Network Innovation Allowance

Annual Summary 2018/2019

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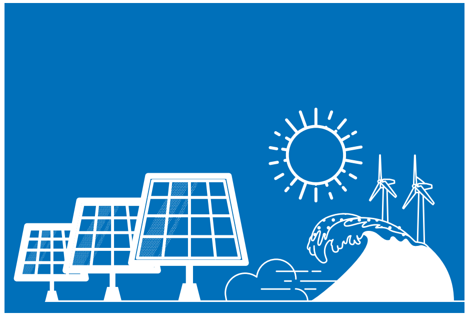
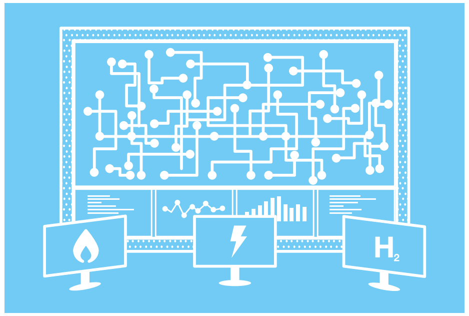




Contents

Projects

All featured projects are linked to System Operator innovation priorities under the following themes:

Introduction

As the Electricity System Operator, we are privileged to sit at the heart of Great Britain's energy system.

This annual summary focuses on innovation projects within the Electricity System Operator (ESO) over the 2018/19 financial year.

We are responsible for operating the electricity network safely and efficiently, while taking action to deliver a secure, low-carbon energy future. We believe that innovation is critical to achieve this, allowing us to explore new technologies and approaches that are likely to play a role in the fundamental transformation of the energy system that lies ahead of us.

It sits alongside our recently refreshed **Innovation Strategy**, which outlines our ambition and progress against our work last year.

Our portfolio of innovation projects is funded through the Network Innovation Allowance (NIA) and the Network Innovation Competition (NIC), as determined by Ofgem. This funding gives us, and those who work with us, welcome and needed opportunities to explore new, riskier ideas than our business-as-usual activities would allow. It means we can identify and test new methods that could deliver even more benefits to the Great Britain consumer.

For example, through our new NIC-funded Distributed ReStart project (formerly Black Start from DER), we aim to demonstrate that it is possible to co-ordinate a large pool of diverse distributed energy resources to restart the GB electricity system following a blackout, while significantly reducing carbon emissions. Using NIA funding, we are looking at a Frequency Response Auction Trial project. This aims to test a fairer and faster system for procuring frequency response services closer to real-time. This would increase competition and drive down consumer bills.

Projects like these would not be possible without close collaboration. This year, we have broadened the diversity of our innovation stakeholders, working more with GB network operators, start-ups and with partners outside of the energy industry. Through activities such as open innovation days, 'Hackathon' events, and an open-door approach to innovation, we hope to increase the extent and value of collaboration through our innovation projects in the future.

As a business, we have set ourselves a bold ambition to be able to operate a zero-carbon 'electricity' grid by 2025. The path to get there is both exciting and uncertain, and with our continued focus on innovation, we hope to work alongside you to help shape the future of energy in Great Britain.

Fintan Slye
Director
UK System Operator

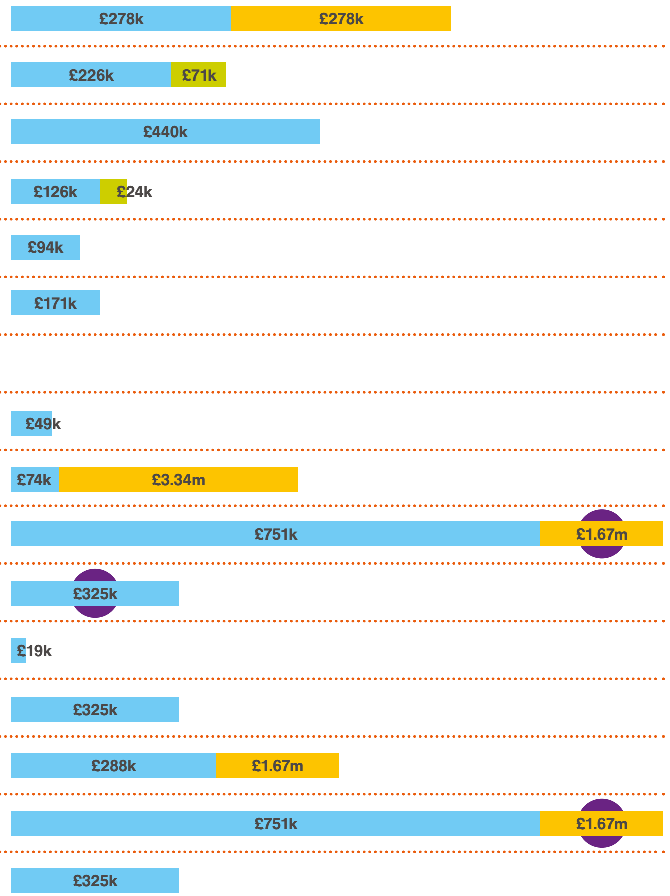
Performance against our strategy

Our innovation strategy not only gives the industry a clear view of where we'll be investing our efforts over the coming year, it also rates our performance as an innovation-focused organisation.

Below, we show how we performed against last year's SO innovation priorities. The graphic shows our 'committed spend' for innovation projects registered in 2018/19, and gives a picture of how we balanced what we spent against our innovation priorities. The committed spend is adjusted based on whether a project directly or indirectly tackles a priority area. Each bar, therefore, shows the number of links a project has to a priority. NIC spending has been scaled down by a factor of 10, so it's easier to compare to NIA and other (non-Ofgem) funding. Innovate UK projects, which we're not directly funded to take part in, are represented in the purple circles.

