System Operator Innovation Strategy

A refresh for 2019/20 and how we performed over the last year

nationalgridSO

National Grid Innovation Strategy 2019/20

Energy is the lifeblood of our economy and society. As Great Britain's System Operator (SO) we sit at the heart of the energy system, performing a leading role in delivering energy safely and reliably while driving the transformation towards a more sustainable and decarbonised future; the challenge of a generation. As the industry transforms, we believe our role at its heart must also evolve as we call on innovative technologies, open markets and new ways of working.

Last year we published our first ever System Operator Innovation Strategy, setting out our innovation priorities for 2018/19 and how we intended to work with industry partners to solve the challenges facing Great Britain's energy system. We are now looking back on how we performed against what we set out to do, and more importantly we are revisiting and revising our priorities for 2019/20 to ensure we keep delivering the most value for consumers in this ever-changing landscape.

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Innovate with us!

More details on how you can get involved with innovation at the System Operator can be found in 'Innovation – Get Involved with the System Operator' below.

Click here for more details

01

Innovating for our shared energy future

A year on from the publication of our first ever System Operator Innovation Strategy, it is important for us not only to take stock of what we have achieved, but also to recognise the continued unprecedented pace of change that our industry is experiencing.

In the last 12 months we have seen Great Britain (GB) make further advancements in decarbonisation, with renewed commitments from the Committee on Climate Change and the Government's Spring Statement to further the decarbonisation of gas agenda, renewable electricity generation records being broken, and further digitisation of the energy system with the UK's first physical energy trade on a blockchain taking place. We have also seen progress in decentralisation with the opening of the Balancing Mechanism to aggregated units and the completion of project CLoCC, which will enable smaller, cheaper gas customer connections to the transmission network.

The System Operator is evolving to keep up with this rapid change. The Electricity System Operator (ESO) is now a legally independent organisation, separate from National Grid Electricity Transmission, focused on enabling competition, coordination, and innovation across the system. We have responded to rapid decentralisation and decarbonisation in many ways, including introducing a dedicated distributed energy resource desk into our electricity control room and by taking a leading role in the discussion of decarbonisation of gas. As we enter the new financial year, we have published our 'Towards 2030' document, outlining the key challenges ahead for the GB energy system, and setting out five focus areas to guide the efforts of the System Operator through the energy transformation.

To achieve these key transformations, we must innovate together as an industry. At the heart of the energy system, the System Operator is in a unique position to drive many of the changes needed to deliver the future vision we all share.

This document has been developed in consultation with industry and sets out how we need to innovate in 2019/20 and where we want to focus our efforts to set us on the right path to 2030. It sets out our metrics for success going forward and outlines how we performed against those metrics over the last 12 months.

Most importantly it is a call to arms from the System Operator to the energy industry. We look forward to working with you this year to support System Operator innovation and to help deliver the future. GB energy system.

Kayte O'Neill
Head of strategy and regulation, National Grid System Operator.

02

Why and how the System Operator

Our System Operator mission and priority focus areas for our business

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

Success in 2025 looks 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 achieve our mission our *Towards 2030* publication sets out five priority areas of focus for the System Operator to guide us on this journey:

1 **The engineering transformation:** ensuring reliable, secure system operation to deliver energy when consumers need it

2 **The market transformation:** unlocking consumer value through competition

3 **The sustainability transformation:** enabling and supporting the drive towards a sustainable whole energy future

4 **The smart transformation:** driving innovation and increased participation across the energy landscape

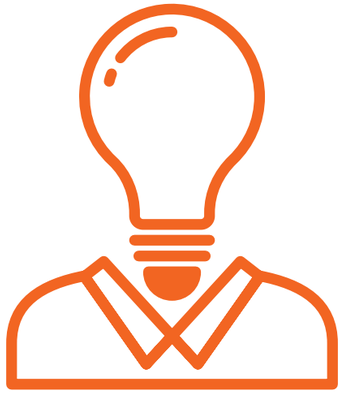
5 **The capability transformation:** developing the right people and systems to deliver the future

Innovation is an important tool that will help us achieve our mission, and our Innovation Strategy sets forth the route to get us there.

