Electricity System Operator

Innovation Strategy 2020/21

nationalgridESO

Innovating across Great Britain's whole energy system

As Great Britain's Electricity System Operator (ESO) we are at the heart of the nation's energy system. We make sure that the electricity network operates safely and efficiently around the clock, so that homes, businesses and industry always have the power they need.

We're also helping to tackle one of the biggest challenges facing society: how to create a sustainable, low-carbon electricity system for the future that will help the UK meet its net zero commitments. Innovation plays a vital role in this effort, which is why we're working with partners from the energy industry and beyond to harness new technologies, markets and ways of working to support the energy transition.

This is the second refresh of our **ESO Innovation Strategy**, since first publishing it in 2018. This sets out our innovation priorities for the final year of our RIIO-T1 regulatory period. We will undertake a more fundamental strategy review next year to set us up for our new RIIO-2 framework.

2020/21

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Developing the net zero whole energy system of the future

Carolina Tortora
Head of Innovation Strategy

I am pleased to introduce our 2020-21 Innovation Strategy.

Since preparing this strategy, we have all been faced with huge changes in our home and business lives as a result of COVID-19. It is clear that disruption will continue during the months ahead and as we aren't quite clear on the impact on the full breadth of our activities and the energy industry just yet, we haven't currently changed the contents of this strategy. However, we will be constantly reviewing our plans taking into account changing priorities for the ESO and our stakeholders making sure we stay focused on our primary role of operating a secure and reliable electricity system.

In what now seems to be an accelerating trend, this year has seen even more records broken as our energy system continues to rapidly decarbonise. In May 2019, Great Britain went a full fortnight without using electricity generated from coal for the first time since the 1880s. 2019 was also the first time ever in the UK that zero-carbon electricity generation outstripped fossil fuels over a full 12-month period.

We have seen significant policy developments including the UK Government's Environment Bill[1], Ofgem's first Decarbonisation Action Plan[2], and the announcement that the ban on the sale of diesel, petrol and hybrid cars will be brought forward by at least five years to 2035 or earlier. Meanwhile, public awareness of the climate challenge has never been higher.

As GB's Electricity System Operator, we are naturally more sensitive to the changes that the system is undergoing, and we must be relentless in our drive for innovation to best meet what has been termed as the challenge of our generation.

In 2018 we published our very first Innovation Strategy for the ESO. Our aim was to bring focus to some of the ESO's top challenges, to concentrate attention and effort to the areas that we, together with our stakeholders, had identified as being the most critical and the most urgent to address. We committed to update it every year to reflect our progress against these challenges, and to redirect investment towards the issues that we feel need more attention. As a consequence of this, our portfolio of projects shows the evolution of our understanding of the issues that sit at the heart of the energy transformation. Interestingly, however, our projects also give us a rare view into the methods, practices and approaches that characterise the solutions that we are exploring. This allows us to recognise the emergence of solutions' macro trends across the various projects, some of which are:

- **Coordination between electricity transmission, distribution and system operation.** An increasing number of our projects involve collaborating with other network companies: we recognise vertical and cross-coordination as key to making optimal planning and operational decisions as we transition to a more decentralised and complex system. ESO's Future Energy Scenarios[3] show how electricity demand and capacity may grow and evolve out to 2050, demonstrating that going forward we will need to extend that same coordination to different sectors, such as transport and heat.
- **Mathematical, digital and analytical tools that deal with increased complexity in the system.** A more uncertain and variable system means our modelling, forecasting and planning activities must step up to the challenge. We have launched projects that will help us manage this uncertainty through agent-based modelling and market simulators; exploring ways of making decisions in ambiguous conditions; and automating complex processes.
- **Investigation of alternative tools/technologies capable of supporting the system.** Decarbonising the grid involves replacing thermal generation with non-synchronous renewables, which drives a need for non-traditional sources of stability. For the past 30 years, thermal generation has been serving double, triple, even quadruple duty: not only in terms of providing energy, it has also contributed to system inertia, it has formed almost the entirety of our Black Start fleet; and provided a wealth of other grid services that are becoming increasingly critical (e.g. voltage support, fault ride through). Going forward we will continue to explore non-traditional solutions to provide these services, and our innovation portfolio is already reflective of that effort.

As our system transforms, new issues emerge that will need new solutions. To truly tackle these evolving challenges, we need to continue to move away from defining the future by extrapolating the past. We need to leverage data to build new, original models that are reflective of the new patterns of behaviour across the whole energy system. We must share data to create more intelligent and coordinated simulations and tools. And we must evaluate new technologies that can more readily adapt to an increasingly complex, more dynamic and less predictable energy system.

This transforming energy system, which is reflected in our innovation portfolio, is fundamentally changing the way that the ESO and our industry thinks, and the direction that we are looking in. We have fully become a future facing organisation, leading the way for a future facing industry.

1 Environment Bill 2020 - www.gov.uk/government/publications/environment-bill-2020
2 Decarbonisation Action Plan - www.ofgem.gov.uk/publications-and-updates/ofgem-s-decarbonisation-action-plan
3 Future Energy Scenarios - www.fes.nationalgrid.com

Drivers of change: Guiding our strategic direction

In refreshing this year's ESO Innovation Strategy we've taken an open approach, consulting widely with our stakeholder community in a variety of ways. We've also considered our published business plans[4] to make sure that we are prioritising not only the most important issues for the ESO, but for the whole system to transition to net zero.

The drivers of change

The three major drivers shaping Great Britain's energy sector remain unchanged, however this year we include another emerging driver - democratisation.

Decarbonisation

Low-carbon records continue to be broken, making it more challenging for the ESO to manage system inertia. New interactions between fuels and sectors, such as heat and transport, are creating new and uncertain challenges to the electricity and whole energy system.

Did you know

Only 5% of the energy used to heat our homes today is from low-carbon sources and our use of electric vehicles may need to grow from 230,000 today to 46 million by 2050. To meet the challenge of net zero, we must now go further and faster, especially in decarbonising transport, heating and our industrial use of energy[5].

Decentralisation

Society's relationship with energy continues to change as we become more active participants. The number and type of players in the energy market continues to grow. More and more distributed energy resources (DER) are looking to access balancing markets and the need for whole energy system coordination and visibility is increasing.