2018/19 innovation priorities

1. Developing DSOs and whole-system operability
2. Improving short-term generation/supply and demand forecasting
3. Managing volatility in a low-inertia system
4. Leveraging analytics in a data-enabled future
5. Delivering enhanced cyber security
6. Enabling more non-synchronous connections
7. Supporting voltage and reactive power
8. Optimising constraint management
9. Redesigning system restoration
10. Creating markets for the future
11. Harnessing a digitised grid
12. Understanding long-term behavioural change in consumption and generation
13. Enabling changing gas flows
14. Enhancing visibility of DER
15. Unlocking flexibility
16. Embracing gas specification diversity



- **Network Innovation Allowance (NIA)**
- **Network Innovation Competition (NIC) (scaled down by factor of 10)**
- **Natural Environment Research Council (NERC)**
- **Innovate UK**

Towards 2030

A System Operator for GB's energy future

Our System Operator (SO) mission is to enable the transformation to a sustainable energy system and ensure the delivery of reliable, affordable energy for all consumers.

Success in 2025 will look like:

- An electricity system that can operate carbon-free
- A strategy for clean heat, and progress against that plan
- Competition everywhere
- The System Operator is a trusted partner.

To help guide us on this journey, our Towards 2030 publication sets out five priority areas for the System Operator:

- **The engineering transformation:** ensuring reliable, secure system operation to deliver energy when consumers need it
- **The market transformation:** unlocking consumer value through competition
- **The sustainability transformation:** enabling and supporting the move towards a sustainable whole energy future
- **The smart transformation:** driving innovation and more participation across the energy landscape
- **The capability transformation:** developing the right people and systems to deliver the future.

Our Forward Plan and RIIO-2 publications, alongside our innovation strategy, describe the steps we'll take towards the future.

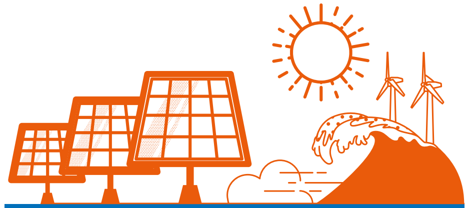
A refreshed innovation strategy for 2019/20

As the industry has continued to evolve rapidly, so too has the System Operator. In particular:

- We can now align ourselves to our newly developed 2030 mission
- We engaged actively on our strategy over the past 12 months and gathered lots of your comments and opinions
- Our understanding of key issues – such as the decarbonisation of heat and transport, and interactions between gas and electricity systems – has moved on significantly. We can now focus our strategic approach on areas of the highest priority, while also consolidating some of these priorities.

Our refreshed innovation strategy can be found here: **Innovation Strategy**

2019/20 priorities	
1.	System stability
2.	Whole Electricity System
3.	Future markets
4.	Forecasting of supply and demand
5.	Digital transformation
6.	Whole Energy System
7.	Whole Gas System
8.	Constraint management
9.	New types of gas
10.	System restoration



How projects are linked to our new strategic priorities

System stability

Synchronous generation supports the stability of the electricity system. As we transform to a low-carbon energy system, there is a reduction in traditional synchronous generation, resulting in effects such as fast system frequency changes and lower voltages. These make it more difficult for both synchronous and non-synchronous generators to operate safely. We must find new ways to understand and improve system stability into the future, ensuring we operate safely and efficiently when stability is reduced.

50Hz

the frequency which a balanced electricity system remains close to

Investigation and Modelling of Fast Frequency Phenomena

We're improving our understanding of a new characteristic on the GB power system: fast frequency phenomena. This will help us connect more renewables in a secure and cost-effective way.

Project overview

All conventional generators across GB are synchronised so that their rotating masses all spin at the same speed (50 times per second), which means that a balanced system has a frequency of approximately 50Hz. Any event on the system – such as the loss of a large generator – causes a change in that frequency which ripples through the system. Not unlike dropping a stone in a pond, these can cause issues if the frequency change is too large and too fast.

Fast frequency phenomena are increasing from the connection of more renewables and can result in two main consequences. Firstly, disturbances on the system are causing a larger ripple effect on the frequency. Secondly, the renewable generation itself is more likely to trip (disconnect from the network) as a result of the frequency fluctuation.

In this project, we're trying to accurately observe and predict how these fluctuations impact the system.

Results

We've developed a 3D visualisation tool, which gives us a remarkably clear picture of how frequency events ripple across the country. This is a significant step forward in how we understand fast frequency phenomena.

We're now developing new modelling techniques that will allow us to better predict frequency fluctuations. We're also building a real-time replica of the GB system, where we can virtually connect sensitive equipment and see how it's affected.

Benefits

By understanding how events unfold and accurately predicting their effects on the system, we'll be able to manage risk better and integrate more renewables securely and cost-effectively.

Project Name:
Investigation and Modelling of Fast Frequency Phenomena ("F2P")

NIA reference:
NIA_NGSO0007

Suppliers:
Brunel University

PEA Cost:
£340,000

Start TRL*:
3

End TRL*:
6

** For an explanation of Technology Readiness Levels (TRL) see page 16.*

Transient Voltage Stability of Inverter Dominated Grids

We've been exploring new ways to analyse and mitigate system instability caused by inverter-connected generators.

Project overview
Some types of generation, such as solar and wind, produce direct current (DC) or non-standard alternating current (AC) electricity. They have to be connected to our network through an inverter, which converts the power to standard AC (50Hz).

As the amount of inverter-connected generation increases, evidence suggests it may create a new type of voltage instability caused by inverters, which can lead to unexpected trips and damage to transmission equipment.

In this project, we investigated the risk of this on the GB system, and what actions or solutions we could take to correct it.

Results
By analysing the power system with a highly detailed model called Electromagnetic Transient (EMT), we found that converter instability could occur on the system in the near future.

Inverter induced instability was found to be a credible risk for the GB grid

In terms of possible solutions, we found that synchronous compensation – a conventional voltage control technology in power networks – is technically effective. Other potential actions include modifying or tuning generators' control systems, or introducing fundamentally different technologies, including Virtual Synchronous Machines.

Benefits
Understanding this new type of instability is critical to operating the system securely and affordably in the future. By analysing the solutions identified in the project, we'll be better placed to support the further growth of zero-carbon, inverter-connected generation.