Innovation and the System Operator Innovation Strategy

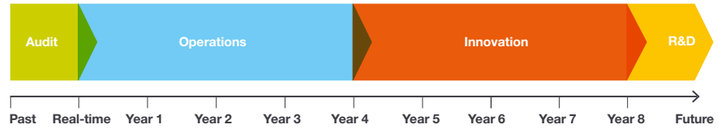
Innovation is about creating a safe space in which to explore and develop novel solutions to new medium-to long-term problems, to create new value and to be prepared for the future. We define the scope in which innovation can be most effective with two criteria:

- **Time:** Does the project deliver value within four to eight years (Figure 1)? Innovation isn't effective in delivering rapid solutions, as too-short time frames don't allow for enough time to properly test and try new higher-risk products and services.
- **Maturity:** How well developed is the solution to the problem? We tend to tackle projects in later stages of research & development versus very early stages. We also don't work on projects that are more about the incremental improvement of day-to-day operations.



Innovation is an essential means to us achieving our 2030 objectives. And if innovation is the vehicle to get us there, our Innovation Strategy sets the route for us to navigate.

Figure 1:
The innovation timeframe, as distinct from R&D and operations.



Last year, we launched our first ever System Operator Innovation Strategy, setting out our priority areas for innovation and how we planned to work with industry to tackle them.

As shown in Figure 2, our method for arriving at our strategy was a combination of bottom-up and top-down approaches:

- **Bottom-up:** we collected all issues facing the energy system through:
  - Consulting our customers and stakeholders
  - Consulting our internal subject matter experts
  - Synthesising System Operator publications (e.g. Future Energy Scenarios, Network Options Assessment, System Operability Framework)
- **Top-down:** we categorised all issues based on the macro trends that the energy sector is facing, ensuring interdependencies were well understood and that we had not missed any important strategic issues.

These issues were then prioritised against the fundamental metrics for the SO: security of the system; impact on consumer bills; impact on customers; and how urgent the issues are.

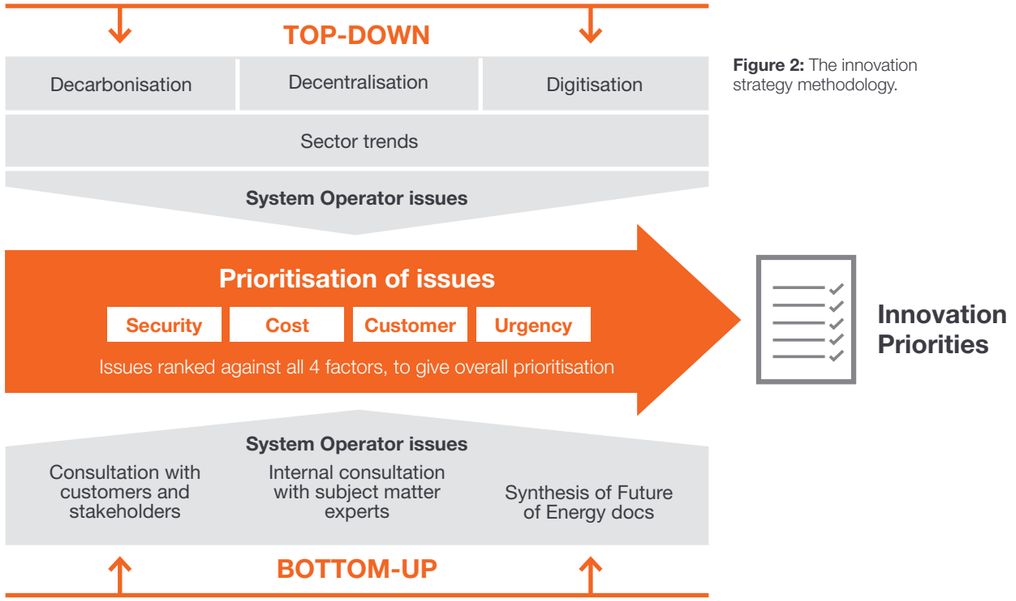
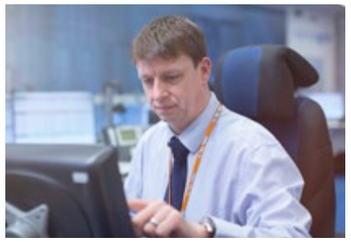


Figure 2: The innovation strategy methodology.