Did you know

Active balancing mechanism units have increased from 2,026 in Q1 2014 to 4,729 in Q4 2019; a 233% increase. Ancillary service participants increased from 73 in Q1 2011 to 137 in Q4 2019; a 188% increase. (National Grid ESO analysis, 2020).

4 ESO Forward Plan 2020-21 (www.nationalgrideso.com/news/our-forward-plan-2021) and RIIO-2 Business Plan (www.nationalgrideso.com/about-us/business-planning-riio/riio-2-final-business-plan) include details on the innovations that will be implemented as part of our ongoing activities or inform the design and development of our proposed transformational activities

5 Ofgem Decarbonisation programme action plan - www.ofgem.gov.uk/system/files/docs/2020/02/ofg1190_decarbonisation_action_plan_revised.pdf

Digitalisation

Increased flows of information and data, are enabling new markets to be created and accessed, ensuring better outcomes for consumers. The Energy Data Taskforce has made clear recommendations that industry needs to work together quickly to make data more accessible. We also need to coordinate to ensure that the rapidly increasing number of market platforms work together effectively and securely.

Did you know

There are over 15.6 million smart and advanced meters operating in homes and businesses in Great Britain[6]

The fourth D – Democratisation

The changing nature of the energy market means that consumers, businesses and communities are far more involved than ever before. This trend will continue as existing and new participants face important choices. When to use energy? Who to buy it from or sell it to? What is the environmental impact? How much will producing or consuming energy cost or earn them?

This will have a profound effect on how the system is operated:

- System behaviour is getting more complex as energy interactions and dependencies between different sectors of the economy become more pronounced
- Participants are increasingly expecting to access and share more data and insights, to help them and others make more informed and closer to real-time decisions
- Services will be delivered by an increasing number and type of parties, such as tracking and forecasting behaviour of DER

Did you know

Around half (49%) of customers either switched supplier, changed tariff or compared tariffs in 2019 (it was 41% in 2018)[7]

6 Smart Meter Statistics in Great Britain - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/848325/2019_Q3_Smart_Meters_Statistics_Report.pdf

7 State of the energy market - www.ofgem.gov.uk/system/files/docs/2019/11/20191030_state_of_energy_market_revised.pdf

Engaging our stakeholders

Our stakeholders recognise the challenges the ESO faces as the energy system continues to evolve rapidly, driven by the 4 Ds. Feedback from our stakeholder survey, as well as several in-depth interviews, confirms that our current innovation priorities are focused on the right areas. However, in terms of their relative importance, some common themes emerged.

Stakeholders put forward a wide range of views. One of the most prominent messages was that many of the priorities are inter-linked. There needs to be greater focus on whole energy system thinking to maximise the benefits of innovation. The growing influence of digitalisation and data were also highlighted as vital related enablers to progress.

We, and our stakeholders, recognise the pace of innovation needs to increase to address these and the other priorities; and the increasing role the ESO has to facilitate this.

Here is a selection of the insights stakeholders gave us:

> There is a real **opportunity to reach out beyond the energy industry** to speak to potential innovation partners. For example, on Digital Transformation, there are organisations which might be able to offer solutions adapted from different sectors but only if they are aware that the opportunity exists.
>
> **Tamar Bourne – Senior Project Manager and Smart Energy Lead, Regen**

> **Better data is a big enabler of innovation**. The ESO sits on a huge amount of data and this is fundamental to how systems are run. As an industry, we can't expect National Grid to solve every problem on its own, but the more quickly data can be shared and the more conversations we have, the greater the progress.
>
> **Sebastian Blake – Head of Markets & Policy, Open Energi**

> **Improving forecasting of supply and demand** is a universal issue that stretches beyond Great Britain. One aspect that's very important is how forecast data can be integrated into day-to-day decision-making more effectively. Better tools are needed so that the value of forecast data is not lost when it passes between teams of people with different responsibilities.
>
> **Jethro Browell – Research Fellow, Strathclyde University**

> What we need to see is **coordinated action across an increasingly decentralised grid**, not least because today there are so many stakeholders to consider. ESO is already making great strides by working with Distribution System Operators (DSOs). Phase 2 of that could involve using datasets of customers or suppliers, broadening the way data is used [to develop markets].
>
> **JoJo Hubbard – CEO, Electron**

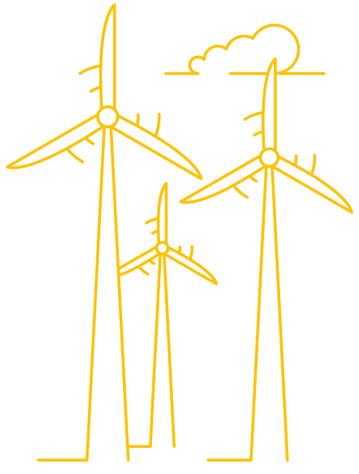
Aligning with the wider network industry on innovation

As ESO, we face some challenges that are unique to us. However, as a networks industry, we recognise that there are many other challenges that we must face together, and that a common innovation strategy is required to help achieve net zero by 2050.

As the energy system evolves to include new types of energy resources, and to cope with new active sectors such as heat and transport, we need to take a whole system view, not just across transmission and distribution, but across electricity and gas. We also need to take advantage of the synergies and efficiencies in innovating across the whole system.

That is why we, as an industry, collaborate to create a joint innovation strategy for electricity networks[8], and one for gas networks[9]. These strategies are coordinated by the Energy Networks Association (ENA) - the first iterations were created in 2018 and this year we are refreshing them for the first time. For this refresh, we are also making a concerted effort to leverage the commonalities across both electricity and gas strategies.

ESO has played a central role in the refresh of these strategies, and we have drawn upon the extensive stakeholder feedback gathered to shape our own strategic reprioritisation for 2020/21. We will continue to work closely with the ENA and our network colleagues to shape our common strategies going forward and to maximize the whole system benefits from network innovation.