Project Name:
Transient Voltage Stability of Inverter Dominated Grids and Options to Improve Stability

NIA reference:
NIA_NGET0187

Suppliers:
Power Nova Technology

PEA Cost:
£424,000

Start TRL:
2

End TRL:
4

VSM Demonstrator and Hybrid Grid Forming Converter

We're developing advanced technologies that allow low-carbon sources of electricity to behave more like conventional generators. It could open the door to more low-cost, low-carbon energy on the system.

Project overview
An increasing amount of electricity supply – mainly from interconnectors and renewables – is connected to the grid through power inverters. While this allows more low-carbon energy on to the system, it creates a variety of challenges for operating the grid. These include low inertia and more rapid changes of frequency.

These two pioneering projects are developing technologies that make newer forms of generation act in a similar way to conventional synchronous machines, helping increase the amount of inverter-connected resources while maintaining system stability.

Results
The VSM Demonstrator Project is developing a Virtual Synchronous Machine (VSM), which uses advanced electronic controls to give inverter-connected generators some key features of more traditional machines. Following research to understand if VSM could be a practical solution to supporting the 100% penetration of renewable generation on the system, this project is now building a prototype of the technology for testing. We're refining its design to overcome previous issues with short circuits and an imbalance of harmonics.

In the Hybrid Grid Forming Converter, we're looking into how the principles of VSM could be applied offshore. We're testing how a mix of devices, placed in parallel as hybrids, could allow us to bring more offshore wind online.

Benefits
Both technologies have huge potential to help us operate a system run on increasing amounts of low-carbon, inverter-connected generation. VSM technology could help us hit key carbon-reduction targets at the lowest cost.

Project Name:
Virtual Synchronous Machine (VSM) Demonstrator and Hybrid Grid Forming Converter

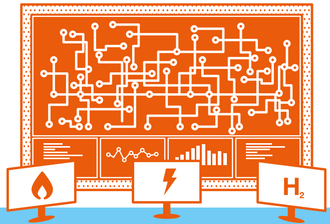
NIA reference:
NIA_NGSO0004 & NIA_NGSO0019

Suppliers:
TTPi, University of Nottingham & University of Strathclyde

PEA Cost:
£456,000 & £292,000

Start TRL:
4 & 3

End TRL:
6 & 4



How projects are linked to our new strategic priorities

Whole electricity system

Decentralised energy resources are connecting to distribution networks, which are transforming the role of Distribution Network Operators (DNOs). These resources can provide valuable services to the ESO, increasing competition in our markets and those of Distribution System Operators (DSOs). Smart technologies also mean consumers can be active players in the system. We need to find innovative ways of designing and operating transmission and distribution networks, and build a whole electricity system approach.

Working with

eight

project partners, we developed, tested and identified potential solutions and benefits.

Enhanced Frequency Control Capability (EFCC)

Our EFCC project was completed this year and has helped us find new ways to stabilise the transmission system as the nation's energy gets greener.

Project overview

As Britain's Electricity System Operator, we rely on a mix of power generation to balance the system.

As renewable generation is increasingly connected to the system, one of the challenges this creates is reduced system inertia (i.e. changes to system frequency occur at a faster rate).

System inertia was traditionally provided by thermal power stations and acts as a natural aid to maintaining system frequency. Any reduction, caused by a rise in renewables, increases the challenge of keeping the system stable.

The EFCC project, which began in 2015, set out to develop a monitoring and control system (MCS) that could manage frequency in a low inertia electricity system. We also wanted to quantify the technical capability of a range of service providers to deliver faster frequency response.

Results

Working with eight project partners, we developed, tested and identified potentially significant solutions and benefits. A cost benefit analysis (CBA) confirmed there are likely to be advantages in introducing a faster frequency response service, co-ordinated by the MCS, that's delivered in just 0.5 seconds.

Benefits

Millions of pounds could be saved every year by reducing the amount of market invention needed to balance the system. To achieve this, we need to further refine the MCS, have access to real-time operational data, and develop the appropriate commercial framework and IS interfaces.

The project concluded in April, and a proposed implementation plan is now in place. Find out more on our **project website**.

Project Name:
Enhanced Frequency Control Capability

NIC reference:
NGETEN03

Partners:
Belectric, Centrica/EPH, Flextricity, Ørsted, Siemens, GE Renewable Energy, University of Manchester & University of Strathclyde

Initial Budget:
£9,344,000

https://www.nationalgrideso.com/innovation/projects/enhanced-frequency-control-capability-efcc

Power Potential

This year, we made significant strides towards creating a world-first system that unlocks more power and flexibility from smaller distributed generators – and could save consumers £400m by 2050.

Central to the project is the creation of a world-first regional reactive power market.

Project overview

Today's energy network includes large volumes of power from distributed energy resources (DERs). These are smaller power generators, such as wind and solar, that are connected to distribution networks.

Through the Power Potential project, we're working with UK Power Networks to create new opportunities for DERs to contribute to the overall efficiency of the electricity system.

Central to the project is the creation of a world-first regional reactive power market. We're developing a distributed energy resource management system (DERMS), which will allow DERs to export more of their energy onto the transmission network, while enabling us, the ESO, to make more efficient decisions on how to manage the grid.

The three-year project is focused on the South of England. Distributed generators involved run from Bolney in Sussex to Canterbury in Kent.

Results

We have been finalising the testing of DERMS, the technical solution, and preparing to integrate new hardware and software with our existing business systems, getting ready for the Power Potential trials. We also recruited DERs to take part in these trials, beginning in summer 2019.

We have received a National Technology Award in the category 'Internet of Things' Project of the Year, which is a great achievement for our team, as it recognises the innovation we are undertaking to deliver a complex but important project for the future.

Benefits

Power Potential could save energy consumers more than £400m by 2050 and allow the connection of a further 3.72 GW in the South East of the UK. It could be rolled out to 59 other transmission sites within the UK, and countless more around the world.

Project Name:
Power Potential

NIC reference:
NGET_UKPN_TDI2.0

Partners:
UK Power Networks

Initial Budget:
£9,560,113

https://www.nationalgrideso.com/innovation/projects/power-potential

Distributed ReStart

In the first project of its kind in the world, we're aiming to prove that smaller, cleaner distributed energy resources can help restore the electricity system after a blackout.

