Network Innovation Allowance

Annual Summary 2017/2018

Electricity System Operator

Contents

Welcome to our innovation annual summary for 2017/18

"Through innovating together, we can build a reliable, secure, affordable and sustainable electricity system for the future."

Fintan Slye
Director
UK System Operator

As Great Britain's System Operator (SO), we're at the heart of our nation's energy system, which gives us early visibility of the rising challenges on the grid.

We therefore have the responsibility as well as the opportunity of addressing those challenges in the best way for our customers. Through innovation, we're finding new ways to improve how our electricity and gas systems are operated, both now and in the future.

This innovation annual summary focuses on the projects of the Electricity System Operator (ESO). It's the first time we've reported these separately from the Electricity Transmission Owner (ETO) and it reflects the two businesses' upcoming legal separation. With a new team in place, the ESO is focusing on innovation that will keep the electricity system secure, reliable and cost-effective as we go through the energy transformation into a low-carbon and decentralised future.

Our new SO Innovation Strategy, published in February, brings together our latest thinking in one place and identifies 16 priority areas. These are consistent with the commitments we made in our 2018/19 ESO forward plan, which highlighted seven key principles for how the ESO business will continue to deliver value for customers and end consumers.

Our innovation portfolio features a novel range of projects funded by Ofgem, through the Network Innovation Allowance (NIA) and Network Innovation Competition (NIC). This funding gives our business, and the people who work with us, the freedom to develop ideas in a way that wouldn't be possible in normal business operations. It allows us to test emerging technologies, or research and develop new systems and methods. We can also figure out how to deliver the biggest benefits at reduced costs, while providing reliable, low-carbon energy for the electricity system and consumers.

Collaborating with partners in industry and academia continues to be crucial. The close relationships we've developed have already helped us integrate more renewable generation on the network and manage the effects of low inertia and intermittent energy resources. We've also worked with experts in machine learning and analytics to improve how we forecast generation and future demand, which is vitally important as these patterns become increasingly unpredictable.

We're actively shaping a future of whole system operation. Our Power Potential project, for example, sees transmission and distribution networks working together to create a way for smaller generators to take part in the market for network services. This project is leading a ground-breaking trial of a new Reactive Power market, planned to begin in January 2019. This will see technologies including battery storage, wind farms, solar PV and Combined Heat and Power (CHP) taking an active role in supporting the operation of the system.

Our EFCC (Enhanced Frequency Control Capability) project, meanwhile, is developing new ways for non-traditional generation, such as demand side response (DSR), batteries, solar, wind, and Combined Cycle Gas Turbines (CCGT), to help keep the system running smoothly in a cost-effective way.

We continue to strengthen our culture of innovation in the ESO. Events such as Hackathons and Open Innovation Days allow us to work with colleagues and industry partners, and imagine new solutions for existing and future system challenges.

It's an exciting time to be in the energy industry. Through innovating together, we can build a reliable, secure, affordable and sustainable electricity system for the future.

Fintan Slye
Director
UK System Operator

Our new innovation strategy

We launched our first ever System Operator (SO) Innovation Strategy in March 2018. It sets out our innovation priorities and how we plan to work alongside industry partners to solve the challenges facing Britain's energy system.

The strategy includes 16 areas of importance for both the Electricity (ESO) and Gas System Operator (GSO). In this section, we'll show ESO's priorities and how **£4.6m** of NIA and NIC funding has been allocated during 2017/18.

As this is a recent strategy, it will take time to rebalance our ESO projects so that each challenge receives an appropriate level of funding.