Enabling ESO's ambitions and plans

Innovation plays a central role in helping the ESO achieve its ambitions. Many of the deliverables in our **Forward Plan 2020-21**[10] have been shaped by innovation projects, and can now be implemented into business as usual. This includes deliverables related to the roll-out of recommended changes to Loss of Mains protection settings[11]; implementation of new technology to measure system inertia in real-time[12]; and creation of a new reactive power market for Distributed Energy Resources (DER)[13]

In our **RIIO-2 Business Plan**[14] we expect to embed further innovation projects, from RIIO-T1, into our ongoing activities. For example we aim to have delivered the RecorDER project[15], to deploy a full-scale blockchain based asset register for flexible energy resources; and our Frequency Response Auction Trial project[16] to support closer to real-time procurement of frequency response, to lower overall procurement costs. Areas where innovation can support our other RIIO-2 ambitions include bringing artificial Intelligence, machine learning and automation into control centre processes; and testing system stability in ultra-low inertia scenarios.

We will complete a detailed review in 2020/21 to ensure our innovation strategy, set-up and approach best supports the ESO to deliver its ambitions for RIIO-2 and beyond, and to facilitate the wider energy industry transformation.

8 ENA Electricity Innovation Strategy - www.energynetworks.org/electricity/futures/network-innovation/electricity-networks-innovation-strategy.html
9 ENA Gas Innovation Strategy - www.energynetworks.org/gas/futures/gas-network-innovation-strategy.html
10 Forward Plan 2020-21 - www.nationalgrideso.com/news/our-forward-plan-2021
11 Loss of Mains Protection Settings project details - www.smarternetworks.org/project/nia_nget0205
12 System Inertia in Real-time project details - www.smarternetworks.org/project/nia_nget0192
13 New Reactive Power Market for DER project details - www.nationalgrideso.com/innovation/projects/power-potential
14 RIIO-2 Business Plan - www.nationalgrideso.com/about-us/business-planning-riio/riio-2-final-business-plan
15 RecorDER project details - www.smarternetworks.org/project/NIA_NGSO0018
16 Project details - www.smarternetworks.org/project/NIA_NGSO0017

Reviewing last year's (2019/20) strategic priorities

Over the last 12 months we have invested across the strategic priorities we set out in our Innovation Strategy 2019/20[17], delivering a portfolio of projects with a wide variety of third parties. The world around us has also continued to evolve. All of this will have an impact on the urgency of some of these priorities in the coming year.

No	Priority (£ scale of spend)	Drivers	Key developments External	Internal	Implications for 2020/21
1	**System Stability** (£££)	Synchronous generation supports the stability of the system. As we transform to a zero-carbon electricity system, synchronous generation capacity is decreasing, and the system is becoming less stable. This results in faster system frequency changes, less voltage and fault ride-through stability, and makes it more difficult for both synchronous and non-synchronous generators to operate safely.	• The events of August 9th highlighted that improvements to system stability should be made • GB system continued to decarbonise with new renewable generation records broken	• ESO launched its Stability Pathfinder, procuring £328m of stability services • Progressed innovation projects to forecast inertia and test technologies to allow inverter-driven generation to support system stability, e.g. Virtual Synchronous Machines	Remains top priority
2	**Whole Electricity System** (£££)	New decentralised energy resources are connecting to distribution networks, turning them into active networks and transforming the role of Distribution Network Operators. Many of these new resources can provide valuable services to us, increasing competition in our markets as well as to those of emerging Distribution System Operators (DSOs). In addition, smart technologies mean many consumers won't just passively use power – they can become active players of the system too.	• ENA's **Open Networks project**[18] continues to develop frameworks for DSOs, as well as for whole electricity system operation and planning • Ofgem published DSO approach and regulatory priorities	• Widespread activity across ESO to support delivery of whole electricity system outcomes (see WES Development paper)[19] • Significant investment in whole electricity system innovation e.g. Distributed Restart, Power Potential, RecorDER • Continued work on Regional Development Programmes with DNO partners around GB to solve location-specific issues	Decrease in priority
3	**Future Markets** (£££)	As we transform to a zero-carbon electricity system, it is increasingly important to explore markets for new services that can meet changing system needs, as well as markets for new products. It is also critical that we facilitate a level playing field for all participants, both traditional and emerging to further promote competition.	• Burst of activity and innovation happening in distributed flexibility markets • Lower inertia system means things happen faster – need to keep pushing for closer-to-real-time markets	• Ongoing development of suite of markets, including Dynamic Containment • Continued investment in closer-to-real-time markets through Auction Trial • Creating foundation for future whole electricity system markets through RecorDER, Residential Response, and participation in Centrica's Local Energy Market	Slight decrease in priority
4	**Forecasting of Supply and Demand** (£)	This considers both, short as well as long term forecasting. Lack of visibility of intermittent embedded generation on electricity networks, combined with more complex usage patterns, makes short-term forecasting of electricity supply and demand increasingly difficult. Long-term supply and demand forecasting are becoming harder to carry out as new technologies and global market forces emerge. These could lead to dramatically different end-user behaviours.	• Renewable generation records continue to be broken – forecasting wind and solar becomes more important • Increase in urgency of decarbonisation of transport and heat means we need to understand their future impact on the electricity system	• Improvements in short-term renewable generation forecasting, particularly solar, realised through suite of innovation projects • Greater understanding of future EV charging profiles • Kicked off project looking at future of heat demand	Slight decrease in priority
5	**Digital Transformation** (££)	Rapid digitalisation and decentralisation of the energy sector comes with many challenges: • On the electricity system, there is a huge increase in the data available through the proliferation of market players. New decentralised assets are often inherently unpredictable, so being able to harness this data is extremely important. Legacy systems and processes struggle to cope with the rapid increase in participants, emerging Internet of Things (IOT) data and technological advancements. • As the electricity networks become more reliant on data and aging ICT, the risk of cyber-attacks becomes greater. • The ESO is also increasingly a custodian of data on the electricity networks. We have a responsibility to ensure this is collected, analysed and shared with consumers in a transparent, responsible way, allowing everyone to extract the most value.	• The Energy Data Taskforce made clear recommendations that the energy industry needs to work together to improve data openness and visibility • The Wider Access programme brings a large increase in the number of market participants in the Balancing Mechanism, and in the associated data that will need to be managed, analysed and optimised	• ESO launched its Data Portal, a centralised repository for all published data • RecorDER project works to create blockchain-based register for all GB energy flexibility assets • Continued investment in advanced modelling and machine learning tools and techniques for planning and operation	Significant increase in priority
6	**Whole Energy System** (£)	The ongoing conversation around the decarbonisation of heat and transport, combined with electricity systems' increased reliance on gas for flexibility (particularly on the distribution networks), present us with a crucial opportunity to consider the energy system as a whole, across multiple vectors (i.e. electricity and the multiple gas types) and the sectors this supports (e.g. heat, power, transport, industry).	• Strong signals from the Department for Business, Energy and Industrial Strategy (BEIS) and Ofgem that energy transition needs holistic approach • Facilitating acceleration in decarbonisation of other sectors, particularly heat and transport, will need whole energy system approach	• ESO undertaking gap analysis to understand what the big questions to answer are in whole energy • Launched innovation project with National Grid Gas System Operator looking at future of heat decarbonisation • Invested in understanding future impact of EV charging • Kicking off project looking at how electric heating could solve whole system network issues	Significant increase in priority
7	**Constraint Management** (£)	Understanding the risk of constraints occurring and managing these effectively is becoming increasingly difficult due to more uncertainties in supply and demand patterns. If constraints can't be avoided or managed in the most efficient way, costs for consumers can increase dramatically.	• Greater wind generation causing constraints, this is set to continue • Planned interconnectors will increase constraints onshore • DNOs launching flexibility markets for constraints	• Launched Constraints Pathfinder to seek solutions for managing constraints in Scotland and Northern England. • Invested in innovation looking at improving forecasting of voltage constraints	Priority level unchanged
8	**System Restoration** (£££)	The availability of conventional Black Start service providers will decrease as part of the shift away from conventional thermal generation.	• Increased focus on the climate agenda accelerates the need to find low-carbon alternatives to provide Black Start services	• Distributed Restart project shows that there are no insurmountable barriers to Black Start from DER • ESO launched competitive procurement process for NW and NE England, as well as Scotland	Priority level unchanged