Last year, this approach produced 16 System Operator Innovation Priorities that we set out to focus on over the course of 2018/19 (listed in Figure 3). For example, our top priority was to tackle 'whole system operability', which resulted in our committing almost £3.8m across five projects aimed at that specific issue this year. Chapter 4 goes into more detail about how we performed against the 2018/19 priorities over the last 12 months.

03

Our refreshed System Operator Innovation Strategy



What has changed since last year?

Much has changed since last year's publication. The timeline in Figure 3 shows that not only has the industry continued to evolve rapidly, but so has the System Operator. In particular:

- We can now align ourselves to our newly developed **2030 mission**. For example, to align with the first of the five focus areas (the engineering transformation), we have placed System Stability at the top of our priorities. We have also increased the priority of Future Markets to manage system costs, and we have prioritised Whole Electricity System and System Stability (managing high penetration of renewables) to drive the sustainability transformation.
- We have engaged actively on our strategy over the last 12 months and have gathered lots of your comments and observations. For example, we heard the importance of decarbonisation of heat and transport, as well as interactions between gas and electricity systems, which has contributed to the introduction of our Whole Energy System priority.
- Our understanding of these issues has moved on significantly over the last 12 months, and we can now take a top-down strategic approach while consolidating some of these priorities. Figure 3 shows how we have consolidated, revised and refined our priorities, based on your feedback, from 16 to 11 (including new ones) for the coming year.

Figure 3:
Chart showing how priorities have changed since last year, and below, a timeline showing events over the last year that have driven our thinking.

2018-2019 Priorities	
01	Developing DSOs and whole system operability
02	Improving short-term generation/ supply & demand forecasting
03	Managing volatility in a low inertia system
04	Analytics in a data-enabled future
05	Enhancing cyber security
06	Enabling more non-synchronous connections
07	Supporting voltage and reactive power
08	Optimising constraint management
09	Redesigning system restoration
10	Creating markets for the future
11	Harnessing the 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

2019-2020 Priorities	
01	System stability
02	Whole Electricity System
03	Future markets
04	Forecasting of supply and demand
05	Digital transformation
06	Whole Energy System
07	Whole Gas System
08	Constraint management
09	New types of gas
10	System restoration

Consolidation of priorities

Expansion of priority

April 2019
Electricity System Operator legally separated from ETO

End of 2020
Ofgem publish final view on RIIO T2

Feb 18 — Launch of the inaugural Innovation Strategy

Mar 18 — Open Innovation Day; System Operator Hackathon:

Apr 18

May 18 — Electricity and Gas Network Industry Innovation Strategies

Jun 18

Jul 18 — FES 2018 launch

Aug 18 — Carbon Intensity record broken (71gCO2kWh)

Sep 18 — Machine-learning-driven solar PV forecast feed launched

Oct 18 — Low Carbon Networks Innovation (LCNI) Conference; Power Responsive Flexibility Forum; Innovation Strategy refresh webinar

Nov 18 — NIC funding awarded to Black Start from DER

Dec 18 — Electricity System Operator internal structure rebuilt; Whole Electricity System Publication

Jan 19 — EDF Cottam coal plant closure announcement; DER desk launched in Electricity System Operator control room; Open Networks 2019 Work Plan consultation; Wind generation record (15.5GW)

Feb 19

Mar 19 — Launch of the 2019/20 Innovation Strategy; Publication of System Operator 'Towards 2030'; Publication of 'Electricity System Operator RIIO2 Ambition'; Publication of '19-21 Forward Plan'

The Innovation Priorities

Our revised innovation priorities reflect the changes we have seen over the last year in the energy industry, and how we will explore and develop solutions to these changes. Figure 4 shows the priorities which are explained in more detail on page 10:

	Priority	Fuel	Change	Notes
01	**System stability**	Electricity	↑	We have combined issues around inertia, voltage, and enabling more non-synchronous generation. This is now our top priority.
02	**Whole Electricity System**	Electricity	↓	Remains a key priority as we look to optimise across distribution and transmission.
03	**Future markets**	Electricity & Gas	↑↑	Unlocking flexibility and markets for the future combined and significantly prioritised based on stakeholder feedback.
04	**Forecasting of supply and demand**	Electricity & Gas	→	Combined short-term and long-term forecasting priorities, remains one of our key focus areas.
05	**Digital transformation**	Electricity & Gas	NEW	Combines data analytics, cyber security and new systems / processes. Remains key priority.
06	**Whole Energy System**	Gas	NEW	Introduced to address electricity and gas interactions, as well as heat and transport.
07	**Whole Gas System**	Electricity & Gas	↑	Introduced to address complex new distribution gas consumers and producers.
08	**Constraint management**	Electricity & Gas	→	No change.
09	**New types of gas**	Gas	↑	Slightly increased priority due to increased urgency.
10	**System restoration**	Electricity	↓↓	De-prioritised due to significant investment in 2018 (NIC and NIA).