ESO innovation priorities

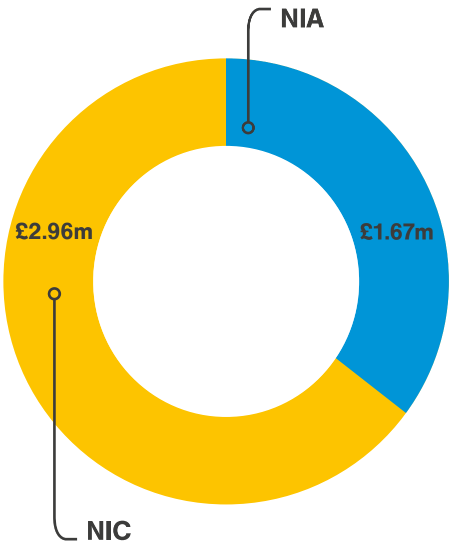
01	Developing Distribution System Operators (DSOs) and whole system operability	£891k	As more energy is connected via distribution networks and consumers actively manage their demand, we must develop joined-up approaches across transmission, distribution and beyond.
02	Improving short-term forecasting of generation/supply and demand	£109k	We need to fully understand what's driving changes in supply and demand, and develop novel ways of forecasting them.
03	Managing volatility in a low-inertia system	£646k	System inertia is decreasing as more renewable generation comes online. This leads to faster changes in system frequency, so we need new ways to manage this.
04	Leveraging analytics in a data-enabled future	£319k	With the huge increase in data available through the Internet of Things, smart meters and third-party technologies, we need new ways to process, analyse and use it.
05	Delivering enhanced cyber security	£24k	The digitisation and decentralisation of energy means better security measures are needed to protect the system from cyber attacks.
06	Enabling more non-synchronous connections	£377k	We need to better understand the impact of more inverter-connected generation (i.e. wind and solar) and find efficient ways of integrating the technology.
07	Supporting voltage and reactive power	£627k	With lower transmission demands and more reactive power coming online, system voltage is becoming harder to manage. We must develop new technologies and commercial approaches to support this.
08	Optimising constraint management	£56k	We'll explore how new technologies and commercial approaches can better prepare for, manage and minimise the cost of managing system constraints.
09	Redesigning system restoration	£6k	The number of Black Start service providers is expected to fall as traditional thermal generation decreases. We'll look for alternative strategies to restore the system.
10	Creating markets for the future	£838k	It's important to create new markets for services that can meet our changing system needs and to work with distribution networks to build a whole-system approach.
11	Harnessing the digitised grid	£58k	We need to adopt new technologies such as artificial intelligence, cloud computing and blockchain, while maintaining the resilience required by our Critical National Infrastructure (CNI) status.
12	Understanding long-term behavioural change in consumption and generation	£81k	It's harder to forecast long-term supply and demand as new technologies evolve across the power, heating, transport and other sectors. We need to fully understand and model this new reality.
13	Enhancing visibility of Distributed Energy Resources (DER)	£266k	We can't always see what's happening with the connection, capacity and output of distributed energy resources. We'll explore how we can share more real-time data across the market.
14	Unlocking flexibility	£331k	Flexibility on the electricity system has traditionally been supplied by power plants and large-scale storage. As the proportion of these falls, we need to test new technologies and markets for flexibility.

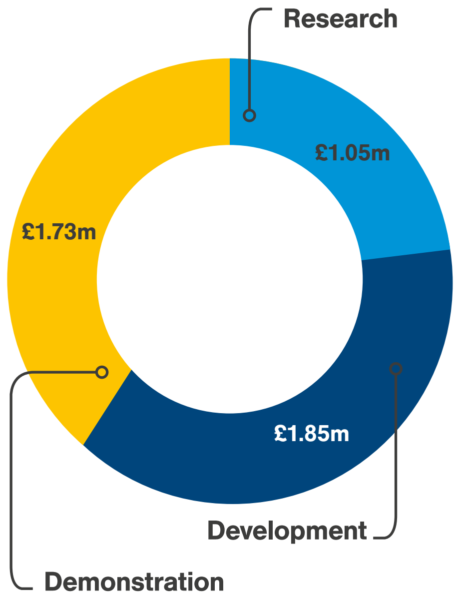
You can find out more about the SO Innovation Strategy at **www.nationalgrid.com/soinnovation**

2017/18 portfolio overview

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

In the past 12 months, we reconsidered how we innovate and produced the first SO Innovation Strategy. This has allowed us to adapt our activities, so we can 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 potential benefits for customers and consumers are maximised.





Big numbers

25,718 hrs
spent internally on innovation within the ESO

78
employees worked on innovation projects in the ESO for 2017/18

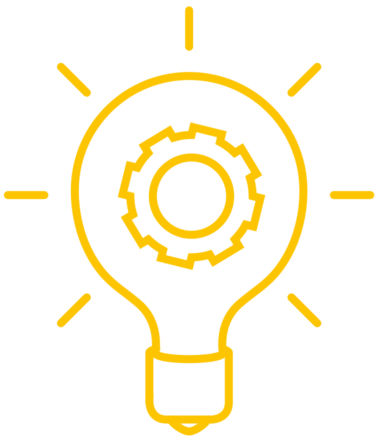
12
projects started

16
projects completed

8
projects continued into 2018/19

The full story of our funding

During the last year, we've spent **£1.67m** of the NIA allowance and **£2.96m** of NIC funding (approximately £4.6m total) on ESO projects. This corresponds to 32 individual NIA projects and three NIC projects (two of which we lead on).



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.

The levels 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 figure above shows how our projects measure up against the TRL. As a proportion of our total NIA and NIC funding, we've spent **£1.05m** on research, **£1.85m** on development and **£1.73m** on demonstration.

Virtual Reality at Utility Week Live 2018.

