months in the Markets department as the Electricity Market Development Manager. My team is responsible for developing the future directions for ESO balancing services markets and answering key strategic market reform questions. We also publish the annual Markets Roadmap, where we provide a transparent view of what market reforms we are introducing.

> *"Being involved in this innovation project has given me the opportunity to answer some of the long term, strategic questions about the future of electricity markets, and given me a fresh perspective on my work. I have been collaborating closely with the wider industry and had the opportunity to hear new and innovative ideas on tackling the stability service challenge; ideas which could one day result in world's first market for stability."*

Innovation Strategy / Case study: Stability Market Design 23

Case Study: Stability Market Design

Future Markets

This project is exploring potential enduring and optimal market design options to procure stability services. The primary objective of our stability market is to ensure cost-efficient provision of services needed to maintain system stability and security in the interests of consumers.

Results

Working in partnership with AFRY, we used qualitative and quantitative studies to understand what the optimal market design would look like.

We broke the market design down into different building blocks, including exploring which time frames worked best (short-, long-term, or both), pricing mechanisms, regional vs national procurement, and the ‘bundling’ of different stability services. We also looked at how we could level the playing field to engage new and existing providers. Stakeholder inputs from webinars and surveys informed our current preferred way forward for these key market design choices. The first phase of this innovation project was completed in March 2022.

The core recommendation of the study is to develop a combination of a dedicated short-term market (day-ahead) and long-term market (building on the well-functioning pathfinder approach) for stability services, while retaining BM actions as a backstop. However, several market design questions remain to be answered before moving on to detailed design and delivery stages.

Innovation Strategy / Case study: Stability Market Design 24

Case Study: Stability Market Design

This project is exploring potential enduring and optimal market design options to procure stability services. The primary objective of our stability market is to ensure cost-efficient provision of services needed to maintain system stability and security in the interests of consumers.

Future Markets

Innovation Strategy / Case study: Stability Market Design 25

Benefits

Creating a fit-for-purpose stability services market will provide efficient dispatch and investment signals and bring value for money, while keeping the grid stable and secure as more non-synchronous generators come online; therefore, supporting the transition to a net zero electricity system. The long- and short-term markets will attract new participants and increase competition. They could lower costs (~£30m* in 2026 and ~£58m* in 2030, Two Degrees FES2019) and carbon emissions as they reduce BM actions.

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: VSM Batteries

VSM – or Virtual Synchronous Machine – technology has the potential to provide stability to the GB electricity system of the future, by enabling us to control frequency and voltage fluctuations without relying on fossil-fuelled power stations.

Constraint Management

Project overview

Currently, we rely on fossil-fuel based stations to stabilise the grid, as they are ‘synchronous generators’ and can give us inertia, to help balance frequency levels, and provide fast acting reactive power to stabilise voltage when required.

Renewable power generators use converter-based technology, which doesn’t have the same properties as fossil-fuelled power stations, so they are less able to stabilise the grid.

Therefore, if we are to bring more renewable power suppliers online in the future, we need to be able to provide the stabilising properties which are inherent within the synchronous generators.

The emerging field of VSM technology has the potential to assist us in overcoming this barrier – in particular, the development of VSM batteries, which could help renewable energy suppliers control their power generation in a new way.

This project set out to investigate the capabilities of VSM battery technology and to discover how it would fair in a test environment. The information could be used to develop a test specification for developers, so they can test VSM-controlled batteries to benefit both us, as the operator, and renewable power suppliers.

Connection Operability Assessment Manager

Name: Djaved Rostom

About: I work within the Networks department, which manages connection applications to ESO. We ensure that solutions meet the technical requirements of the network and that the network is designed efficiently. I have been involved in a number of innovation projects before, but this is the first one based around demonstrating the capabilities of new technology.

> “*There are numerous challenges in creating a sustainable system for the future, so we need to adapt and find new solutions. Innovation is the key to meeting net zero targets, and helps us be on the front foot by exploring new technologies and solutions as opposed to reacting to problems when they come up.*”

Innovation Strategy / Case study: VSM Batteries 26

Case Study: VSM Batteries

VSM – or Virtual Synchronous Machine – technology has the potential to provide stability to the GB electricity system of the future, by enabling us to control frequency and voltage fluctuations without relying on fossil-fuelled power stations.

Constraint Management

Results

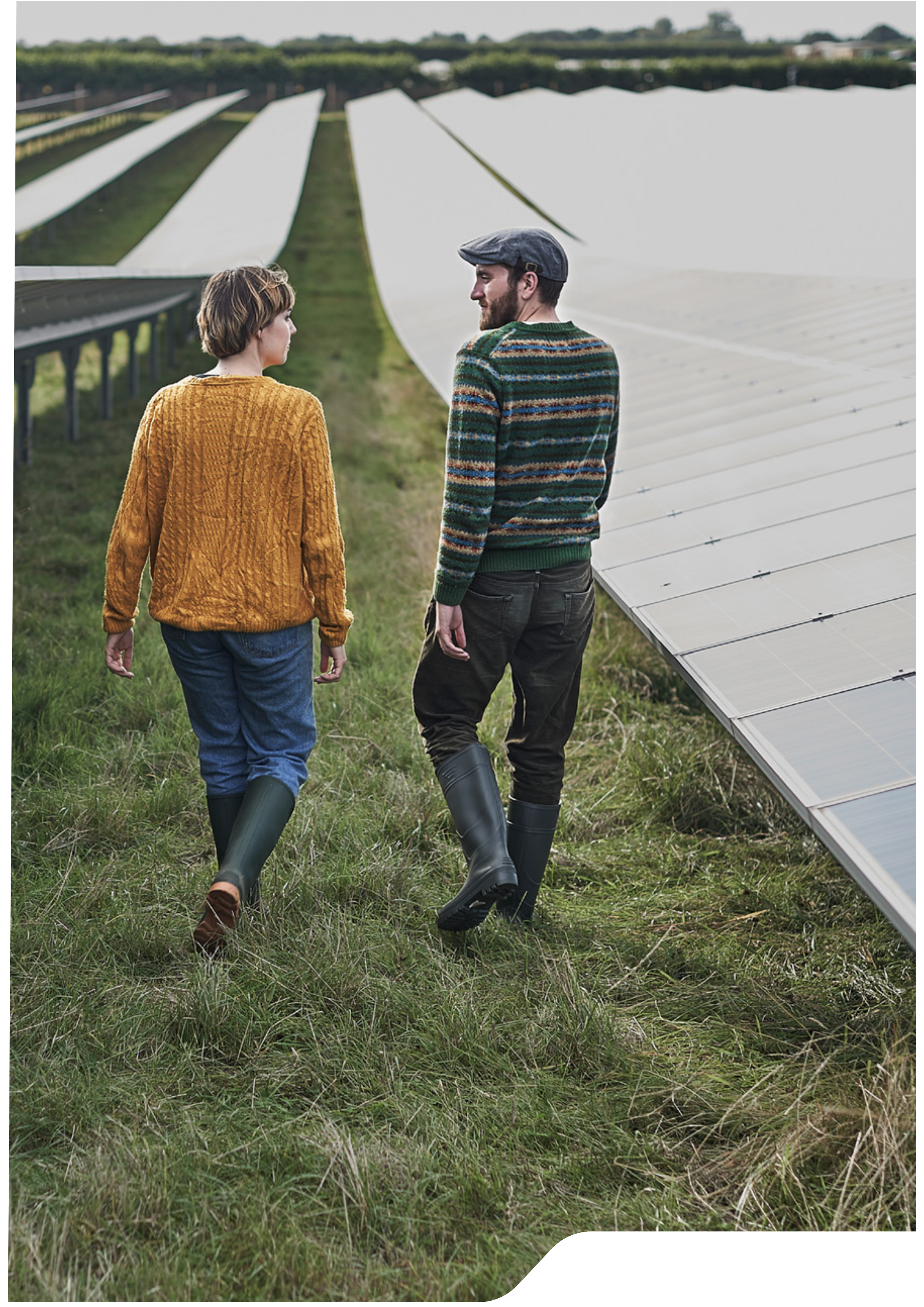
A VSM battery was tested in both the physical environment – on a test grid in Cumbernauld, Scotland – and in a computer-generated simulated environment.