Figure 4:
Chart shows our new list of priorities.

	Priority	What is driving this?	What do we need to do?
01	**System stability** Electricity only	Synchronous generation supports the stability of the system. As we transform to a low-carbon energy 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 safely operate.	We need to explore new ways to enhance system stability, as well as support the safe and efficient operation of the system in times of lower stability.
02	**Whole Electricity System** Electricity only	New decentralised energy resources are connecting to distribution networks, turning them into active networks and transforming the role of Distribution Network Operators (DNOs). Many of these new resources can provide valuable services to us, increasing liquidity and thus 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.	We need to explore innovative ways of designing and operating transmission and distribution networks. We need a whole electricity system approach with our customers and stakeholders to ensure the delivery of services and the operation of networks are done efficiently and effectively as well as to further promote competition in our markets.
03	**Future Markets** Electricity & Gas	As we transform to a low-carbon energy system, it is increasingly important to explore markets for new services that can meet changing system needs, as well as markets for new products (e.g. hydrogen, stability). It is also critical that we facilitate a level playing field for all participants, both traditional and emerging to further promote competition.	We must work with other networks and with all market participants, traditional and new, to facilitate a cost-effective and whole system approach, improving access and price signals in gas and electricity markets for new participants.
04	**Forecasting of supply and demand** Electricity & Gas	This priority looks at both, short as well as long term forecasting. Gas supply patterns are becoming more difficult to predict due to increased volatility, variability and uncertainty in the way our customers use the gas network. 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. This electricity variability is in turn causing higher usage of gas-fired generation, which then means that the variability of one system impacts that of the other. Long-term supply and demand forecasting is becoming harder to carry out as new technologies and global market forces emerge. These could lead to dramatically different end-user behaviours.	We need to understand the changing drivers of supply and demand, and deploy innovative new ways of forecasting them. Building our capabilities in this area would support further understanding of these complex interdependencies (e.g. supply/demand scenarios). We also need to identify the underlying policies, properly model the technical constraints, the economics, revisit our assumptions on consumer behaviour, as well as the potential resulting impacts. By researching future scenarios, we can help mitigate the risk of negative outcomes and contain future bill increases.

	Priority	What is driving this?	What do we need to do?
05	**Digital transformation** Electricity & Gas	Rapid digitisation 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 IOT data and technological advancements. • As the gas and electricity networks become more reliant on data and aging ICT, the risk of cyber-attacks becomes exponentially greater. • The System Operator is also increasingly a custodian of data on the gas and 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.	We need to harness the power of Big Data through new systems, capabilities and processes. We also need to understand and test new technologies such as artificial intelligence, machine learning, cloud computing and blockchain, to extract additional insights and share these in a transparent way. With everything, we need to maintain the highest standards of security and resilience which are required by the Critical National Infrastructure status of our systems
06	**Whole Energy System** Electricity & Gas	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).	We need to understand whole energy issues (e.g. decarbonisation of heat); including which stakeholders are most impacted and how operability issues are influenced by interactions between the gas and electricity systems. We will explore how data can be used to optimise across the whole system and what changes to markets, infrastructure and regulatory mechanisms are necessary to enable this.