17 During this period the ESO has become a separate legal entity within National Grid Group, with the GSO becoming part of National Grid Gas Transmission. Therefore, this year's list of eight refreshed priorities no longer includes any that are gas specific
18 ENA Open Networks Project - www.energynetworks.org/electricity/futures/open-networks-project/
19 Whole Electricity System Development paper - www.nationalgrideso.com/document/163026/download

Key – Scale of NIA and NIC innovation spend in £m - £ (>£1m), ££ (£1m-£3m), £££ (>£3m)

Our refreshed priorities

Focusing our efforts in 2020/21

Based on our consultation with stakeholders, and on our evolved understanding of the issues based on the work we've done over the past 12 months, we have refreshed our priorities for 2020/21. The two priorities where we see significantly greater innovation focus being required are Whole Energy System and Digital Transformation.

Whole Energy System is now ranked as the second highest priority, reflecting the widespread acknowledgment that the industry needs to take a holistic approach to the energy transition, including working with other sectors.

Digital Transformation has been promoted to our third highest priority, despite significant investment last year, due to an urgent need to improve the availability and use of data across the industry. These two priorities are very closely linked.

The table below summarises our strategic priorities for 2020/21, their longer-term target states and where we see potential opportunities for innovation to help achieve them.

Our refreshed priorities reflect where you can expect to see us concentrating our innovation focus over 2020/21. To illustrate how we might continue to tackle these issues, the following pages contain case studies of how existing projects are addressing our top 4 priorities for 2020/21. These have been funded by either the Network Innovation Competition (NIC) or Network Innovation Allowance (NIA).

We have illustrated over the next few pages how the top four priorities are being addressed through innovation projects we are delivering with our partners.

No.	Priority	Target state	Opportunities for innovation
1	**System Stability**	Safe, reliable and secure operation of a zero-carbon electricity system by 2025	• Understand the behaviour of new technologies and their impact on the system, e.g. Virtual Synchronous Machines, V2G etc, to support their participation in future Stability Pathfinder procurement • Improve our understanding of how the system behaves in extremely low levels of inertia
2	**Whole Energy System**	An holistic, integrated view across all energy vectors and sectors that supports efficient and effective system planning, development and operation.	• Identify and tackle the critical uncertainties around how different vectors and sectors will interact and behave as we move to net zero, particularly electricity, gas, heat and transport
3	**Digital Transformation**	Efficient digital processes established across GB energy system; the power of Big Data and associated technologies fully leveraged; new insights created and shared; and new services developed and accessed	• Address the recommendations of the Energy Data Taskforce • Work with distribution network colleagues to facilitate more open data across the whole electricity system • Explore technology platforms to effectively store, use and exchange much higher volumes of data and services, such as portals and cloud computing
4	**Future Markets**	Competition everywhere, with greater market participation on the supply and demand-side, including all participant types and sizes	• Continue to level the playing field for non-traditional participants, increase participation and competition in existing markets and develop new, whole electricity system markets • Accelerate ways to move to day-ahead procurement of response and reserve
5	**Forecasting of Supply and Demand**	Sophisticated and accurate energy forecasting in both operational and planning timescales	• Improve visibility and granularity of embedded wind and solar data to better forecast their output and impact on the wider system • Drive an open innovation approach to forecasting distributed energy resources through cloud-based platform • Improve understanding of changes in energy demand, such as from increased uptake of EVs or electric heating
6	**Whole Electricity System**	Efficient and effective planning and operation across transmission and distribution	• Achieve greater visibility for all network and system operators across transmission and distribution • Work with DNO colleagues to understand the impact of a rapidly changing distribution network on the whole electricity system • Address how new markets to provide distribution network flexibility can work efficiently alongside transmission level markets • Test new roles and rules for market players in whole electricity system markets
7	**Constraint Management**	Optimised management of networks across transmission and distribution with minimal curtailment of renewable generation and at minimum overall cost to consumers	• Explore and test new ways of managing constraints across transmission and distribution • Explore sophisticated new tools and techniques for forecasting constraints of all types and in different scenarios of supply and demand • Develop new tools and processes for decision making under uncertainty • Understand the opportunity for long-duration storage
8	**System Restoration**	Ability to restore GB from total or partial shutdown, with zero carbon sources, by 2025, at minimum cost to consumers	• Deliver Distributed Restart project to facilitate Black Start from DER

Case studies

System Stability

Case study:

Phoenix – NIC[20]

As the shift to a more flexible energy landscape continues, one of the biggest issues is maintaining system stability. Led by SP Energy Networks, the Phoenix project is developing a technological solution to this by bringing together two existing technologies to develop and trial a Hybrid Synchronous Condenser. Ultimately, the roll-out of this new technology will help to create stability in the grid, reacting when extra power is needed and increasing control over voltage.

www.spenergynetworks.co.uk/pages/phoenix.aspx

Project partners:

Jay Ramachandran, Power Systems Engineer, ESO

"Phoenix is important because it provides a new solution to maintain system stability and security, releasing additional capacity to the network and reducing operating costs. The results are also being fed into the ESO's Stability Pathfinder work. We are working towards the commissioning phase and the start of a one-year trial to assess the benefits in a real-world situation."