Working with partners

Collaboration is vital to successful innovation. By sharing the lessons we learn and being open to ideas from across 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:

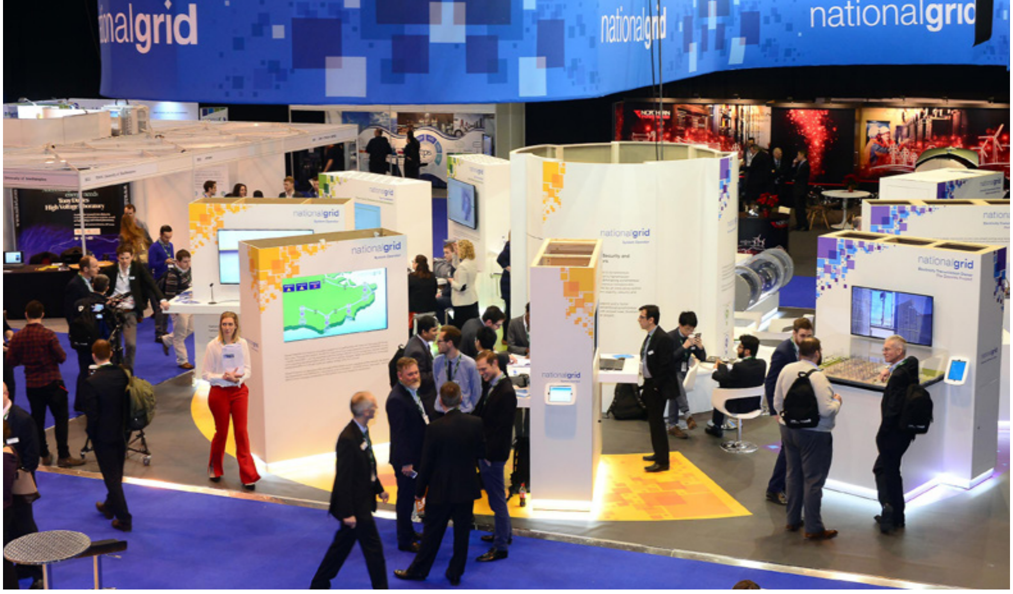
Sheffield and Reading Universities
We've been working with University of Sheffield on the Sheffield Solar project, which is developing a live feed of solar generation. Alongside University of Reading, we're looking at the probability of different weather conditions and the effect that has on renewable generation.

UK Power Networks
UK Power Networks has been our partner on the £9.5m Power Potential project, which paves the way for Distribution System Operators (DSOs) to actively support the transmission network.

Smith Institute
We've been working together to improve the way we model and forecast generation from embedded sources.

Scottish Power Transmission
With Scottish Power and other industry partners, we've been working to create a novel way of managing future system operability challenges. The technology we're developing, as a part of the NIC-funded Project Phoenix, is called a Hybrid Synchronous Compensator (H-SC).

The device will help regulate frequency and voltage on the grid, and compensate for the loss of large traditional power stations. This will help squeeze more renewable generation on to the grid as this technology makes it easier for these generators to connect. It has the potential to help build a clean and stable future energy system, save consumers money and bring 662MW of extra capacity on to the network. We're currently developing our design solutions and will begin a one-year field trial in summer 2019.



Collaboration

Timeline: a year of engaging events

January 2018:
We held an SO Innovation Day at Winnersh, Berkshire. This encouraged internal stakeholders and representatives from EDF to form project ideas around the theme of open data.

March 2018:
We held a Hackathon called Hack the Demand Curve in Reading with National Grid staff and industry partners.

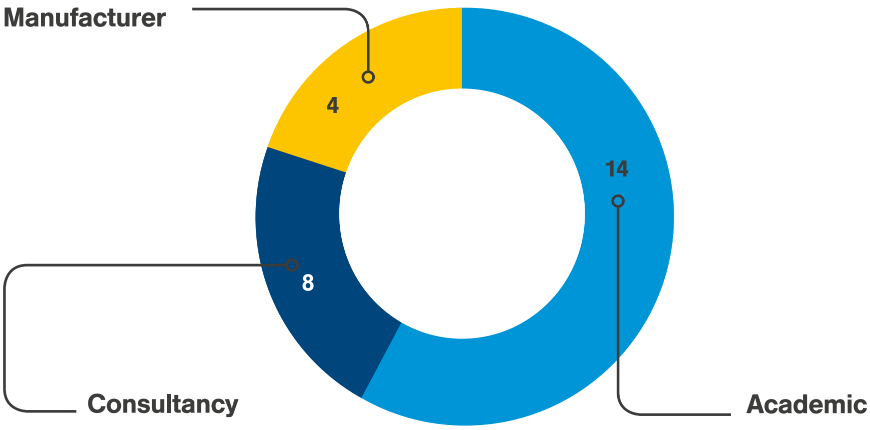
March 2018:
We held an Open Innovation Day in Birmingham, which encouraged discussions between our staff and external partners, who then submitted innovation project ideas.

May 2017-March 2018:
Mark Herring and Cian McLeavey-Reville, SO Innovation Managers, represented us at industry workshops for the ENA Joint Network Innovation Strategy and subsequent Q&A panel session in London.

June 2017-March 2018:
Cian McLeavey-Reville engaged with stakeholders and our customers on the new SO Innovation Strategy.

We worked with 26 different partners on ESO innovation projects this year

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



The above figure shows the split of supplier types as a proportion of 26 total suppliers.

Out and about

Our innovation team held new types of collaborative events this year to encourage more project ideas.