Potential for:

0.81Mt
reduction in CO_2 by 2050

At least £115m by 2050
saved through more competition and reduced costs associated with the readiness of large generators

Project Name:
Black Start DER

NIC reference:
ESOEN01

Partners:
SP Energy Networks

Initial Budget:
£11,690,880

https://www.nationalgrideso.com/project-black-start-from-der

Project overview

Black Start is the process of restoring electricity to consumers after a blackout. While this type of event is unlikely, as ESO we need to have the right processes and resources in place to restart the GB electricity system.

The current strategy for electricity transmission system operators worldwide is to use large, conventional fossil-fuelled power stations and interconnectors to restore electricity systems, but the energy landscape is changing.

There are now fewer large fossil-fuelled power stations generating in GB, while the amount of smaller generators connected to the distribution networks continues to grow. These are known as distributed energy resources – or DERs. We need to adapt our Black Start services to reflect these changes.

This project sets out to demonstrate something no other system operator in the world has done: that it's possible to co-ordinate a number of different DERs to provide a safe and effective Black Start service and deliver significant cost and carbon emission reductions in the process.

The work follows on from our NIA project, Black Start from Non-Traditional Technologies. This showed us how ready different DER technologies are to support the restoration of the system.

This groundbreaking project is a complex challenge that requires broad co-ordination between numerous resources and networks, as well as new commercial, regulatory and engineering solutions.

Results

We're in the early days of this three-year project, but are already making good progress. Work so far has focused on the first work stream, Power Engineering and Trials. We're modelling different types of DERs as well as looking at how we can reduce risk to providers and networks, while making sure the service is efficient and reliable.

The second work stream, Organisational Systems and Telecoms, will develop a comprehensive plan for how DERs can be practically organised and how Black Start services can be called off. We'll create a clear framework for how services will be controlled and how different parties will communicate, so that restoration can be achieved across all Distribution Network Operator areas.

In the third work stream, Procurement and Compliance, we'll prove that our solutions are cost-effective for consumers. We'll also make recommendations on any necessary code changes and propose the best methods for procuring the services.

Benefits

We're leading the world by proving that DERs can be co-ordinated to provide a safe and effective Black Start service. This will increase competition in the market, while achieving major reductions in cost and carbon emissions. Our solution will be the first of its kind and will create the blueprint for other international system operators to follow.

Electric Vehicle Charging Profiles

For the first time, we've created an hour-by-hour picture of the charging habits of electric vehicle users. It's a major stepping stone towards keeping tomorrow's system secure.

Analysis of 8.3m EV charging events produced an hour-by-hour demand profile of charging trends throughout the year.

7–8pm

There's a large evening peak on weekdays when drivers charge their EVs at home. The peak is largest on Monday evenings, then decreases steadily each evening over the course of a week.

Project Name:
Development of GB Electric Vehicle Charging Profiles

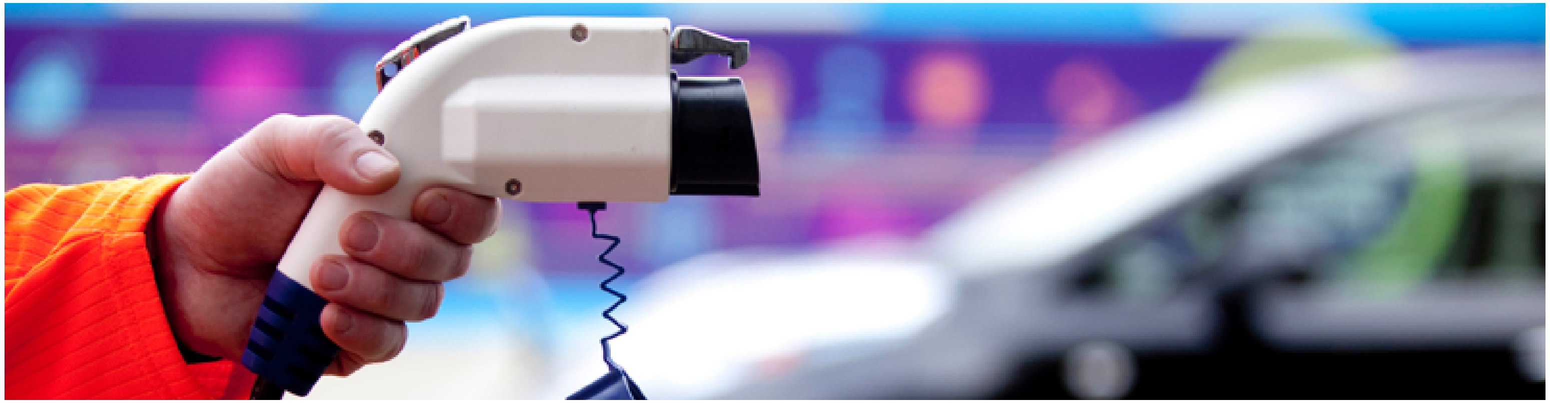
NIA reference:
NIA_NGSO0021

Suppliers:
Element Energy, Charge Master, Pod Point

PEA Cost:
£60,000

Start TRL:
3

End TRL:
4



Project overview

As the number of electric vehicles (EVs) on Britain's roads rises, it's vital we understand their potential impact on the electricity system, especially at times of high demand.

An increase in demand at existing peak periods could lead to major investments in networks and the need for more generation capacity, which would mean higher bills for consumers.

It's important we avoid this, so we want the energy industry to work together to encourage drivers to charge their vehicles outside of these peak hours.

Before we can do that, we need to understand what current charging behaviour looks like. If we know its overall pattern, we can work out the best times of the day to move it to.

This project has been about creating a clear national picture of today's charging habits. We looked at the pattern of EV charging in three areas – at home, at work, and in public places.

We gathered charging data from charge point operators and the Office of Low Emission Vehicles (OLEV) and worked with project partner Element Energy to analyse millions of rows of the charging data we received. This was then turned into an incredibly detailed hour-by-hour profile of charging throughout the entire year.