SP Energy Networks | ESO | ABB | University of Strathclyde | Technical University of Denmark

Whole Energy System

Case study:

4D Heat – NIA[21]

The 4D Heat project is in its initiation stage. We will be investigating whether residential-scale flexibility from electric heat can provide a solution to significant constraint issues across the transmission and distribution networks in Scotland.

Project partners:

Jon Slowe, Director, Delta-EE

"The 4D Heat project is interesting because it's taking a whole system approach across both Transmission and Distribution. It will focus on a specific region in the north of Scotland where many households might already have electric heat, for example through storage heating.

"We'll be looking to see if we can match the flexibility from electric heat to times when, at present, wind farms might need to be constrained. The challenge is to find a solution that works both for the ESO and DNO".

ESO | Delta-EE | PassivSystems | Everoze | SSEN

20 NIC – Network Innovation Competition
21 NIA – Network innovation Allowance

Case studies

Digital Transformation

Case study:

RecorDER – NIA

The RecorDER project aims to create the first whole electricity system register for generation and flexibility assets using blockchain. The register, developed by specialist energy-tech company Electron, will hold information about the location, capability and availability of assets. As well as greater visibility across the whole electricity system, RecorDER will bring a range of other benefits including easier trading of assets across transmission and distribution and a more dynamic way to register assets.

www.smarternetworks.org/project/nia_ngso0018

Project partners:

Jo-Jo Hubbard, CEO Electron

"The idea is to create a single access point – like a portal – that contains multiple sets of data on generation and flexibility assets to make coordinating balancing decisions more effective.

We are testing new forms of shared data governance and proving whether blockchain technology provides the right solution. Phase 2 would then involve actually building the system itself."

ESO | Electron | SP Energy Networks UK Power Networks

Future Markets

Case study:

Testing Coordinated DSO-ESO Procurement and Dispatch – NIA

This project is breaking new ground in efforts to support a more flexible and responsive electricity system. For the first time, the ESO and Distribution Network Operator Western Power Distribution are buying flexibility services at the same time, using a single platform – Centrica's auction-based marketplace.

Coordinated procurement of flexibility across the whole electricity system will increase competition in flexibility markets, lowering overall costs to consumers. It will also bring more low-carbon sources into the market, supporting the energy transition.

www.smarternetworks.org/project/nia_ngso0027

Project partners:

Colm Murphy, Electricity Market Change Delivery Manager, ESO

"The trial helps us to access and understand how new, smaller sources of generation and demand can help to manage the grid and balance the system going forward. It's part of a wider series of reforms and developments… that will enable us to meet our net zero target for carbon."

ESO | Western Power Distribution | Centrica

Last year's performance: Delivering innovation projects through 2019/20

In the 12 months, from April 2019 to March 2020, we have once again committed our full Network Innovation Allowance (NIA) funding allocation to tackling our strategic priorities. We've engaged with a wider range of partners and delivered a balanced portfolio of projects from early-stage research through to demonstration.

Our investment this year saw the completion of six projects, continued delivery of ten and the start of eight new projects that align to our innovation priorities.

All of our projects address more than one priority area. Figures 1 and 2 indicate the level of effort we are investing against our priorities, and show that we are broadly allocating this effort according to the strategy that we set out at the beginning of 2019/20. **System Stability**, our top priority, is receiving the most attention, followed by **Whole Electricity System**, which was our number 2 priority, and so on. One significant outlier is that we are investing more heavily than we anticipated last year on **Digital Transformation** projects. This is for the reasons outlined on page 14 and we realise that there is a lot more to do, so it has increased in priority this year.

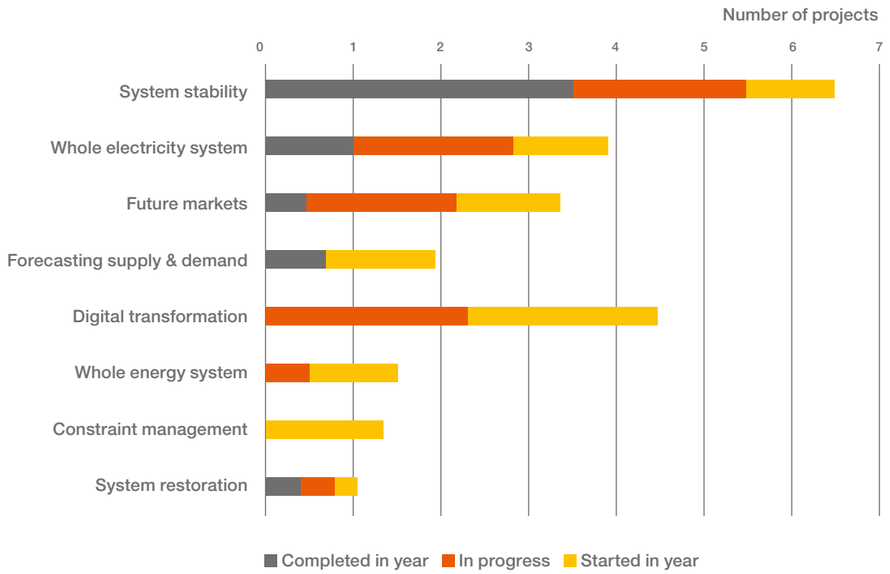


Figure 1 - Proportion of innovation projects[22] live in 2019/20 across our innovation priorities