- Hackathons brought staff and external partners together to consider specific industry challenges over two dedicated days.
- Open Innovation days asked suppliers to suggest novel solutions to our innovation challenges, then paired them with ESO experts to create viable project proposals. The best of these are now awaiting NIA funding.

At the Low Carbon Network and Innovation conference (LCNI), we hosted a Virtual Reality (VR) game to give attendees a better understanding of what the ESO does and the challenges we face. This encouraged lots of useful discussion and creative new ideas.

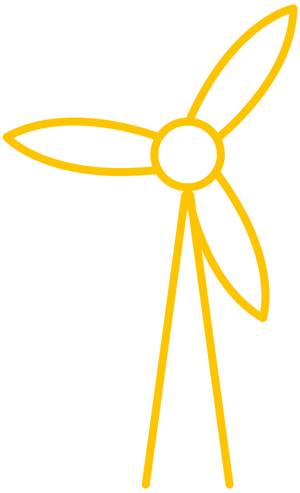
At the Carbon Intensity Tracker launch.

Beyond NIA and NIC

Our commitment to innovation extends beyond our own projects. This year, we provided letters of support for innovation activities by other companies, including investigations into blockchain for flexibility trading and new revenue models for residential storage, and Vehicle to Grid (V2G) technologies. We also linked up with Nissan and other partners on two V2G projects, V2GB and e4future, which were awarded BEIS funding.

The Carbon Intensity Tracker, a world-first in green energy forecasting, was also launched in 2017, an idea formed from a previous Hackathon and delivered by innovators within the ESO.

Title: Power Potential (TDI 2.0)	
NIC reference: NGET_UKPN_TDI2.0	
Suppliers: UK Power Networks	
PEA Cost: £9,560,113	



Big numbers

4GW

Power Potential aims to generate up to an extra 4GW in South East England

Power Potential

As greater volumes of renewable energy like wind, solar and batteries connect to the network, there is the opportunity to tap into these technologies in new ways. With UK Power Networks we've taken important steps towards unlocking this unexploited power. By 2050 it could save consumers up to £412m.

Power Potential is looking at how sources of generation connected to the distribution network can help us to increase capacity and run the grid more affordably. For example, could solar panels or wind turbines provide services such as fast dynamic voltage control? This is a way of maintaining voltage at short notice after a system fault.

Progress towards trials

This year our focus has been on preparing, on both a technical and commercial level, for a ground-breaking real-world trial due to begin in January 2019. For the first time we will be taking a whole system approach – looking at transmission and distribution together.

The trial will focus on the South East of England where distributed generation has grown significantly. It's also an area of the country that is at the limit of its capacity to import and export power to the rest of the grid. If successful, the approach could be rolled out nationwide. Battery storage, wind farms, solar PV and synchronous generation have all expressed an interest in taking part in the trial.

Building the capability

Technology developer ZIV Automation is currently building a Distributed Energy Resources Management System (DERMS). This is a vital piece of technology that will enable communication between distributed energy resources connected to UK Power Networks and National Grid. It is due to be completed by the end of 2018.

Secondly, we have developed the commercial framework that underpins the project. It is designed so that participants can stack revenues in parallel with existing services they provide. To ensure the playing field is fair for all parties, a Regional Market Advisory Panel is now in place chaired by Dame Fiona Woolf. It held its first meeting in January 2018.

Benefits and next steps

By connecting more renewable energy and storage regionally we will reduce the need to build electricity assets. Estimated savings for consumers are £1m by 2020. If the regional model is extended to a further 59 sites, these savings could total £412m by 2050.

Title:
Enhanced Frequency Control Capability (EFCC)

NIC reference:
NGETEN03

Suppliers:
Belectric Solar, Centrica, Flexitricity, Ørsted and Siemens, GE Grid Solutions, University of Manchester and University of Strathclyde

PEA Cost:
£9,344,000

The Enhanced Frequency Control Capability (EFCC) project

System frequency must be kept within strict limits to ensure that the GB electricity transmission network remains stable. This is becoming more difficult with the growth in renewable generation and consequent fall in system inertia. The EFCC project aims to find new ways to tackle this issue.

Maintaining system frequency at 50 Hz is a challenge for the GB electricity network. Rapid changes in system frequency can lead to serious faults on the network. Inertia – an object's resistance to any change in motion – acts as a natural aid to frequency. However, the closure of many thermal plants which provide inertia mean this option is becoming more restricted.

The EFCC project is one approach examining how technologies such as demand side response (DSR), batteries, solar PV, wind and Combined Cycle Gas Turbines (CCGT) can help to keep the system running in an efficient and cost-effective way. National Grid is working with industry and academic partners to enhance fast frequency services.

What we aim to achieve

An innovative Monitoring and Control System (MCS) has already been developed and is currently being trialled. It will allow frequency data to be gathered regionally. The required very fast response could then be calculated and initiated in seconds, or in some cases, sub-seconds, using one or more technologies.

Progress this year

The project was due to conclude in March 2018 but has been extended until October 2018 to allow trials to be completed.