	Priority	What is driving this?	What do we need to do?
07	**Whole Gas System** Gas only	As the energy system decarbonises there's a growing number of new gas use types (e.g. peaking generation) as well as new types of producers (e.g. biogas, hydrogen) increasingly connecting to the gas system, particularly on distribution networks. This is creating more complex operability situations across gas distribution and transmission (including access and charging arrangements). These new customers are requesting very different levels of service, e.g. distributed gas requesting gas compression, which can be costly to meet.	We need to work with Distribution Networks on new market arrangements for the whole system. We will consider the changing behaviour and requirements of those connecting to the gas networks, and their impact on the whole gas system. We must ensure we are making the most efficient and economic planning and operational decisions for the whole gas system (across transmission and distribution networks).
08	**Constraint management** Electricity & Gas	For the Gas network, 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 can increase dramatically for consumers while putting security of supply at risk.	We need to ensure gas quality does not become a barrier to trade, or to new gas sources. The technical and stakeholder accepted limits for gas specification on the NTS need to be understood, with technical and market solutions found to facilitate this wherever possible.
09	**New types of gas** Gas only	GB is becoming more reliant on imported gas, which does not match the current regulatory requirements for gas quality on the gas National Transmission System (NTS). New types of local gas supplies are also increasingly looking to connect to the network (e.g. shale gas, hydrogen, bio-methane etc.)	We need to ensure gas quality does not become a barrier to trade, or to new gas sources. The technical and stakeholder accepted limits for gas specification on the NTS need to be understood, with technical and market solutions found to facilitate this wherever possible.
10	**System restoration** Electricity only	The availability of conventional Black Start service providers is expected to decrease as part of the shift away from conventional thermal generation.	We will look for alternative approaches to Black Start, and new strategies to restore the system.

We need to explore innovative ways of designing and operating transmission and distribution networks.

04

How we performed in 2018/19

Our Innovation Strategy not only provides the industry with a clear and transparent view of where we will be investing our efforts over the coming year, it also rates our performance as an innovation-focussed organisation. This chapter sets out how we performed against what we set out to do 12 months ago. This is not just a matter of tackling priorities with the appropriate effort, but of how we balance our portfolio of projects in terms of risk, the kind of partners we work with, the types of outcome and the benefits they bring to consumers.

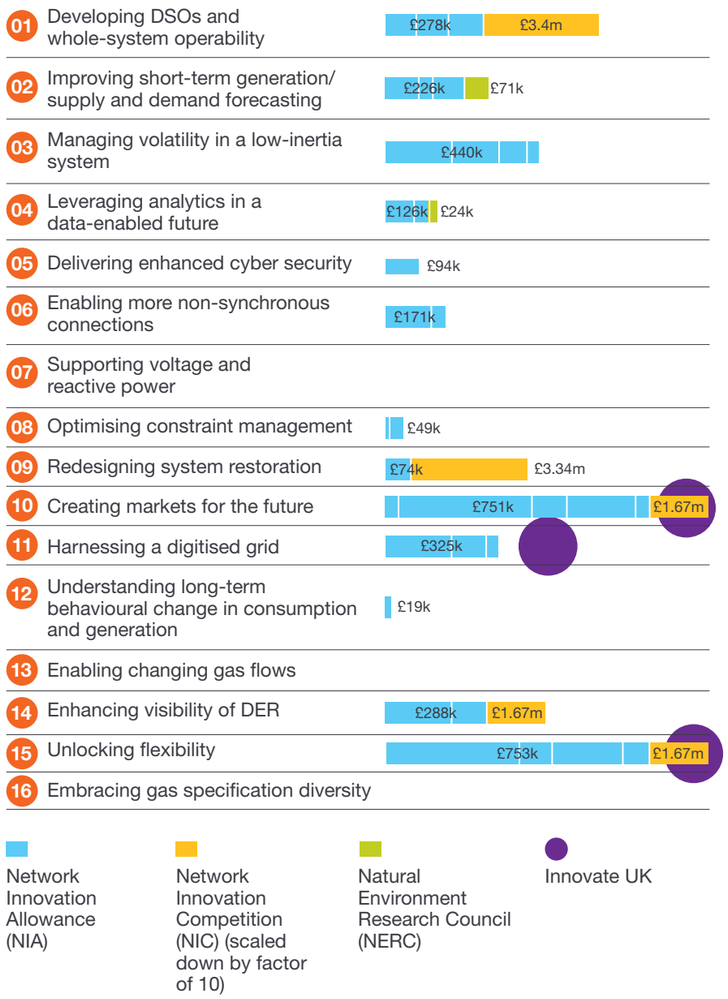


Figure 5:
The committed spend for innovation projects registered in 2018/19 against the innovation priorities. The committed spend is scaled according to whether a project directly or indirectly tackles a priority. Therefore, each bar shows the number of direct and indirect links a project has to a priority. NIC spend is scaled down by a factor of 10 for easier comparison to NIA and NERC spend. Innovate UK projects, which we are not directly funded to participate in, are represented in the purple bubbles.