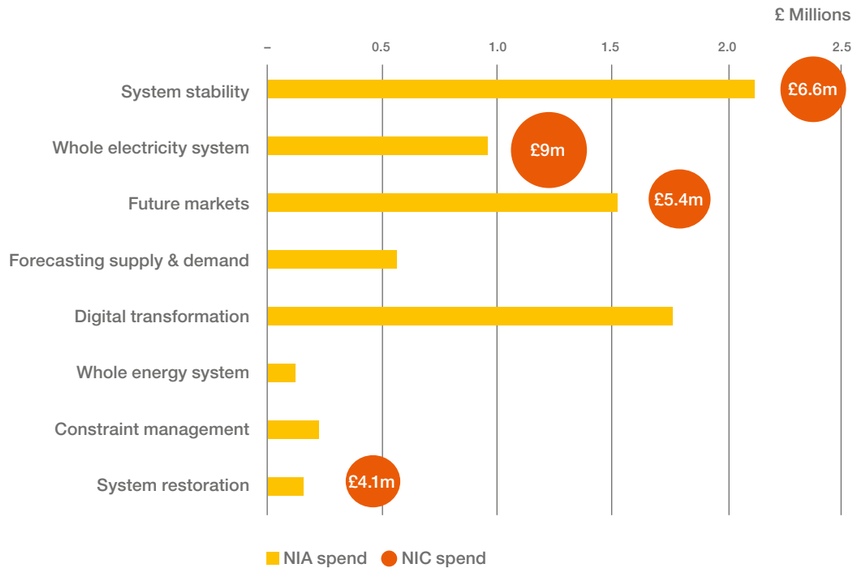


Figure 2 - Committed NIA and NIC spend across live innovation projects in 2019/20 against our innovation priorities[23].

22 Where an Innovation project addresses more than one priority area, it is proportioned accordingly and a percentage of the project attributed to each relevant priority to reflect the extent of its impact.

23 Figures based on the total registered project value. This has been proportioned across the priority areas each project addresses.

Engaging with partners

Collaboration with third parties is critical to the success of ESO innovation.

80% **of our NIA spend is with external partners**

We have focused 80% of our innovation spend on our work with external partners. We have engaged with more than 130 organisations across a range of activities in the last year. This extends from refreshing our innovation strategy through to hosting our Open Innovation Event. We have also actively participated in a wide range of external events, such as the Low Carbon Network Innovation (LCNI) Conference. The LCNI event was organised in partnership with the electricity networks and the Energy Networks Association (ENA) and over two days was attended by over 1,000 delegates.

48% **of our partners were SMEs**

We have continued to build a broader network of partners through 2019/20. We have increased our partnerships with network operators and technology & service providers, to accelerate research and development of new solutions to tackle the big challenges facing the industry. We have also increased our project collaborations with Small and Medium Enterprises (SMEs) to access new ideas, fresh thinking and more agile ways of working to facilitate the energy transition. 48% of our partners were SMEs, 26% had <10 employees and 25% we worked with for the first time in 2019/20.

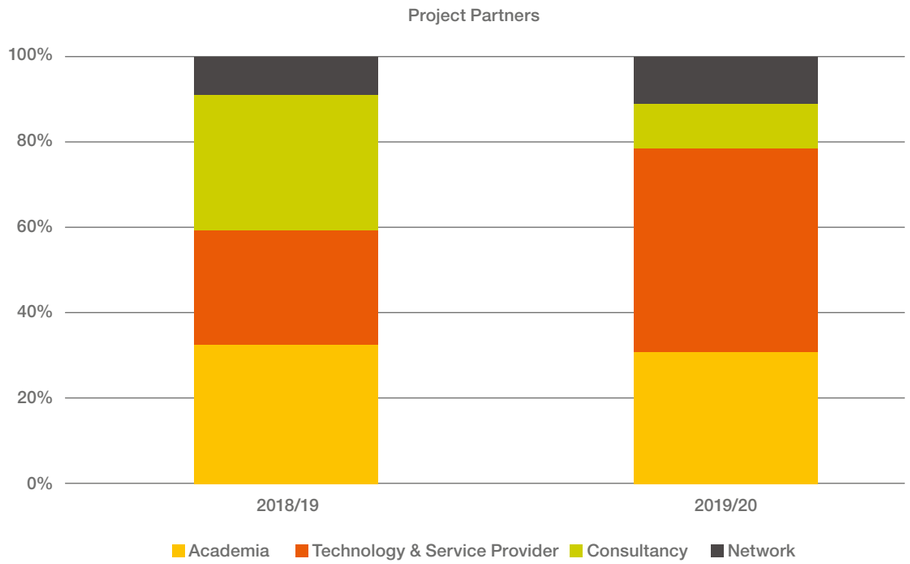


Figure 3 - Mix of project partners vs 2018/19

2019 Open Innovation Event

We also expanded our successful Open Innovation Event, which took place over two days in November 2019. We welcomed more than 40 representatives from academia, consulting, technology & service providers and software firms to develop proposals to tackle three of our innovation priorities:

Digital Transformation, System Stability and Whole Electricity System.

87

The event generated a total of 87 submissions

11

Ideas taken forward – three on Stability, three on Whole Electricity System and five on Digital Transformation

07

Projects funded, worth around £2m, with approximately £1m of funding coming from the ESO

Innovation project delivery

Our innovation spend has largely focused on initiating riskier, early-stage research with most projects starting at Technology Readiness Level (TRL) 4 or below. This reflects our risk appetite and ambition to optimise innovation funding to focus NIA at research and development, and NIC funding at demonstration projects.

While lower-TRL projects carry greater uncertainty, they have the potential to deliver significant value to our customers and stakeholders if their hypothesis is proven correct. These projects enable us to advance our understanding and capabilities in ground-breaking areas such as blockchain and machine learning, as well as state-of-the-art technologies such as Virtual Synchronous Machines.

We have maintained a balanced portfolio of projects focusing our efforts between research and development. In 2019/20, the majority of our project portfolio (90%) started in the research stage (TRL 3 and under) while our portfolio is fairly well balanced at completion between 47% completing at research (finishing at TRL4) and 53% completing at development or demonstration (TRL 5 and above).