This year the MCS has been fully developed and validated. Trials are taking place in the field to assess the speed of frequency response that could be achieved from different technologies. So far, the trials have demonstrated that solar PV could support frequency response. This is a first for the GB market.

Data has also shown that both DSR and batteries can provide a sub-second response, while offshore wind and CCGT responses were slower but still below 10 seconds. As the project concludes, we are developing a project to demonstrate the scheme on National Grid's network.

Benefits of the work

The work will show how different response technologies may be co-ordinated and stacked together in a commercial setting, which could create cost savings to the end consumer.

Big numbers

500 milliseconds

The speed of frequency response that could be achieved with faster-acting new technologies.

Title:
GB Non-renewable Embedded Generation Forecasting Study
NIA reference:
NIA_NGSO0002
Suppliers:
Smith Institute
PEA Cost:
£91,500
Start TRL:
3
End TRL:
4

Title:
Optimisation of Energy Forecasting through analysis of datasets of metered embedded wind and PV generation
NIA reference:
NIA_NGSO0001
Suppliers:
The Alan Turing Institute
PEA Cost:
£34,150
Start TRL:
3
End TRL:
7

"These two projects are helping us to understand more clearly the role of embedded generation."

Kevin Tilley
Project Lead

Improving Forecasts with Advanced Modelling

Two NIA projects are helping the System Operator to develop more accurate short-term forecasting for embedded generation.

Great Britain's electricity system has seen more embedded generation connecting in recent years. This is generation connected at local level to the electricity distribution network rather than the transmission network. It includes both renewable and non-renewable sources of energy.

Growth in embedded generation makes running the system more challenging because it is not visible to the SO. This lack of visibility makes accurate national transmission system demand forecasts more difficult, as the demand is reduced by any embedded generation running. Ultimately, better demand forecasting helps to reduce the cost of managing the system and savings being shared with our customers.

Smith Institute: Non-renewable generation

The first project was undertaken by the Smith Institute for Industrial Mathematics and System Engineering. It studied how to improve short-term forecasts of up to seven days for non-renewable embedded generation. The study assessed 4.7 GW of generation from technologies including biomass, gas (combined), hydro, landfill and waste. The aim was to create forecasting models for one, two and seven days ahead.

The study used four years of data on embedded generation. It also investigated the impact of electricity prices on the one-day-ahead model. Electricity prices have not previously been used in National Grid's demand forecasts.

Results and potential benefits

The project has given us a better understanding about the types of non-renewable embedded generation connected to the grid and how each contributes. The project also showed that forecast electricity price was a major factor in the level of embedded generation.

The next step is to validate the models and to assess how they could improve demand forecasting accuracy. Generation from these technologies is most important in the winter season, when output tends to peak.

Alan Turing Institute: Renewable generation

Meanwhile, the Alan Turing Institute led a forecasting study focused on renewable generation. It looked specifically at embedded solar PV and wind, again up to seven days ahead. The project also examined ways to detect partial outages on wind farms and the effect of shutdowns caused by high wind speeds.

Results and potential benefits

The Turing project has developed models that will improve the way both embedded solar PV and wind generation are forecast. For example, at the end of the project, the proposed forecasting method for national PV generation showed a 10% improvement in Mean Absolute Error (MAE) compared with existing methods for seven-day ahead forecasts.

Since the project completed, we have continued development of the Turing PV model. An enhanced version of the model is planned for this summer.

The model showed further benefits, particularly for regions with sparse weather forecasts. The software will now be tested and validated. It could then be added to our demand forecasting pipeline.

Title:
Virtual Synchronous Machine Demonstration

NIA reference:
NIA_NGSO0004

Suppliers:
Nottingham University

PEA Cost:
£456,000

Start TRL:
4

End TRL:
6

Virtual Synchronous Machines (VSM)

Project overview
Most traditional generators turn at the same rate and are synchronised with the power grid. Renewable generation, however, utilise non-synchronous technologies and are connected through power inverters.

This gives renewable generation the freedom to harvest power in all conditions without, for example, wind turbines being restricted by a need to turn at the same frequency as the system.

Using non-synchronous technologies has allowed more low-carbon energy onto the system at lower connection costs. However, as it continues to grow and replaces traditional synchronous machines, it could pose significant challenges for the day-to-day operation of the grid.

We're attempting to develop and specify a technology to solve this, called Virtual Synchronous Machines (VSM). It uses advanced electronic converter controls so non-synchronous generation can inherit key features of conventional synchronous machines.

Results and learning
Our study with University of Strathclyde showed that VSM is a practical solution for any mix of up to 100 per cent renewable energy on to Britain's power grid. We're now beginning to build a full prototype of VSM technology.

Consumer benefits
The technology has huge potential and is expected to allow a system to run with even higher penetrations of non-synchronous generation. If successful, it will help us hit our targets for cutting carbon at lower cost to consumers.