Results

Data showed us that the primary way car drivers currently charge their EVs is at home. We found that between Monday and Thursday, there's a regular pattern in daily demand. This changes on Fridays and at the weekend. There's a large evening peak on weekdays, which hits its highest point between 7-8pm. This peak also exists, but is lower, on weekends.

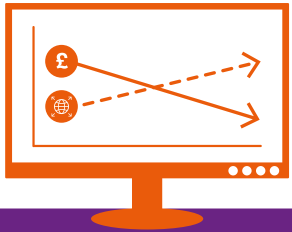
The project also gave us results for workplace and public charging – and showed how demand changes across different distribution network operator regions.

What we've learned has opened the door to a huge amount of further work. This will include honing our analysis based on more data as time progresses. We'll also look to explore how EV charging can be optimised within the electricity system.

The project was completed in time to be included in this year's Future Energy Scenarios (FES).

Benefits

As the uptake of EVs increases, understanding the patterns of charging will help us plan ahead, ensuring the future electricity system is able to support this large source of demand. By including this new data in the analysis for FES, we're improving the quality of our scenarios that inform both the operation and design of the electricity network. This can help us reduce investment in network reinforcement or increased generator capacity – and potentially save consumers millions of pounds.



How projects are linked to our new strategic priorities

Future markets

It is increasingly important to explore markets for new services that can meet changing system needs – as well as markets for new products, such as stability. We also need to create a level playing field for all those taking part in these markets. By working with other networks and all market participants, we will stimulate a cost-effective, whole-system approach, where new participants in the electricity market can expect better access and price signals.

£320k per year

expected savings by introducing more competition into the market

Frequency Response Weekly Auction Trial

We're trialling a fairer and faster system for procuring frequency response services, which is set to increase competition – and ultimately drive down consumer bills.

Project overview

One of our goals as the ESO is to offer equal access to all providers of balancing services. Frequency response is one such service.

We keep system frequency within a set range by continuously balancing the national demand for electricity with the total output of all the generators in Great Britain.

To help us do that, we buy frequency response services from a wide range of generation, demand-side providers and electricity storage. When system frequency is too high they reduce their output or increase their demand; when it's too low they increase their output or reduce their demand. This keeps the system in balance.

Operators of non-traditional energy resources – like renewable generation, storage and demand side response – have told us that our current monthly tender process doesn't work for them, since they can't confidently predict their availability that far into the future.

To address this concern, we're experimenting with making a fundamental change to how we buy frequency response by designing and trialling a weekly pay-as-clear auction. This will help create a more level playing field that will allow a wider range of technologies to participate in frequency response markets.

Results

We've been working with project partner EPEX SPOT to develop the main elements of the new procurement route – both the algorithm that will run the auction and the platform that will act as the link between service providers and ourselves. We'll shortly publish a document on how the auction platform and process will work for providers.

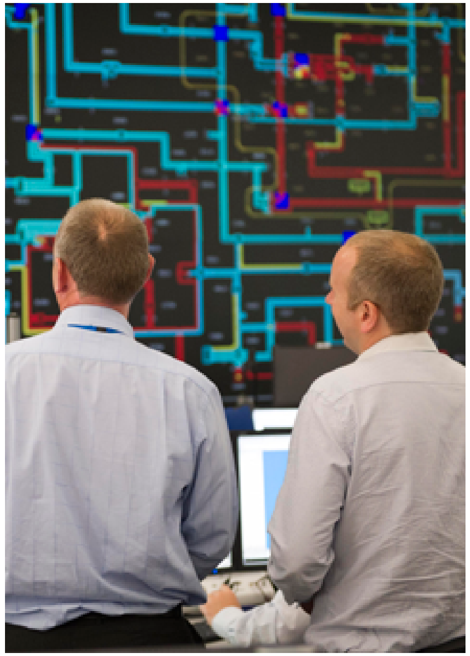
We're also developing new processes and arrangements that will make sure service providers are paid quickly and accurately. This will give greater peace of mind about being part of this market.

Once the auction platform has been developed and tested internally and with stakeholders, we'll run a live trial for two years. This will help us understand how procuring frequency response much closer to real-time than ever before impacts the market. The auction with EPEX SPOT is due to go live in September 2019, and ahead of that we launched a simplified weekly auction in June to trial buying one service.

Benefits

Reducing timescales from a month to a week ahead means more non-traditional service providers will be able to confidently predict their availability. This should increase both the number and diversity of energy businesses taking part in the market.

More participation will create more competition, which we expect will drive down the price our business pays for these services. These savings will ultimately flow through to consumers' bills, while creating new revenue streams for some of the market's newest energy providers.



Project Name:
Frequency Response Weekly Auction Trial

NIA reference:
NIA_NGSO0017

Suppliers:
EPEX SPOT

PEA Cost:
£1,142,000.00

Start TRL:
5

End TRL:
7

Energy Flexibility from Wastewater Catchments

In an industry first, we've teamed up with the water sector to see if megawatts of extra flexibility can be unlocked by holistically controlling wastewater systems.

Our industry and consumers could save

£11m–£17m

per year if the project is successfully rolled out GB-wide

Project overview

Demand side response (DSR) – where businesses turn up, turn down, or shift their energy use in real-time – is an important tool that helps us operate the electricity system securely, sustainably and affordably.

We've identified significant, untapped potential in the water sector to provide DSR. Some of this could be realised by monitoring wastewater catchments; these are the areas built into water systems to protect against rare events such as storms, floods and droughts.