The real and virtual tests looked at the VSM's performance in a variety of scenarios, such as whether it could stay connected through a fault, if it could withstand changes to voltage and frequency, and if it could support energy system restoration following a blackout.

The tests concluded that that VSM can play an important role in the transition to net zero, however variances in performance depending on design highlighted the need for a standard criterion for VSM technology. This has been addressed as part of a Grid Code working group. Compliance tests will also be important to ensure the performance of new VSM technology is quantifiable.

As the first trial in Great Britain to demonstrate a working industry standard VSM prototype in a highly realistic testing environment, the findings from this project will greatly advance the use of VSM batteries for system stability. All findings and reports have been shared with industry, including the publication of two academic papers:

- Comparative Evaluation of Dynamic Performance of a Virtual Synchronous Machine and Synchronous Machines
- Experimental assessment and validation of inertial behaviour of virtual synchronous machines



Innovation Strategy / Case study: VSM Batteries 27

Case Study: VSM Batteries

VSM – or Virtual Synchronous Machine – technology has the potential to provide stability to the GB electricity system of the future, by enabling us to control frequency and voltage fluctuations without relying on fossil-fuelled power stations.

Benefits

VSM technology will play a major role in helping us operate the network with more renewable power generators and it has many potential uses including supporting system stability. This project has advanced our knowledge in this area, refined our approach to future specifications and created a test framework which we can apply to other new grid support solutions.

Project Information

NIA Reference	Project Name	Status
NIA_NGSO0026	Demonstration of Virtual Synchronous Machine control of a battery system	Complete

Project Partners
University Of Strathclyde, Belectric Solar Ltd

Registered Value	Start TRL	End TRL
£275,000	4	6

Innovation Strategy / Case study: VSM Batteries 28

Case Study: Gas And Electricity Transmission Infrastructure Outlook

This project explores a 'whole energy system' approach to the development of transmission infrastructure, as GB's gas and electricity networks will need to work together more in the future to balance energy production and use.

Whole Energy System

Project overview

The decarbonisation of transport, heat, industry and power is likely to create increasing interactions between GB's electricity and gas systems in the future, particularly where new technologies overlap or compete such as the generation of hydrogen.

Currently, the gas and electricity systems operate separately but, to deliver a reliable, flexible, affordable and sustainable energy system, we need to swap silo thinking for a more collaborative and strategic 'whole energy system' approach.

This desktop study and modelling project brings together a consortium of partners, including ESO, National Grid Electricity Transmission and National Grid Gas Transmission, to explore what the transmission network of the future might look like and what infrastructure will be needed to optimise the development of a more integrated system.

Energy Insights & Stakeholder Manager

Name: Alex Haffner

About: I joined National Grid ESO as a physics graduate in 2005. I gained experience in various roles and departments before being appointed most recently as Energy Insights & Stakeholder Manager for the Strategy and Regulation team. My main focus is the Future Energy Scenarios reports (FES), and the innovation projects I am currently involved in are heavily linked to this work.

"The thing I enjoy most about innovation projects is that they are a truly collaborative process, with parties often putting differing views to one side and coming together to solve one specific problem. The projects are crucial in helping ESO meet its decarbonisation targets which is also of particular interest to me personally, as I have made many lifestyle changes over the past few years – such as changing my diet and swapping my old diesel car for an EV – to reduce my own carbon footprint and live more sustainably."

Innovation Strategy / Case study: Gas And Electricity Transmission Infrastructure Outlook 29

Case Study: Gas And Electricity Transmission Infrastructure Outlook

This project explores a 'whole energy system' approach to the development of transmission infrastructure, as GB's gas and electricity networks will need to work together more in the future to balance energy production and use.

Whole Energy System

Results

Using ESO's Future Energy Scenarios (FES) data, the project team agreed on a series of assumptions about how GB's energy demand and supply would change in the years ahead, which would form the basis of the modelling. The FES data was taken from the latest available publication (FES 2021) but there was also an opportunity to factor in current events - such as high energy costs, energy security and the cost of living crisis - into the team's considerations.

Once the scope and requirements of the project had been established, insights were developed into what an integrated energy network might look like, where gas and electricity systems may interact across different industries/sectors and what the benefits of the whole system approach would be for operators and consumers.

The project engaged external stakeholders, such as BEIS and the ENA, through workshops and events to gather feedback on the proposed Net Zero Energy Transmission Network structure, which was considered and used to develop the model further.

The modelling and analysis work is due to complete over the summer, with the publication of findings report due in October.

Innovation Strategy / Case study: Gas And Electricity Transmission Infrastructure Outlook 30

Case Study: Gas And Electricity Transmission Infrastructure Outlook

This project explores a 'whole energy system' approach to the development of transmission infrastructure, as GB's gas and electricity networks will need to work together more in the future to balance energy production and use.

Whole Energy System

Benefits

This project will show how working in collaboration with gas and hydrogen networks to deliver a co-ordinated, whole energy model, will help the ESO better identify where future transmission infrastructure investments should be made to maximise value for money for the consumer. This approach will also optimise the operation of the network to reduce costs and help achieve the ESO's net zero ambitions.