Title:
Dynamic Modelling Development - PLL

NIA reference:
NIA_NGSO0005

Suppliers:
Power System Consulting

PEA Cost:
£80,000

Start TRL:
3

End TRL:
4

Dynamic Modelling (PLL)

Project overview
An increasing amount of Britain's electricity demand is met by Non-Synchronous Generation (NSG). This is power generated in non-traditional ways, such as from renewable sources, batteries and interconnectors. NSG uses converters to change its power into a form that's compatible with our system.

The process involves a control system called Phase Locked Loop (PLL), which tells the generator how to stay in step with the demands of the electricity network.

It's vital we understand how these PLLs behave, yet our existing planning software isn't able to fully interpret their behaviour. Through this project, we're doing the missing detective work and applying everything we learn to improve our planning.

Results and learning
We carried out a review of the PLL systems, both in use and under development, and researched their hallmark behaviours. We uncovered that PLLs don't react to disturbances as fast as we'd thought and that there are a variety of different types of behaviour, which means we can better reflect how new generation can respond to system events. We'll now update our planning software to reflect these insights. We will also be preparing guidance based on this work to inform other Transmission and Distribution Network Owners and Operators so they can reflect these insights within their own modelling.

Consumer benefits
Past experience from improving dynamic models has illustrated that as we gain new insights in modelling, this allows us to operate the system more efficiently across a full range of electrical faults and disturbances. This could potentially deliver millions of pounds of savings for consumers over future years as we apply these new modelling techniques to support the development of a lower carbon energy system.

"This could potentially deliver millions of pounds of savings for consumers over future years."

Ben Marshall
Project Lead

Title:
Investigation & Modelling of Fast Frequency Phenomena ("F2P")

NIA reference:
NIA_NGSO0007

Suppliers:
Brunel University

PEA Cost:
£340,000

Start TRL:
3

End TRL:
6

"By improving our understanding and modelling of F2P, we'll reduce the costs of managing this challenge."

Martin Bradley
Project Lead

Fast Frequency Phenomena (F2P)

Project overview

In the past, when traditional forms of generation supplied most of our electricity demand, we were able to treat system frequency as one value across the whole country. Traditional generators were large, heavy machines spinning at 3,000rpm, and these rotating masses provided lots of angular momentum or "inertia" to the power system.

One of the major impacts of having more renewables connected to the network has been a reduction in inertia, which previously provided a natural aid for keeping the system stable. We now see larger and more rapid frequency changes following a disturbance, which vary from region to region.

This creates new challenges for how we operate the system, so we need to make sure we understand and can accurately forecast how fast frequency fluctuations spread across the network.

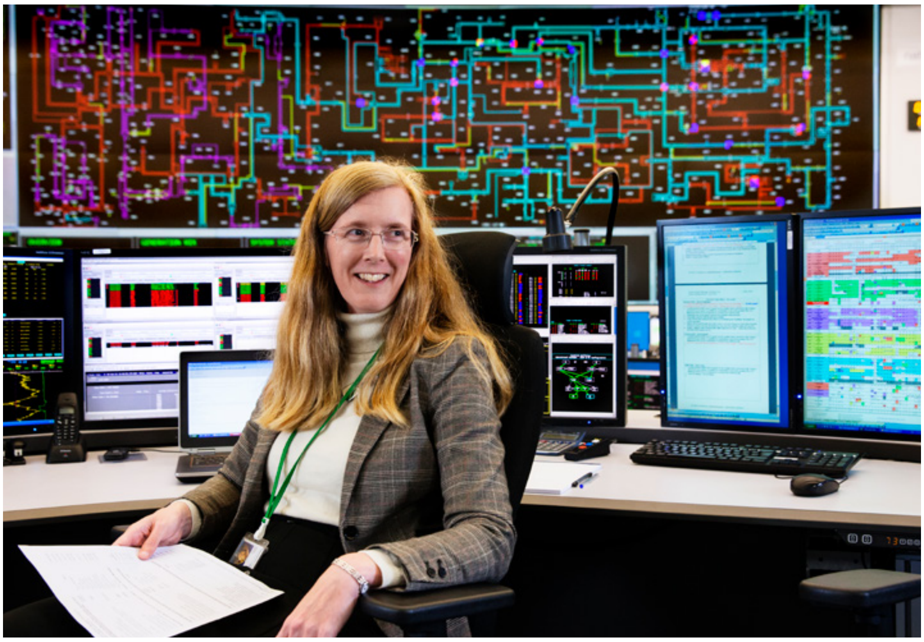
In this project, we're investigating how well our existing planning tools – which weren't specifically designed to model this effect – can model fast frequency phenomena.

Results and learning

We have recruited a research fellow to investigate how well our existing models correlate with measurements taken using GPS signals and other technology. This will be followed by recommendations on whether to improve our existing tools or introduce more sophisticated software.

Consumer benefits

By improving our understanding and modelling of fast frequency phenomena, we'll reduce the costs of managing this challenge, which currently amounts to around £5m a month.