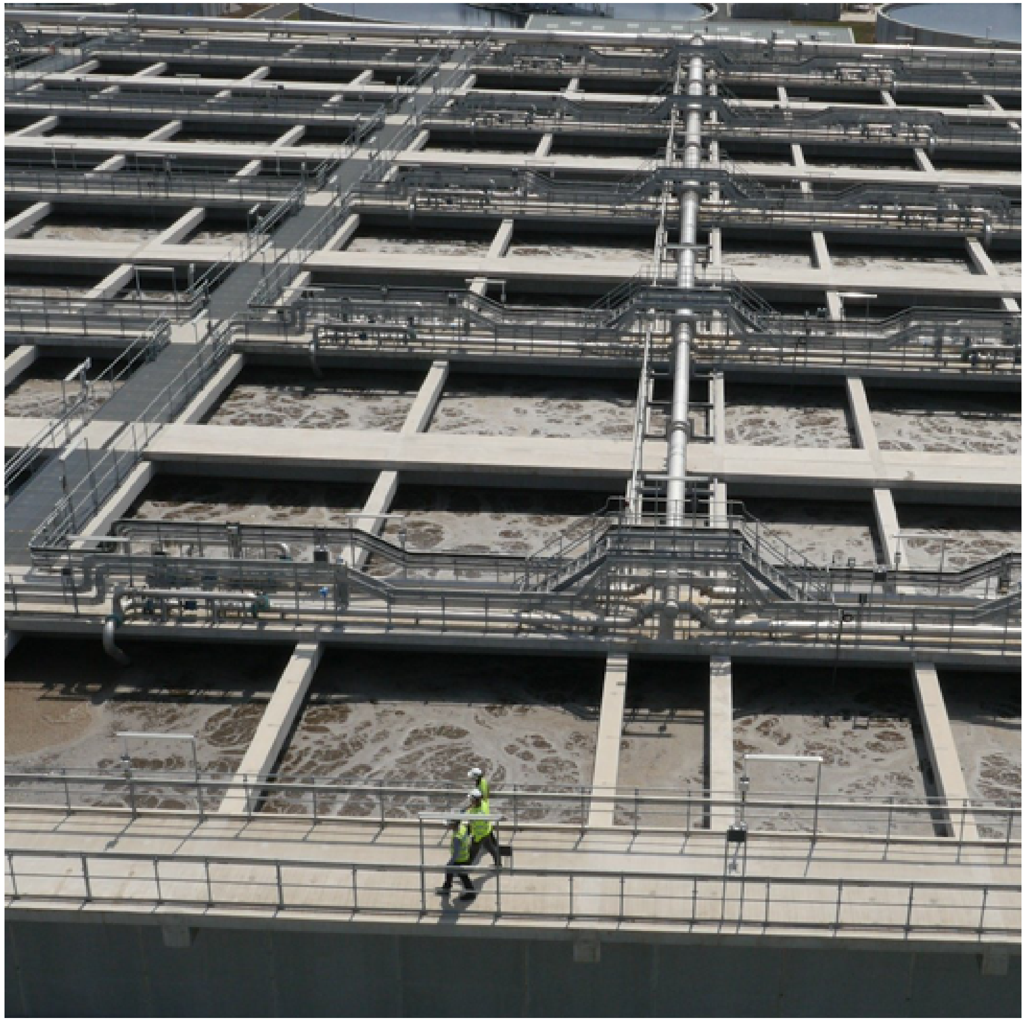
In this project, we've teamed up with water company United Utilities to see if we can use the assets across a whole wastewater system – rather than a single site or process – to provide cost-effective flexibility.

Results

The project started in March. Since then, we've been conducting site surveys across a complete wastewater catchment area. We're collecting data to see how the wastewater assets are operated and how much energy they're consuming. From there, we'll develop a number of models to determine storage capacity across the system and establish where pumps could be potentially turned down to provide flexibility.

Benefits

If the project is successful – and rolled out across Great Britain's water utilities – it could unlock 63-93MW of new flexibility for the electricity system. This could save our industry and consumers between £11m and £17m per year.



We have identified significant, untapped potential in the water sector to provide DSR.

Project Name:
Enhancing Energy Flexibility from Wastewater Catchments through a Whole-System Approach

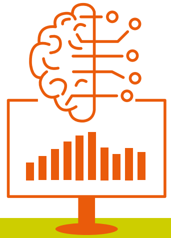
NIA reference:
NIA_NGSO0024

Suppliers:
United Utilities Open Energi

PEA Cost:
£225,000

Start TRL:
3

End TRL:
4



How projects are linked to our new strategic priorities

Forecasting of supply and demand

The short-term forecasting of electricity supply and demand is becoming increasingly difficult. Changing patterns of use and a lack of visibility of electricity generation at distribution level are among the causes. Long-term forecasting is becoming tougher, too, as new technologies and global market forces emerge. We need to understand the changing drivers of supply and demand, explore key areas such as consumer behaviour and technical constraints, and develop novel ways to forecast.

System Impacts of Embedded Storage

We've enhanced our understanding of how batteries connected to the distribution networks may behave, so we're better equipped to keep GB's evolving electricity system secure.

Project overview

As GB's ESO, we can see – and to some extent influence – the behaviour of resources and users on the transmission system. However, that doesn't extend to the distribution networks.

As more energy assets increasingly connect at distribution level, our visibility of these resources decreases.

This is particularly true for electricity storage, much of which is not only found in the distribution networks, but also operates in ways that are complex and poorly understood. This poses a potential risk to the stable operation of the GB system.

In this project, we set out to improve our understanding of the potential risks of embedded storage to system operation.

Results

Through a combination of desktop research, expert input, software modelling and analysis, we've radically improved our understanding of batteries.

After establishing how and why storage assets on the distribution networks are (and could be) used, we developed a tool that helps us quantify the impact of different combinations of storage use on the system. This allows us to identify and classify risks, and take any appropriate action.

Benefits

These scenarios for the behaviour of storage and the innovative tool that we've developed are a powerful starting point for understanding the level of risk from embedded storage over the next decade.

Sharing our learning

We presented the findings from the project to an audience of industry stakeholders at the Electricity Innovation Forum event in February.

Project Name:
System Impacts of Embedded Storage (SIES)

NIA reference:
NIA_NGSO0006

Suppliers:
Carbon Trust

PEA Cost:
£220,000

Start TRL:
2

End TRL:
3

Solar PV Monitoring Phase 3

By improving how we monitor and forecast solar generation on the distribution networks, we're aiming to save money for the consumer, as well as further improve the management of transmission system stability.

By understanding solar generation better, we can forecast supply and demand on the system more accurately.