Project Information

NIA Reference	Project Name	Status
NIA_NGGT0184	Gas and Electricity Transmission Infrastructure Outlook	In Progress

Project Partners

Guidehouse Europe Limited
Lead Network: National Grid Gas Transmission

Registered Value	Start TRL	End TRL
£320,000	2	3

Innovation Strategy / Case study: Gas And Electricity Transmission Infrastructure Outlook 31

Case Study: The Role Of Hydrogen As An Electricity System Asset

This project looks at the impact on the electricity system of the increasing use of hydrogen as a low carbon gas, and its potential to support the future decarbonisation of the electricity system.

Whole Energy System

Project overview

There has been a lot of interest in recent years in using low carbon gases - such as hydrogen - for heat, transport, industry and carbon capture applications to help GB achieve its carbon reduction targets by 2050.

Currently, there are two main ways that hydrogen can be made; using natural gas, through the process of methane reformation, or by electrolysis, which requires electricity. The increased generation and use of hydrogen therefore will have an impact on the whole energy system in the future, both by providing an opportunity to support decarbonisation, and in the challenges it could present to gas and electricity demand and infrastructure.

This project was set up to take a closer look at the different ways hydrogen could affect the GB energy system, the costs to create it (using gas and electricity), the cost to move and store it and also whether it could be used to provide balancing services to the ESO.

Energy Insights & Stakeholder Manager

Name: Alex Haffner

About: I joined National Grid ESO as a physics graduate in 2005. I gained experience in various roles and departments before being appointed as Energy Insights & Stakeholder Manager for the Strategy and Regulation team. My main focus is the Future Energy Scenarios reports (FES) and the innovation projects I am involved in are linked to this work.

"*The thing I enjoy most about innovation projects is that they are a truly collaborative process, with partisan needs put to one side and people coming together to solve one problem. The projects are crucial in helping the ESO meet its decarbonisation targets which is also of interest to me personally, as I have made many lifestyle changes over the past few years – such as changing my diet and travel habits – to reduce my own carbon footprint and live a more sustainable life.*"

Innovation Strategy / Case study: The Role Of Hydrogen As An Electricity System Asset 32

Case Study: The Role Of Hydrogen As An Electricity System Asset

Whole Energy System

This project looks at the impact on the electricity system of the increasing use of hydrogen as a low carbon gas, and its potential to support the future decarbonisation of the electricity system.

Results

Working in partnership with Delta EE, we reviewed and developed our existing Future Energy Scenarios (FES) data to include more information about what the future for hydrogen might look like, based on the latest innovations and how they could potentially be used.

We studied how hydrogen might interact with the electricity and gas systems, both in terms of market-based activities and physical infrastructure, and we engaged stakeholders from within ESO and from external organisations, to complete our review.

Next, we chose ten different roles for hydrogen and studied in more detail the impact of each one on the whole energy system. The analysis included road transport and rail, aviation and shipping, industrial and commercial, residential (such as for heating), power generation, carbon capture and storage.

The project will conclude in the summer with the publication of all our findings, including reports for each hydrogen supply chain which can be shared with the industry, providing a rich source of information.

Innovation Strategy / Case study: The Role Of Hydrogen As An Electricity System Asset 33

Case Study: The Role Of Hydrogen As An Electricity System Asset

This project looks at the impact on the electricity system of the increasing use of hydrogen as a low carbon gas, and its potential to support the future decarbonisation of the electricity system.

Whole Energy System

Benefits

This project has provided detailed numerical data which will feed into ESO's Future Energy Scenarios reports (FES), to highlight how hydrogen use and demand is likely to develop in the future. The information will help ESO make better informed decisions about how to run an increasingly decarbonised electricity system in the most cost effective way, and flag up where infrastructure investments should be made to optimise hydrogen's potential to provide low carbon energy and services to help the operator reach net zero targets and improve reliability.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO010	The Role for Hydrogen as an Electricity System Asset	In Progress

Project Partners
Delta-EE

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

Innovation Strategy / Case study: The Role Of Hydrogen As An Electricity System Asset 34

Case Study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind

System Stability

This project is using advanced data-driven power system modelling techniques to investigate how to minimise the risk of control interactions as more High Voltage Direct Current (HVDC) and renewable energy generation are integrated into the future power grid.

Project overview

As the electricity system transitions to net zero operation, there will need to be an additional 40GW from offshore wind farms and 18GW of HVDC Interconnectors between GB and neighbouring countries/regions by 2030.

With extra ‘traffic’ coming into GB’s energy highway, there is a considerable risk of control interactions with existing equipment. To mitigate the risk, offshore wind and HVDC developers are obliged to appropriately design their controllers for those fast-response power electronics applications, but due to confidentiality and IP rules, the ESO is not able to share detailed information with them about other suppliers on the grid to help them do this accurately. This can slow down project lead times and the speed at which new providers can be integrated onto the grid.

The D3 project was established to create a so-called black-box power system dynamic model which will provide accurate data over a wide range of frequencies for new HVDC interconnector and offshore wind developers, without revealing confidential system data.

Power System Engineer

Name: Dr Dechao Kong

About: I am a Specialist Engineer with expertise in DC Systems and Power Electronics. I am currently leading a series of new technology and innovation development projects to manage the risk of increasing the integration of power electronics applications e.g. offshore wind, HVDC into the GB transmission system. My role includes leading on the development of documented technical codes, good practice guidance and relevant tools for stakeholders and customers.

> *“I started my career in academia, but now that I am working in industry, I am in a position where I can develop concepts and make them a reality. The D3 project is a great example of this, as we are strategically investigating the innovative and cost-effective methods/tools for risk management of potential control interactions, which may become a key constraint for increasing the integration of offshore wind and HVDC interconnectors in the future and opening the door to possible solutions using advanced data-drive power system modelling and analysis.”*

Innovation Strategy / Case study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind 35

Case Study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind

This project is using advanced data-driven power system modelling techniques to investigate how to minimise the risk of control interactions as more High Voltage Direct Current (HVDC) and renewable energy generation are integrated into the future power grid.

System Stability

Results

The first phase of the project set out to deliver a benchmarking testing system using an advanced power system dynamic simulation environment which could analyse the behaviour of a complex power network with power electronics integrated into it, focusing on HVDC and wind generation systems.

In the next phase, the project will focus on the development and validation of a frequency-dependent power system model which will identify potential control interaction risks when adding new HVDC and offshore wind systems in close proximity to existing ones.