Figure 5 considers how we balanced our investment and number of projects against the priority areas over the last financial year.

01 **We invested heavily in whole electricity system this year.** Investigation and testing of Black Start from distributed energy resources, creating a whole electricity system register for flexibility assets, and facilitating residential DSR providers to access balancing markets were some of the highlights.

03 06 **Managing volatility in a low-inertia system and enabling more non-synchronous generation were a strong focus.** We launched several projects, including building a machine learning-driven inertia forecast, and a study into how renewable generation might support the grid as synchronous generation would. Given the increasing urgency of system stability issues, we have consolidated these two issues, as well as voltage and reactive power, into one priority for the coming year, making it our top priority.

04 05 11 **The high level of focus on cyber security and digital strategy at the National Grid PLC level,** means we were able to prioritise System Operator innovation spend in other key areas. Cyber security remains a critical priority for the System Operator over the coming year.

10 15 **Unlocking flexibility and creating markets for the future became higher priorities for the industry than we had initially foreseen.** We invested heavily in these areas, through investigating new ways of procuring Black Start, frequency response and residential DSR to name but a few. These priorities have now been consolidated and given significantly greater importance.

13 16 We did not spend against gas as planned in 2018/19 but have 2 projects in evaluation for funding going into 2019/20.

Case studies

01 09 **Black Start from Distributed Energy Resources.** In November 2018, Ofgem awarded our project, in collaboration with SP Energy Networks and the consultancy TNEI, funding in the Network Innovation Competition. This £11.7m ground-breaking project will design and test ways to restore the GB electricity system from a black out, by coordinating distributed energy resources.

10 15 **Frequency Response Auction Trial.** We are trialling closer-to-real-time procurement of frequency response via a cleared-price auction platform. This should enable more non-traditional players such as wind and DSR to participate in the market, boosting liquidity and lowering overall system balancing costs.

14 **RecorDER.** We are working with UKPN, SPEN and Electron to design and test a prototype blockchain-based register for GB flexibility and generation assets. This creation of 'one version of the truth' should facilitate more trust in asset capability for trading of flexibility across the whole electricity system.

03 04 **Short-term inertia forecast.** We are working with Imperial College London to build a proof of concept for accurate day-ahead and intra-day system inertia forecast with multi-time resolution, using machine learning methods. With an accurate inertia forecast, our Control Room Engineers will be able to take more informed decisions about how to secure system stability.

10 15 **Residential Response.** In collaboration with Ovo Energy, Moixa, Lightsource, Upside Energy and Element Energy, we are scoping and testing new ways to test and manage large portfolios of residential DSR assets, lowering prohibitive costs to these new providers while ensuring reliable performance for the ESO.

Innovate UK Projects. We are involved in 4 Vehicle To Grid projects, funded by InnovateUK, looking to test the technical and commercial feasibility of this technology.

NERC. We supported and won a bid for Natural Environment Research Council (NERC) funding to support a project looking at the relationship between demand forecast errors and large scale meteorological conditions.

Advancements in Technology Readiness Level (TRL)

We innovate to progress solutions from ideas through to commercial readiness, along the scale of technology readiness level (TRL). Figure 6 shows how our efforts in 2018/19 have pushed our new ideas along this path.