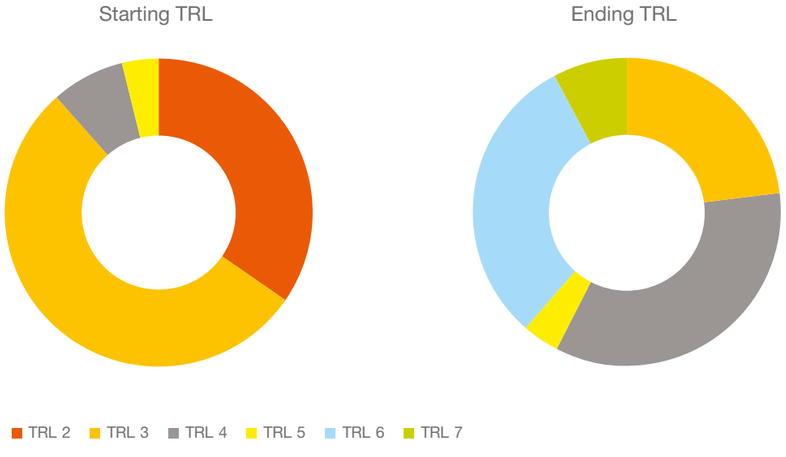


Figure 4 - Start and End TRLs of live projects in 2019/20 demonstrating that innovation projects typically start in the research stage and complete either at development or demonstration stage.

We have continued this balanced approach for new projects started in 2019/20, as demonstrated in the figure 5 below.

We have set out over the next few pages a selection of case studies that illustrate the range of benefits our innovation projects seek to demonstrate.

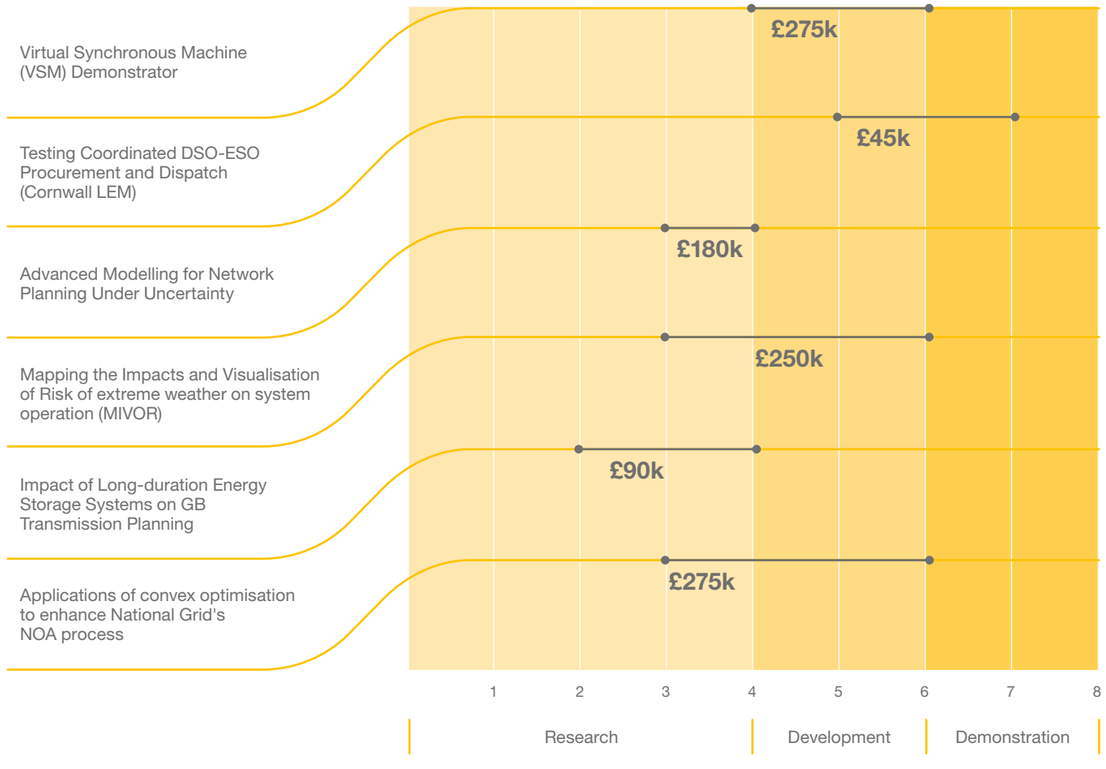


Figure 5 - Advancements in Technology Readiness Level (TRL) for projects sanctioned in 2019/20 demonstrating a continued focus on initiating projects at research stage and progressing through to development and demonstration. Value (£) shown is registered value for the project.

Unlocking benefits

All of our innovation projects go through a rigorous Cost Benefit Analysis before we approve and fund them. Consumer value, in terms of lower bills, is a significant part of what we look to achieve through innovation. This, however, only represents one of several benefits that our portfolio of innovation projects can realise. We equally focus on innovations that will reduce environmental damage, improve safety and reliability of the grid, deliver better quality services and bring wider benefits to society as a whole.

Benefits explained:

Improved safety and reliability

Maintaining a balanced and secure electricity system, now and in the future.

Improved quality of service

Optimising our service to stakeholders based on efficient and effective engagement.

Lower bills

Reduced transmission and balancing charge on consumer bills, through improvements in how we plan and operate the system.

Reduced environmental damage

Facilitating the transition to a zero-carbon electricity system.

Benefits for society as a whole

Facilitating other socio-economic benefits for GB and wider society such as job creation or improved public health.

Case studies

Lower bills

Frequency Response Auction Trial – NIA

We are trialling a weekly auction platform with project partner EPEX SPOT to test how procuring frequency response closer to real time can increase competition and lower the overall procurement cost while creating a faster and fairer system. Ultimately, these cost savings would be passed on to customers as lower bills.

www.smarternetworks.org/project/nia_ngso0017

Case study:

Project partners:

Howard Wright, Head of UK Public and Regulatory Affairs, EPEX SPOT

"This is an exciting project to be involved with. The weekly trial is an important step because enabling closer to real-time procurement of frequency response will open up the market to a wider set of participants, including renewables providers. Increased competition is important in allowing prices to better reflect market fundamentals, driving a better outcome for the energy community.

We're working in an agile and dynamic way with the ESO team to adapt the solution so that it delivers the maximum benefit to the market."

ESO | EPEX Spot

Wider benefits:

Improved safety and reliability

Improved quality of service

Case studies

Reduced environmental damage

Case study:

Distributed ReStart – NIC

The Distributed ReStart project explores how Distributed Energy Resources (DER) could be used to restore power in the highly unlikely event of a total or partial blackout of the National Electricity Transmission System. We have partnered with SP Energy Networks and TNEI on the project, which is assessing cleaner, greener alternatives for Black Start.

www.nationalgrideso.com/innovation/projects/distributed-restart

Project partners:

Neil Miller, Lead Design Engineer, SP Energy Networks

"Replacing the small number of power stations that currently provide Black Start capability with potentially hundreds of DER is a significant technical challenge. However, it is also an opportunity to maximise the contribution of these resources, and to find a radically different approach, to network restoration with the potential to reduce carbon and cut costs.