Once this groundwork has been completed, a black-box model will be delivered that brings together accurate system data and computational learnings using comprehensive data-driven simulations. This model can be shared with stakeholders, as an accurate reflection of the white-box model used by the ESO.

Innovation Strategy / Case study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind 36

Case Study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind

This project is using advanced data-driven power system modelling techniques to investigate how to minimise the risk of control interactions as more High Voltage Direct Current (HVDC) and renewable energy generation are integrated into the future power grid.

System Stability

Benefits

The D3 power system model is a blueprint for best practice which will help ESO speed up connection project delivery and bring new offshore wind and HVDC systems onto the GB transmission system on time to meet net zero targets at different stages. The model will also help de-risk power electronics and provide valuable insights into the dynamics and stability of a power electronic-dominated system.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO009	D3 - Data-Driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind	In Progress

Project Partners

The University Of Birmingham

Registered Value	Start TRL	End TRL
£300,000	2	5

Innovation Strategy / Case study: D3- Data-Driven Network Dynamic Representation For Derisking The HVDC And Offshore Wind 37

Case Study: Resilient EV Charging (REV)

System Stability

This project is investigating the potential impact on grid security of having an increased number of electric vehicle chargers on the GB electricity system.

Project overview

When the sale of new petrol and diesel cars is banned in 2030, sales of electric vehicles (EVs) are expected to increase significantly. This mass adoption of EVs will have a significant impact on the GB electricity system as it will greatly increase demand, and introduce new risks that operators have not seen before.

Individually, one EV charger will not impact grid stability. But collectively, just 2% of the total number of EVs forecast to be in service by 2035 (estimated to be between 12-26 million) could generate a load of 1.7-3.6GW by charging their batteries at the same time.

This project will identify and evolve our understanding of the risks to grid stability associated with an increase in electric vehicle charging and vehicle-to-grid (V2G) generation, and how big the impact could be as EV adoption continues to increase.

Power System Engineer

Name: Annu Tiwari

About: I started my career with National Grid ESO as a power system engineer 13 years ago after completing my master's degree from the university of Strathclyde. I have worked in different teams during that time, giving me experience in a number of business areas including year ahead planning, data modelling, system performance and now in the operability policy team.

> *"I enjoy the challenge of working on this innovation project as I believe knowledge will always enhance you. EVs are a really interesting topic, and everyone wants to know more about them and how they are going to impact us in the future. I particularly like the free-flowing exchange of ideas in this project, it's fascinating to see what will come next."*

Innovation Strategy / Case study: Resilient EV Charging (REV) 38

Case Study: Resilient EV Charging (REV)

System Stability

This project is investigating the potential impact on grid security of having an increased number of electric vehicle chargers on the GB electricity system.

Results

The project started by identifying the risks to the grid from EV charging and V2G, using desk-based research and brainstorm sessions with multiple stakeholders.

Six findings were highlighted as possible events which could cause a power outage. Step, Ramp and Oscillations problems were all flagged as potential outage issues caused by EV chargers turning on or off together or at similar times. The constant power load was identified as a potential cause for degraded stability and also demand control problems, as EV chargers don't respond to voltage reduction. EV chargers could also hinder the restoration process in the unlikely event of a blackout.

The project is using simulations to look at each potential event in more depth, studying its impact across the network from a low voltage circuit level up to UK-wide grid stability. A report of these findings will be published in the autumn.

Innovation Strategy / Case study: Resilient EV Charging (REV) 39

Case Study: Resilient EV Charging (REV)

This project is investigating the potential impact on grid security of having an increased number of electric vehicle chargers on the GB electricity system.

System Stability

Benefits

This project is furthering the ESO's understanding of the risks EV chargers and V2G generation pose to system stability. The information generated will be used in future network planning to mitigate risks, ensure increased demand is met and to prepare the GB electricity system for the large scale adoption of electric vehicles which could include updates to grid codes and new standards for smart energy appliances, and support the zero carbon transition.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO006	Resilient Electric Vehicle charging (REV)	In progress

Project Partners
Sygensys

Registered Value	Start TRL	End TRL
£350,000	2	3

Innovation Strategy / Case study: Resilient EV Charging (REV) 40

Case Study: Solar Nowcasting

This project is using Machine Learning (ML) to develop a tool for the ESO control room which can more accurately predict short-term solar generation.

Forecasting of Supply and Demand

Project overview

As we transition to a zero-carbon future, the penetration of solar generation on the GB electricity network will continue to increase. This brings with it a number of challenges for the ESO – firstly, solar is embedded generation so it is invisible to the grid operators. Secondly, current 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 use machine learning techniques to improve short term solar forecasting and to develop a tool which could give the control room five-minute solar forecasts.

Lead Data Scientist (Machine Learning) / Data Science Manager

Name: Lyndon Ruff

About: I started with ESO as a graduate nine years ago. My specialist field is machine learning and artificial intelligence, and how these can be applied to solve business issues. I am currently working on establishing the ESO's AI Centre of Excellence to share ML/AI best practice across the business.

"I enjoy being involved in innovation projects as they satisfy my curiosity. I also 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 the ESO and UK's carbon emissions targets."

Innovation Strategy / Case study: Solar Nowcasting 41

Case Study: Solar Nowcasting

This project is using Machine Learning (ML) to develop a tool for the ESO control room which can more accurately predict short-term solar generation.

Results

Working with Open Climate Fix, the project has already delivered a machine learning pipeline which is 2.8x more accurate than the ESO's existing solar forecasting tools. It 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.

With proof of concept, the project team is now developing the system into a product with a user interface which can be connected to the control room. Once the finished product has been installed, the project team will gather feedback from control room operatives to see where updates or improvements can be made.

Innovation Strategy / Case study: Solar Nowcasting 42

Case Study: Solar Nowcasting

This project is using Machine Learning (ML) to develop a tool for the ESO control room which can more accurately predict short-term solar generation.

Forecasting of Supply and Demand

Benefits

By improving the accuracy of solar forecasting and reducing the margin for errors in demand, 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.

Project Information

NIA Reference	Project Name	Status
NIA2_NGESO002	Solar PV Nowcasting	In Progress

Project Partners
Open Climate Fix

Registered Value	Start TRL	End TRL
£500,000	2	4

Innovation Strategy / Case study: Solar Nowcasting 43

Case Study: Distributed ReStart

Distributed ReStart is a ground-breaking project exploring whether smaller, renewable energy resources can be used to restore power to the GB electricity system following a blackout.

System Restoration

Project overview

In the very unlikely event that we need to perform an Electricity System Restoration (ESR), also known as a black start), we need to get power back to consumers as soon as possible. Historically, we have done this by using fossil-fuelled power stations which are always on standby to provide the electricity needed to get the transmission system back online.