Project Name:
Solar PV Monitoring Phase 3

NIA reference:
NIA_NGSO0008

Suppliers:
Sheffield Solar (The University of Sheffield)

PEA Cost:
£690,000

Start TRL:
3

End TRL:
7

Project overview

In just over seven years, around 13 GW of solar photovoltaic (PV) generation has been connected to GB distribution networks. This reduces demand at Grid Supply Point (GSP) level, where we flow power from the transmission system onto a distribution network. Some of the generated energy also flows in the other direction onto the transmission system on particularly sunny days, and where there are significant installations of solar PV.

It's critical that we can forecast the generation from these systems in order to manage the GB network in a secure and cost-effective way.

Across the three phases of this work, we've been developing our understanding of the monitoring, measuring and forecasting of PV generation.

In the earlier stages of this work, we measured generation at various sites, developed 30-minute generation patterns for PV, and created a new service to provide this monitoring for National Grid and the wider industry. At phase 3, we're further developing this service.

Results

The work we've done at phase 3 thus far has led to much better estimates of solar power at GSP level. These high-quality estimates allow us to precisely monitor and forecast how much power will flow onto and around the transmission system.

The existing outcomes of the work had been used for some years to make better decisions on how to balance the system at the national level.

For the first time this year, the estimates of GSP solar power produced by phase 3 are being used to support real-time decisions on network outages and constraint management.

Benefits

By understanding solar generation better, we can forecast supply and demand on the system more accurately. This will reduce system balancing costs, and help us improve system stability. We estimate savings for our industry and consumers from the successful outcome of this project to be millions of pounds each year.

Portfolio overview

Innovation, and the new tools and technologies it generates, is playing an important role in building the System Operator (SO) of the future.

Big numbers:

33,102 hours
spent internally on innovation within the ESO

101
employees worked on innovation projects in the ESO for 2018/19

9
projects started

14
projects completed

13
projects continued into 2019/20

Two years ago, we reassessed how we innovate, and produced the first SO Innovation Strategy. This robust piece of work has allowed us to adapt our activities and meet the challenges of a changing energy industry head-on. We're innovating in a more targeted way, using funding more efficiently, and making sure the benefits for both customers and consumers are maximised.

The full story of our funding

In the past year, we spent £3.36m of the NIA allowance and £5.27m of NIC funding (approximately £8.6m in total) on ESO projects. This amounts to 27 individual NIA projects and three NIC projects (two of which we lead on).

NIA: £3.4m

NIC: £5.3m

Technology Readiness Levels (TRL)

We have a broad range of projects in our portfolio and we regularly look to rebalance them. They include activities to develop, demonstrate or research new technologies and processes, which we measure against Ofgem's TRL. This is a scale that measures the maturity of evolving technologies.

Technology Readiness Levels (TRL) are defined as:

- **2-3 Research:** activity to investigate an issue based on observable facts.
- **4-6 Development:** exploring and testing potential solutions to overcome an issue.
- **7-8 Demonstration:** work focused on generating and testing solutions on the network, to get them ready for use in everyday business.

NB: Levels 1 and 9 aren't eligible for NIA funding.

The following figure shows how our projects measure up against the TRL. As a proportion of our total NIA and NIC funding, we've spent the following amounts on these three key areas:

Research: £1.5m

Development: £4.3m

Demonstration: £2.8m

Working with partners

Collaboration is vital to successful innovation.

We worked with 34 different partners on ESO innovation projects this year.

These include universities, DNOs, original equipment manufacturers, infrastructure partners, technology companies and SMEs.

Academia: 5

Technology and service provider: 17

Consultant: 6

Network: 6

By sharing the lessons we learn and being open to ideas from across the industry and academia, we can build projects that transform the gas and electricity systems and bring the greatest benefits. Here's a selection of some of our innovation partnerships:

Frequency Response Auction Trial
We are working with EPEX SPOT to trial closer-to-real-time procurement of frequency response through a cleared-price auction.

RecorDER
We are working with UKPN, SPEN and Electron to design and test a prototype blockchain-based register for GB flexibility and generation assets.

Enhancing Energy Flexibility from Wastewater Catchments through a Whole-System Approach
Following one of our highly successful Open Innovation Days, we are working with north-west water company United Utilities. Together, we're exploring whether extra flexibility on the electricity system can be provided from demand side response (DSR) in the water sector.

Out and about

We've run engagement and dissemination events throughout the year, including:

May 2018 Utility Week Live, Birmingham

July 2018 Future Energy Scenarios (FES) conference, London

September 2018 Transient Voltage Stability of Inverter Dominated Grids and Options to Improve Stability webinar presentation

October 2018 Low Carbon Network Innovation (LCNI) conference, Telford

October 2018 SO Innovation Strategy Refresh for 2019/20 webinar presentation and engagement session

October 2018 Power Responsive Flexibility Forum, London

October 2018 Power Potential dissemination event, London

February 2019 System Impacts of Embedded Storage presented at ENA's 'Innovating with SMEs', Glasgow

February 2018 Enhanced Frequency Control Capability (EFCC) final webinar presentation

April 2019 Electric Vehicle Charging Profile project update shared through FES newsletter

June 2019 WI-POD webinar presentation

July 2019 Investigation & Modelling of Fast Frequency Phenomena (F2P) workshop, London

2018/19 Projects

To learn more about these projects, click the project name to go to the ENA Smarter Networks Portal, or visit: www.smarternetworks.org