Title:
System Impacts of Embedded Storage

NIA reference:
NIA_NGSO0006

Suppliers:
The Carbon Trust

PEA Cost:
£220,000

Start TRL:
2

End TRL:
3

System impacts of embedded storage

The electricity storage market has developed significantly in the past year and is expected to continue to grow rapidly. Up to now, most analysis has focused on how storage can help address some of the challenges facing the system.

However, as the market continues to develop quickly, particularly within the distribution networks, there may be some risks to system operation from unexpected behaviour of embedded storage. This project will identify the largest and most urgent risks and provide recommendations for innovation projects that can help us manage them.

Results and learning

With the project in its early stages, we're now exploring which areas of storage may have the biggest impacts on system operation. Once we've made this evaluation we'll look to propose further activities to address these issues.

Benefits to consumers

By consolidating our understanding of risks around storage, we'll have a strong foundation to propose solutions that offer the best value for consumers.

Update: Power oscillation damping

Title:
WI-POD- Wind Turbine Control Interaction With Power Oscillation Damping Control Approaches

NIA reference:
NIA_NGET0188

Suppliers:
University of Warwick

PEA Cost:
£350,000

Start TRL:
2

End TRL:
3

Project overview

During certain disturbances on the network, such as a major loss of generation or trip of a transmission line, power swings between different parts of the system. We need to make sure that the oscillations caused by these swings aren't too large and are quickly reduced, which we call damping.

Traditionally, this damping has been met by the natural behaviour of conventional generators. However, as more wind generation replaces traditional generation, we need to find new ways of providing this.

One option is to introduce Power Oscillation Damping (POD) on wind farms. Through this project, we're exploring the risks involved – both to wind farms and the broader grid – of introducing PODs and suggesting ways to manage them.

Results and learning

Following a literature review and preliminary simulations, we've found that POD control for wind turbines is possible and can effectively reduce oscillations on the power system.

Benefits to consumers

Fewer oscillations to manage means we'll need to make fewer expensive interventions, which will cut costs for consumers. It will also create a stable environment for more wind farms to connect.

Update: Solar Photovoltaic (PV) Generation Forecasting

Title:
Solar PV Forecasting Phase 1

NIA reference:
NIA_NGET0177

Suppliers:
The Met Office

PEA Cost:
£440,000

Start TRL:
3

End TRL:
7

Title:
Solar PV Forecasting Phase 2

NIA reference:
NIA_NGET0183

Suppliers:
University of Reading

PEA Cost:
£300,000

Start TRL:
4

End TRL:
6

Phase 1 of the Solar PV Forecasting project with the Met office aims to develop more accurate short-term forecasting for embedded solar. The work looks at improving one of the biggest drivers of PV forecasting error, solar radiation forecasts. Within-day errors from PV forecasts alone are around 400MW.

The project has helped to develop an optimal blend of Met Office forecasts. This led to a 100MW improvement in the PV forecast error.

In the past year the team investigated a technique for statistical post-processing of forecasts. It compares and corrects the initial forecasts, considering recent observations. The work is now in its final stages of development. If successful, it could potentially reduce forecasting error by another 40MW.

Phase 2 of the Solar PV Forecasting project with the University of Reading addresses the variability of solar PV and other renewable sources and examines ways to improve PV forecasting models.

The team developed a 38-year hourly time series of wind, solar and demand. This was used to explore the scale and frequency of high-impact events such as low renewable output, high demand days. Data has already been used to aid Capacity Market planning and will be an excellent reference to support system operability, helping to reduce system balancing costs for customers.

The work also proposed a new model, for PV forecasting techniques which took account of time of day and season. The team looked at potential improvements by combining forecasts with observations of PV outturn. The proposed method out-performed simpler models at all timeframes from one to six hours ahead.

Project portfolio

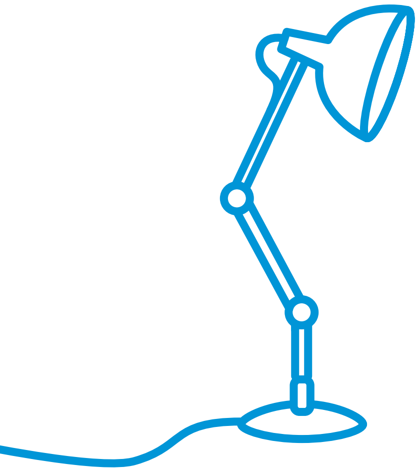
To learn more about the projects, click the title to be taken to the ENA smarter networks portal or visit: www.smarternetworks.org