As we move towards a national electricity system with fewer fossil-fuelled power stations and more Distributed Energy Resources (DERs), we need to find alternative, more cost-effective solutions to restore the network.

This project is exploring and testing new ideas, focusing on how smaller, renewable generators can be co-ordinated to get the electricity system up and running again.

Knowledge & Dissemination Lead

Name: Julie Balch

About: I have worked with National Grid for over six years, in a variety of roles across the GSO and now the ESO as part of their Change Team. In August I joined this exciting ENCC led project to lead the PMO, more recently taking the role as the Knowledge & Dissemination Lead.

> *"I am really enjoying the Distributed ReStart project as I'm passionate about tackling climate change – it's something I work on professionally, and also in a volunteer capacity in my local community. We don't often get the chance to be at the forefront of something so important or to do something which makes a big difference to climate change, but this project has the potential to resolve a major challenge for countries switching to renewable energy sources and our progress is being watched by industry experts around the world. It's really exciting to be part of it."*

Innovation Strategy / Case study: Distributed ReStart 44

Case Study: Distributed ReStart

System Restoration

Distributed ReStart is a ground-breaking project exploring whether smaller, renewable energy resources can be used to restore power to the GB electricity system following a blackout.

Results

We are running live trials in 'power islands' in Scotland to test different design ideas for a DER-based electricity system restoration. The first live trial has already been completed and the fundamental principle of a Distributed Restoration Zone was proven in practice. There will be two more trials later this year.

We completed our desktop exercises to see what organisational systems and communication tools were needed to ensure ESO, DNOs and DERs worked together and communicated effectively. Our model was proven to be effective.

We completed designing the commercial service and procurement process, and we have tested this during a test procurement event. We have also made recommendations for industry code modifications to enable this new service.

Stakeholder engagement is very important for this 'world first' project. We share regular updates on our progress and learnings through published reports, podcasts, webinars, our website and through email campaigns.

Innovation Strategy / Case study: Distributed ReStart 45

Case Study: Distributed ReStart

System Restoration

Distributed ReStart is a ground-breaking project exploring whether smaller, renewable energy resources can be used to restore power to the GB electricity system following a blackout.

Benefits

By using a larger number of distributed energy resources to provide electricity system restoration services, we can open up a new market for restoration service providers providers which will increase competition and diversity in the market. This will reduce our operational costs, and therefore lower bills for our customers.

Removing our dependence on large fossil fuel generators for electricity system restoration services will also support the transition to a zero-carbon energy system and make possible the government's net zero carbon target for 2050.

Project Information

NIA Reference	Project Name	Status
NIC_ESOEN01	Black Start from Distributed Energy Resources	In progress

Project Partners
SP Energy Networks, TNEI

Registered Value	Project Webpage
£11,690,880	https://www.nationalgrideso.com/future-energy/projects/distributed-restart

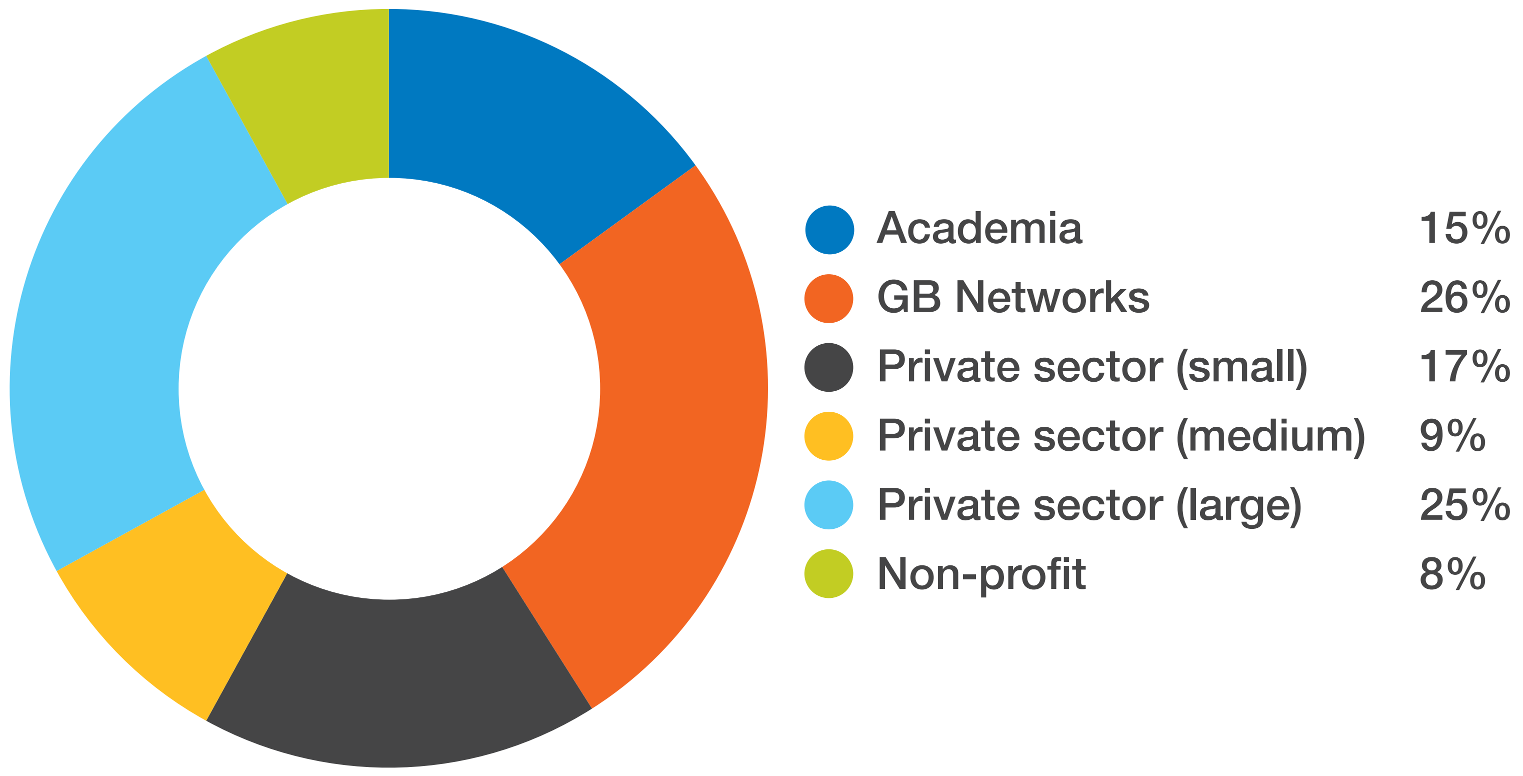
Innovation Strategy / Case study: Distributed ReStart 46