Project reference	Project name	Status	Supplier
NIA_NGET0170	PV Monitoring Phase 2	Completed	Sheffield Solar (The University of Sheffield)
NIA_NGET0174	Embedded Cyber Risks Within the Procurement Process	Completed	University of Warwick
NIA_NGET0177	Solar PV Forecasting Phase 1	Completed	The Met Office
NIA_NGET0183	Solar PV Forecasting Phase 2	Completed	University of Reading
NIA_NGET0187	Transient Voltage Stability of Inverter Dominated Grids and Options to Improve Stability	Completed	Power Nova Technology
NIA_NGET0188	WI-POD – Wind Turbine Control Interaction with Power Oscillation Damping Control Approaches	In progress	University of Warwick
NIA_NGET0193	Project DESERT (Hybrid Battery and Solar Enhanced Frequency Control)	In progress	Belectric
NIA_NGSO0001	Optimisation of Energy Forecasting – Analysis of Datasets of Metered Embedded Wind and PV Generation	Completed	The Alan Turing Institute
NIA_NGSO0002	GB Non-Renewable Embedded Generation Forecasting Study	Completed	The Smith Institute
NIA_NGSO0004	Virtual Synchronous Machine (VSM) Demonstrator	In progress	University of Nottingham, TTPi
NIA_NGSO0005	Phase Lock Loop-Related Improvements to Non-Synchronous Generation Models	Completed	Power System Consultants
NIA_NGSO0006	System Impacts of Embedded Storage (SIES)	Completed	Carbon Trust
NIA_NGSO0007	Investigation & Modelling of Fast Frequency Phenomena ("F2P")	In progress	Brunel University
NIA_NGSO0008	Solar PV Monitoring Phase 3	In progress	Sheffield Solar (University of Sheffield)
NIA_NGSO0010	Situational Awareness Using Comprehensive Information	Completed	EPRI
NIA_NGSO0011	Application of New Computing Technologies and Solution Methodologies in Grid Operations	Completed	EPRI
NIA_NGSO0012	Risk-Based Analysis into Planning and Resiliency Processes	Completed	EPRI
NIA_NGSO0013	Flexibility and Resource Adequacy for System Planning	Completed	EPRI
NIA_NGSO0014	System Planning Methods, Tools and Analytics	Completed	EPRI
NIA_NGSO0015	Optimisation of Weather Data to Improve Energy Forecasting	In progress	The Smith Institute
NIA_NGSO0017	Frequency Response Auction Trial	In progress	EPEX Spot
NIA_NGSO0018	RecorDER	In progress	Electron
NIA_NGSO0019	Hybrid Grid Forming Converter	In progress	University of Strathclyde
NIA_NGSO0020	Short-Term System Inertia Forecast	In progress	Imperial College London
NIA_NGSO0021	Development of GB Electric Vehicle Charging Profiles	In progress	Element Energy, Charge Master, Pod Point
NIA_NGSO0022	Black Start Capabilities from Non-Traditional Technologies	In progress	TNEI
NIA_NGSO0024	Enhancing Energy Flexibility from Wastewater Catchments through a Whole-System Approach	In progress	United Utilities Open Energi

Who we are

We have a new team and a new process in place for ESO innovation, which means we can review and approve projects in a more agile way:

Carolina Tortora
Head of Innovation Strategy

Michael Ashcroft
Manager New Project Applications

Cian McLeavey-Reville
Manager Project Funding

Joshua Visser
Manager Portfolio Governance

Geoff Down
Senior Analyst Portfolio Governance

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

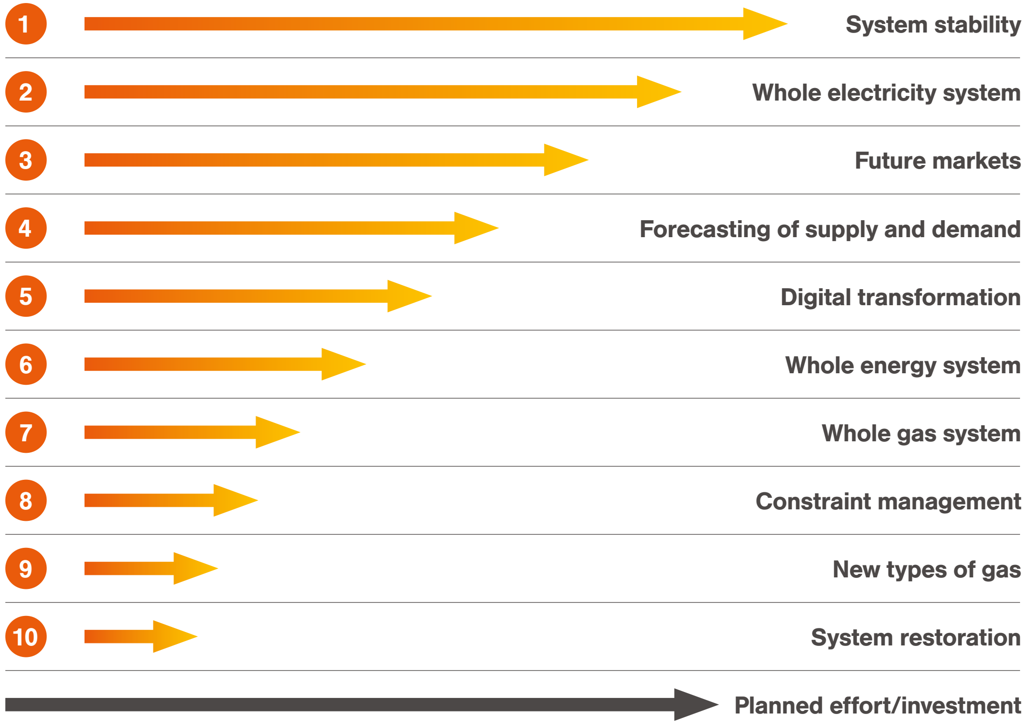
Looking ahead

In the coming year, we will continue to improve our innovation process and rebalance the project portfolio to reflect our strategic priorities. We will hold collaborative events with our partners and form new ideas and successful projects that will help deliver the energy system of the future.

In 2018/19, we went through the important process of refreshing our innovation strategy after engaging with industry stakeholders. We will continue to work closely with them through 'Hackathons' and other collaborative events to create new opportunities and build partnerships. Our strategy will be refreshed again in 2019/20.

In April 2019, the ESO became legally separate within the National Grid group. Since then, we've created specific branding and messaging for ESO innovation. This is consistent with our 'Towards 2030' vision and Forward Plan, published in April 2019.

We will take a leading role in key conferences throughout the year, sharing the results and outcomes from our projects and discussing future proposals. Events include the LCNI (Low Carbon Networks & Innovation) conference on 30th-31st October in Glasgow. In autumn 2019, we will hold a call for new Network Innovation Competition (NIC) bids – and the best will be entered into the 2020 competition.



Get in touch

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