The project is looking at the regulatory, commercial and power engineering solutions aspects needed to harness DER for Black Start. This will include several live network trials to demonstrate in practice how we can re-energise the network from the bottom-up using a mix of DER."

ESO | SP Electricity Networks | TNEI

Wider benefits:

- Improved safety and reliability
- Lower bills

Benefits for society as a whole

Case study:

Solar PV Monitoring Phase 3 – NIA

Working with partner Sheffield Solar (University of Sheffield) we are studying ways to forecast more precisely the levels of solar photovoltaic (PV) generation flowing into the GB network. The project will help to improve system stability and reduce balancing costs.

www.smarternetworks.org/project/nia_ngso0008

Project partners:

Dr Alastair Buckley, Academic Project Lead, Sheffield Solar

"In this phase of work, we will be creating an independent model to evaluate the amount of solar PV on the system, including regional capacity for each electricity supply region. This provides much more precise estimates of PV at Grid Supply Point (GSP) level – where power flows from the transmission network onto a distribution network.

Ultimately, this helps to reduce the forecast error for solar, which is important because it leads to lower costs to balance the system."

ESO | Sheffield Solar

Wider benefits:

- Improved safety and reliability
- Lower bills
- Reduced environmental damage

Case studies

Improved safety and reliability

Case study:

Long-term Storage for Transmission Constraints – NIA

We are partnering with Form Energy to analyse the impact of a range of energy storage systems on transmission network constraints. The goal is to enable better-informed investment and operational decisions so that the grid runs securely and efficiently. The project is modelling the optimal size and operation of an energy storage system placed upstream on a constrained part of the transmission system.

www.smarternetworks.org/project/nia_ngso0030

Project partners:

Aly Eltayeb, Business Development & Analytics Manager, Form Energy

"Building new wires to connect sources of generation over long distances to areas with high energy demand is both expensive and time-consuming. Instead, we are exploring how existing and future energy storage technologies could achieve the same effect but in a novel way."

There are many potential benefits, most notably strengthening the reliability of the network. Reducing infrastructure and constraint costs translates into lower bills for consumers, while the project also supports decarbonisation efforts by ensuring that the ESO can maximise the contribution or renewable asset."

ESO | Form Energy

Wider benefits:

- Lower bills
- Reduced environmental damage

Improved quality of service

Case study:

Enhancing Energy Flexibility from Wastewater Catchments through a Whole System Approach – NIA

We are investigating a potential new source of flexibility in partnership with the water industry for the first time. This project is looking at whether the extra system capacity built into wastewater assets could be used to provide extra demand-side flexibility services. Specifically, we are working with Open Energi and United Utilities to understand if the protections in place to guard against rare weather events such as floods and droughts can be harnessed to unlock demand-side flexibility.

www.smarternetworks.org/project/nia_ngso0024

Project partners:

Natalie Jones, Demand Response Manager, United Utilities

"The water and energy industries share many challenges, such as how to decarbonise effectively and minimising bills for consumers. Flexibility is a big part of those efforts. In this project we've selected one wastewater catchment area in Preston, Lancashire where we'll be testing ways to use our existing assets more flexibly, particularly storage capacity to provide demand-side services. If successful, the approach could be replicated regionally and GB-wide."

ESO | United Utilities | Open Energi

Wider benefits:

- Lower bills
- Reduced environmental damage
- Benefits for society as a whole

Enabling delivery: Our commitments in 2020/21

We have outlined our refreshed innovation priorities for 2020/21, the final year of the RIIO-T1 regulatory period. As we prepare to enter RIIO-2, we are also committing to:

- Undertake a detailed review of our Innovation Strategy, to ensure we align with ESO's 2025 ambitions and RIIO-2 Business Plan, as well as the network industry innovation strategies, ensuring we have the right structure and resources
- Adopt a consistent framework to track and report on project progress and benefits, aligned to other network companies
- Increase our communications and stakeholder engagement, using a wider range of publications and channels

Working together: Meet the team and get in touch

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 current innovation portfolio.

We're always on the look-out for new ideas and opportunities to partner on innovation projects too. Our publication 'Innovating with the System Operator'[20] provides more information on how we lead innovation projects and support third party ones. All these projects share a common goal: to solve the increasingly complex challenges facing the energy industry and society.

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Manager Portfolio Delivery

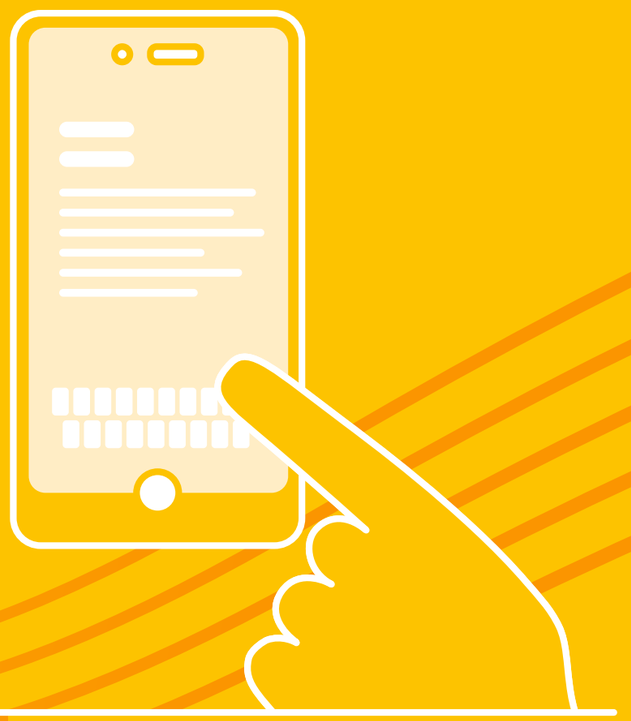
Alison Dineley
Senior Innovation Analyst

24 Innovating with the System Operator - www.nationalgrideso.com/document/155196/download

Get in touch

Contact the team: **box.SO.innovation@nationalgrid.com**

Visit our website: **nationalgrideso.com/innovation**



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