Collaborating To Drive Innovation

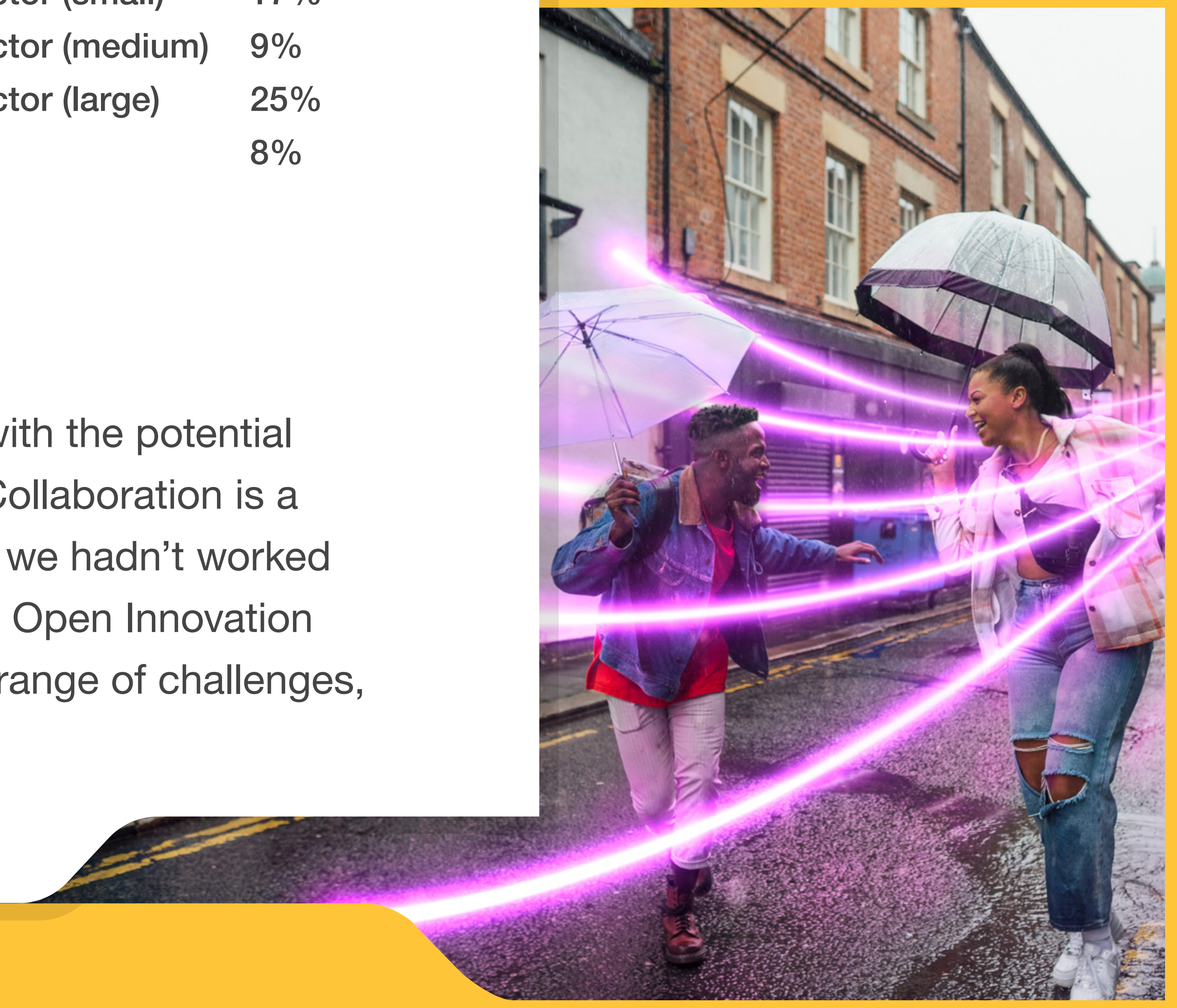
Collaboration remains paramount to innovation at the ESO; we are continually developing new and exciting partnerships to unlock value for consumers and drive towards net zero.

And 2021/22 was no exception. Throughout the last twelve months we have worked with 53 different partners on our innovation projects from across industry including academia, energy networks, non-profit organisations and a range of small, medium and large companies.

We recognise that being open to ideas from across the industry and beyond will ensure we build projects with the potential to transform the energy system and deliver the greatest benefits. Over half of all ideas we received in 2021/22 were submitted from third parties. This is also reflected in our portfolio with half of our registered NIA projects originating from third party ideas.



2021/22 was also our first opportunity to use the new Strategic Innovation Fund (SIF) to kickstart innovative projects with the potential to accelerate the net zero transition. In the first Round of SIF, we partnered on eight Discovery projects and led two. Collaboration is a key criterion of SIF and as such, we worked with 34 partners on these Discovery projects, 23 of which were suppliers we hadn't worked with before. Ahead of the second round of SIF, which will open to applications in early September, we are planning an Open Innovation Event to engage new and existing project partners to explore the opportunities for innovation projects that address a range of challenges, including the SIF Innovation Challenges.



Innovation Strategy / Collaborating To Drive Innovation 47

Collaborating To Drive Innovation

We always strive to expand the range of project partners that we work with, recognising that diverse partnerships can bring a fresh perspective and deliver creative solutions. In order to engage new companies and organisations we have introduced several measures in the last twelve months to make it quicker and easier to innovate with the ESO:

1

Suppliers can now submit a 'Big Idea' directly to the Innovation Team using a **short online form** to capture their idea and the benefits it could deliver.

2

Our recently updated '**Innovating with the Electricity System Operator**' report explains our process in detail and what you can expect when innovating with us.

3

We are introducing a new short survey at project closure to capture feedback from our suppliers about their experience working with us. We are hoping this will identify barriers to successful innovation and opportunities to refine the innovation process further.

We have continued working closely with the Electricity Innovation Managers and Gas Innovation Governance Group, alongside the Energy Networks Association (ENA), on a number of key projects throughout 2021/22. Highlights this year include the publication of our third joint Electricity Networks Innovation Strategy, published in March 2022 alongside the Gas Network Innovation Strategy. The Energy Networks Innovation Conference was held virtually in October 2021 and featured 409 speakers, the highest number of speakers to date at this annual conference. Over 3,000 people registered for the event from 116 countries providing exciting opportunities to share insights and experience globally.