Project Reference	Project Name	Innovation Priority see p4 for details
NIA_NGET0039	A Combined Approach to Wind Profile Prediction	2, 6, (4)*
NIA_NGET0052	Mathematics of Balancing Energy Networks Under Uncertainty	4, 13
NIA_NGET0058	Scalable Computational Tools and Infrastructure for Interoperable and Secure Control of Power System	4, 5, 11
NIA_NGET0059	Protection and Fault Handling in Offshore HVDC grids	(13)
NIA_NGET0105	Enhanced Weather Modelling for Dynamic Line Rating	8, (4)
NIA_NGET0106	Control and Protection Challenges in Future Converter Dominated Power Systems	3, 6
NIA_NGET0110	Electrical Demand Archetype Model (EDAM2)	3, 12, (4), (6)
NIA_NGET0134	Granular Voltage Control	3, 7, 11, 14
NIA_NGET0144	Integrated Electricity and Gas Transmission Network Operating Model	4, 8, 12
NIA_NGET0156	DNO Investigation into Voltage Interaction and Dependancy Expectation (DIVIDE)	1
NIA_NGET0161	Detection and Control of Inter-Area Oscillations (DACIAO)	3, 4
NIA_NGET0167	South East Smart Grids (SESG)	1, 7, 8, 10, 11, 14, (2), (4), (13)
NIA_NGET0169	Transmission Network Topology Optimisation	4, 8, 10, 11
NIA_NGET0170	PV Monitoring Phase 2	13, (4)
NIA_NGET0174	Embedded Cyber Risks with Procurement	5
NIA_NGET0175	Improving Cyber Security Culture	5
NIA_NGET0177	Solar PV Forecasting Phase 1	2, 3, (4)
NIA_NGET0183	Solar PV Forecasting Phase 2	3, 12, (4)
NIA_NGET0187	Transient Voltage Stability of Invertor Dominated Grids and Options to Improve Stability	4, 7
NIA_NGET0188	WI-POD- Wind turbine control Interaction with Power Oscillation Damping control approaches	6
NIA_NGET0192	SIM - Samuel Inertia Element	3, 11
NIA_NGET0193	DESERT (Hybrid Battery and Solar Enhanced Frequency Control)	3, 8, 14, (12)
NIA_NGET0205	Vector Shift Initial Performance Assessment	6
NIA_NGSO0001	Optimisation of Energy Forecasting through analysis of datasets of metered embedded wind and PV generation	2, 4, 13
NIA_NGSO0002	GB Non-renewable Embedded Generation Forecasting Study	2, 4, 13
NIA_NGSO0003	Assessment of Operation of Small-Scale Inverter Connected PV Generation During Under-Voltage and Voltage Vector Shift Conditions	3, 6, (13)
NIA_NGSO0004	Virtual Synchronous Machine Demonstration	3, 6
NIA_NGSO0005	Dynamic Modelling Development (PLL)	3, 7, 9, (4)
NIA_NGSO0006	System Impacts of Embedded Storage	12, 14, (10)
NIA_NGSO0007	Investigation & Modelling of Fast Frequency Phenomena ("F2P")	3, 6, (4)
NIA_NGSO0008	Solar PV Monitoring Phase 3	2, 13
NIA_NGSO0010	EPRI - Situational Awareness Using Comprehensive Information (39.011)	1, 4, 8, 13
NIA_NGSO0011	EPRI - Application of New Computing Technologies and Solution Methodologies in Grid Operations (39.014)	1, 4, 11
NIA_NGSO0012	EPRI - Risk-Based Analysis into Planning and Resiliency Processes (40.022)	1, 6, 7, 8, 14
NIA_NGSO0013	EPRI - Flexibility and Resource Adequacy for System Planning (PS173C)	3, 10, 14
NIA_NGSO0014	EPRI - System Planning Methods, Tools, and Analytics (PS173A)	1, 7, 8, 12, 13

NIC Projects		
NGETEN03	Enhanced Frequency Control Capability (EFCC)	1, 3, 10, 14
NGET_UKPN_TDI2.0	Power Potential (TDI 2.0)	1, 7, 10
SPTEN03	Phoenix	3, 6

*The innovation priority numbers in brackets are indirectly linked to the projects.

Looking ahead



In the year ahead we will continue improving our innovation process and rebalancing the portfolio to reflect our strategic priorities. We will hold collaborative events with partners to create new ideas and produce successful projects aimed at delivering the energy system of the future.

From April 2019 the ESO will become legally separate within the National Grid group. This separation will be reflected in more individual branding and messaging for ESO innovation. It is hoped this will provide better opportunities to deliver innovation projects focused on challenges which the ESO can address, and help realise the maximum benefit for electricity consumers.

In 2018/19 we will conduct a refresh of the innovation strategy following engagement with industry stakeholders and will regularly arrange Hackathons and collaborative events to facilitate new opportunities and partnerships. We participate in conferences throughout the year to disseminate our project outcomes and discuss upcoming proposals. This includes the LCNI (Low Carbon Networks & Innovation) conference on 16th-17th October in Telford. In autumn 2018 we will be holding a call for new Network Innovation Competition (NIC) bids, for submission in the 2019 competition.

Who we are

The refreshed process for innovation in the ESO means we can review and approve projects in a more agile way. Visit our website or contact us to learn more about the new ESO innovation process, our priorities, and the NIA and NIC funding available.

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Mark Herring

Senior Manager Innovation Strategy

Michael Ashcroft

Manager New Project Applications

Cian McLeavey-Reville

Manager Project Funding

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