In 2021/22 we focused on increasing our industry engagement further, sharing our experience and collaborating across the energy sector at a series of external events. Particular highlights include:

- Sharing our perspective at the **Ministerial Roundtable** on AI assurance services.
- Exhibiting our innovation projects at the **House of Commons** to showcase the Digitalisation of Energy.
- Delivering two presentations at the **Energy Innovation Forum**.
- Speaking at the highest attended **Utility Week Live** session on 'Smart Homes, Smart Cars and Smart Energy'.

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Towards A Net Zero Energy System

The energy Landscape is changing at an ever increasing pace to deliver a fully decarbonised energy system by 2035. As we transition to this net zero energy system, the increased adoption of cleaner energy approaches such as small-scale renewables, storage and demand-side participation, is making the system more challenging to operate.

The ESO is rising to the challenge by having a clear vision of how we, and the industry, must change to build the energy system of the future. Our Bridging the gap to net zero project has identified the critical milestones on this journey and the actions required to meet each one, through extensive collaboration with the energy industry.

Innovation is playing a central role in facilitating the ESO, and industry, bridge the gap to a flexible energy system by identifying the market and technical solutions needed for system operation in 2035 and beyond.

2022 Key Messages

1 Flexibility needs broad and large-scale investment to start now

Strategic investment is needed in flexibility related assets, which are digitalised and interoperable. This is alongside the need for urgent market reform and investment in all networks.

2 Consumers are part of the solution

Unlocking end-consumer flexibility is fundamental to effectively managing a fully decarbonised energy system. Facilitating access to this flexibility is complex and needs to start now.

3 Net Zero needs cross-sector coordination

A whole system approach to coordinating the delivery of Net Zero across the country is required to prioritise and drive action.

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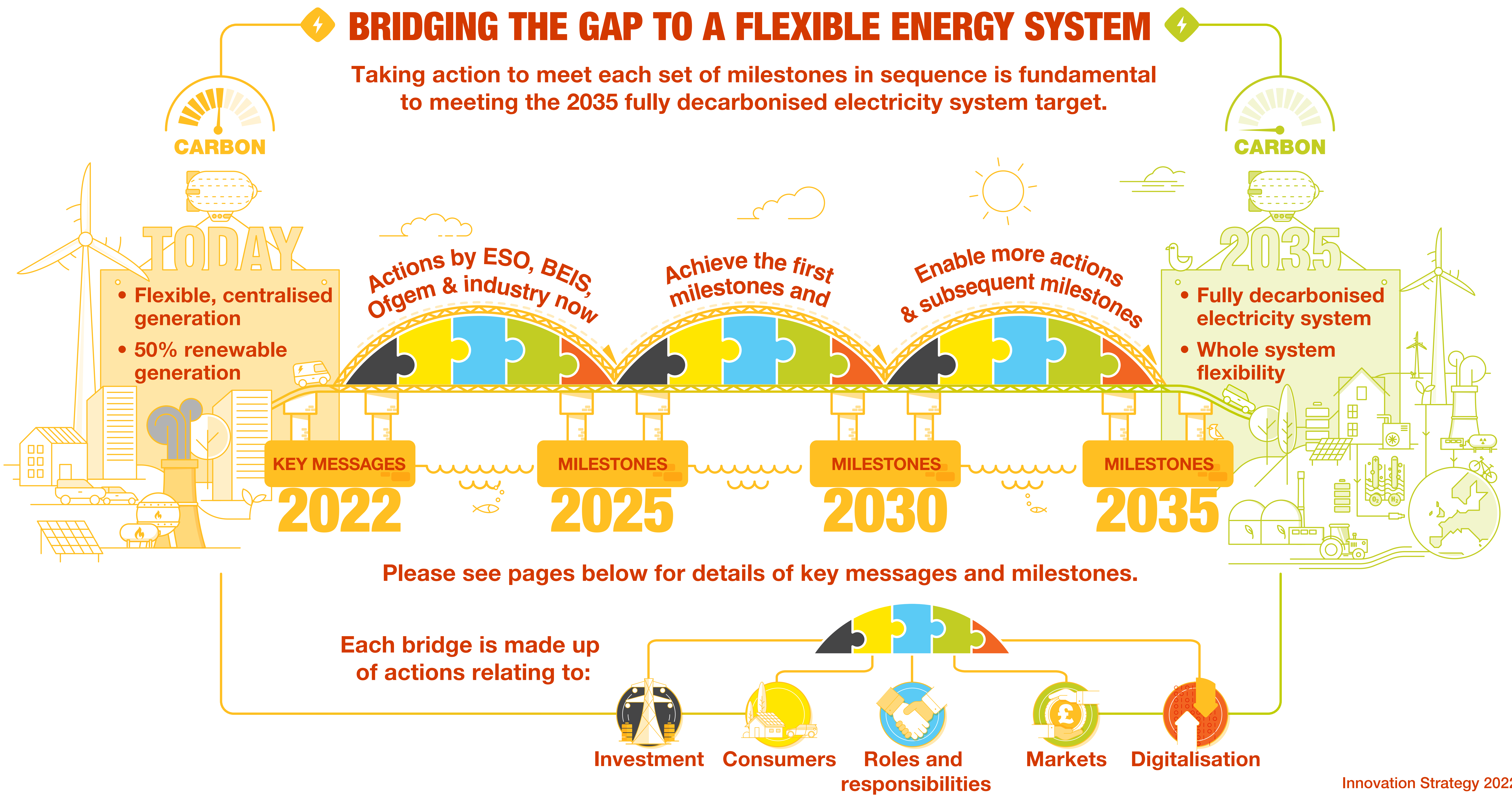
Towards A Net Zero Energy System



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Towards A Net Zero Energy System

2025 PRIORITY MILESTONES

Investment
Strategic flexibility infrastructure projects are underway, e.g. long duration storage, electrolysis.

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

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

Markets
Revenue streams will be more certain for investment in flexible assets.

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

2030 PRIORITY MILESTONES

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

Consumers
Consumer facing businesses enable consumers to provide flexibility.

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

Markets
Reformed markets create incentives for flexibility.

Digitalisation
System balancing and stability actions are automatically deployed.

2035 TARGET MET

Investment
Whole system flexibility infrastructure is in place to enable decarbonised system operation.

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

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

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

Digitalisation
Digitalisation is a fundamental part of the whole energy system as it enables greater market facilitation of flexibility actions.

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Projects Live In 2021/22

Project Reference	Project Name	Status	Project Partners
NIA_NGSO0020	Short-term System Inertia Forecast	Complete	Imperial College London
NIA_NGSO0023	Mapping Impacts and Visualisation Of Risks of extreme weather on system operation (MIVOR)	Complete	University Of Bath
NIA_NGSO0026	Demonstration of Virtual Synchronous Machine control of a battery system	Complete	PNDC, Beletric Solar Ltd.
NIA_NGSO0028	Advanced Modelling for Network Planning Under Uncertainty	Complete	University of Melbourne
NIA_NGSO0029	Applications of convex optimisation to enhance National Grid's NOA process	Complete	University Of Strathclyde
NIA_NGSO0031	DETECTS - Developing Enhanced Techniques to Evaluate Converter-dominated Transmission System Operability	Complete	Power Nova Technology
NIA_NGSO0032	Control REACT	Complete	TNEI Services, The Smith Institute
NIA_NGSO0034	SHEDD – System HILP Event Demand Disconnection	Complete	WSP, Western Power Distribution
NIA_NGSO0035	Optimal Coordination of Active Network Management Schemes and Balancing Services Market	Complete	WSP, Western Power Distribution
NIA_SHET_0032	TOTEM (Transmission Owner Tools for EMT Modelling)	Complete	National Grid Electricity Transmission, Scottish Power Transmission, Scottish Hydro Electric Transmission, Manitoba Hydro international (MHI) Limited
NIA_NGGT0184	Gas and Electricity Transmission Infrastructure Outlook	In Progress	Guidehouse Europe, National Grid Gas Transmission

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Projects Live In 2021/22

Project Reference	Project Name	Status	Project Partners
NIA2_NGESO001	CrowdFlex	Complete	Octopus Energy, Ohme, Element Energy, Western Power Distribution, SSEN
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"	In Progress	Sygensys
NIA2_NGESO007	Decarbonisation of Heat – Integrated Market Study	Complete	Aurora Energy
NIA2_NGESO008	Reactive Power Market Design	In Progress	Afry
NIA2_NGESO009	D3 - Data-Driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind	In Progress	University Of Birmingham
NIA2_NGESO010	The Role for Hydrogen as an Electricity System Asset	In Progress	Delta-EE
NIA2_NGESO011	Optimal Outage Planning System	In Progress	The University of Edinburgh
NIA2_NGESO0013	Advanced Dispatch Optimisation	Complete	Google X
NIA2_NGESO0014	A Common Framework for a Virtual Energy System	In Progress	Ove Arup And Partners
NIA2_NGESO017	Probabilistic planning for stability constraints	In Progress	TNEI Services

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Meet the team

We're always on the look-out for new ideas and opportunities to partner on innovation projects. If you'd like to find out more about the way our innovation process works, the ESO Innovation team would be happy to speak to you and share details of our innovation portfolio.

Learn more about how to Get Involved.

You can submit an idea directly to us using our Big Idea form.

Learn more about our process in our newly published 'Innovating with the Electricity System Operator' report.

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Shaun Clohessy
Business Change Project Manager

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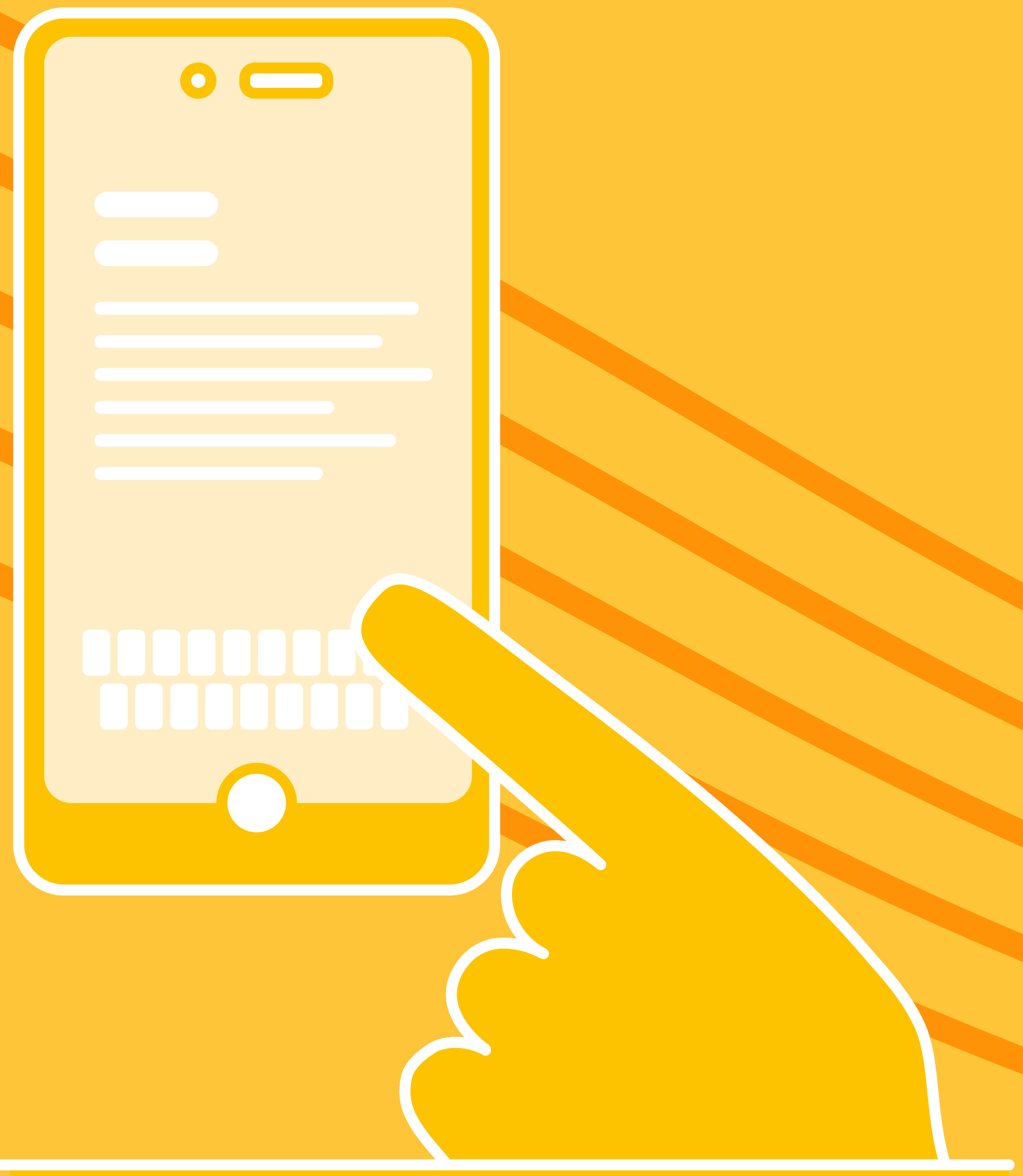
Get In Touch

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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