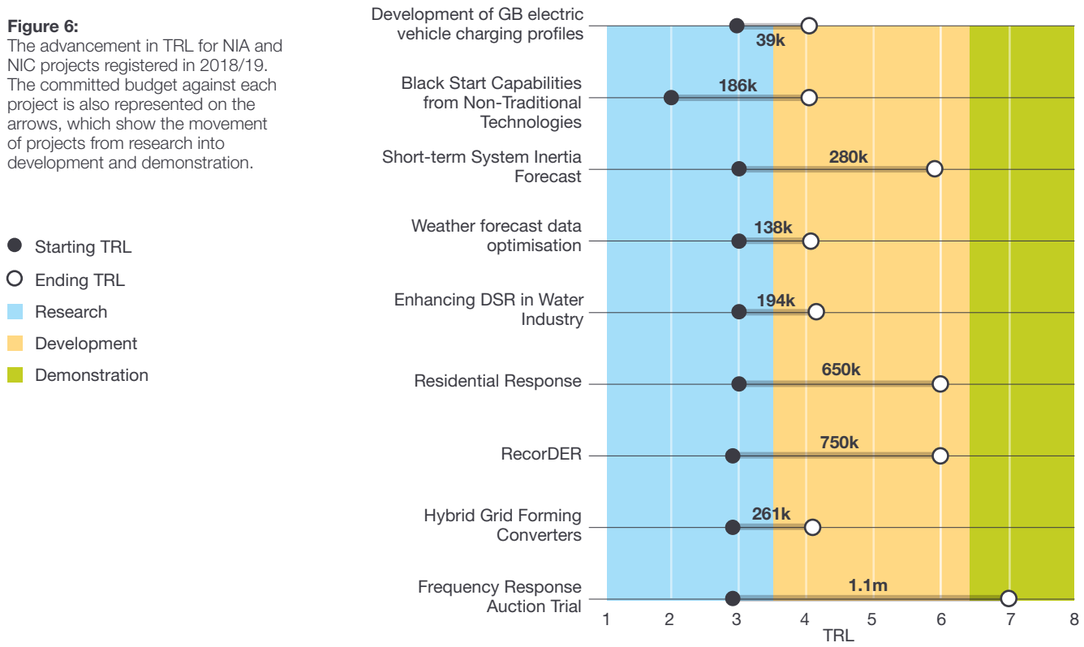


Figure 6:
The advancement in TRL for NIA and NIC projects registered in 2018/19. The committed budget against each project is also represented on the arrows, which show the movement of projects from research into development and demonstration.

Collaboration and third parties

We innovate to solve a range of issues affecting the industry not just the System Operator. This means we are concerned with challenges affecting our customers and stakeholders, as well as the electricity and gas systems, all the way through to broader societal challenges. To achieve this, we need to draw on the expertise and skills of a wide range of organisations, from network companies, to service and technology providers, to academics. This year, we have tried to both increase as well as balance our portfolio of project partners, as in previous years this has been skewed more heavily towards academics and consultants (figure 7).

We now look to partner with other network companies as much as possible. Sitting on both ENA collaboration groups (Innovation Managers and TO-System Operator Collaboration Group) means we take advantage of partnering wherever possible.

In particular, we have worked hard to partner with those companies that look to participate in our balancing services. Residential Response sees us partnering with four leading developers of residential DSR solutions in GB. We also launched projects with two providers of flexibility platforms – EPEX Spot and Electron.

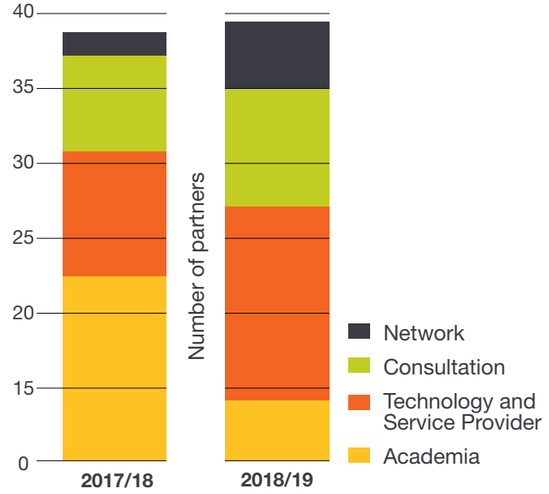


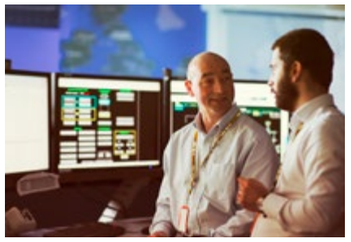
Figure 7:
We have aimed to rebalance our portfolio of partners in 2018/19 vs 2017/18. This graph shows the proportion of partners for projects registered in 2017/18, and 2018/19.

Benefits

Our benefits evaluation is a system-wide case, and though we are fully committed to creating efficiencies for end consumers, “financial” benefits are only one piece of the puzzle.

Consumer value sits at the heart of our System Operator mission and as such, during 2019/20, a key objective for the System Operator is to strengthen the framework for estimating consumer benefits. The innovation team will apply the benefit criteria here shown during the development phase of our projects; we will then endeavor to develop a system for their tracking and monitoring once the solutions are implemented.

Benefit Category	Example projects
Lower bills than would otherwise be the case Current or future savings in BSUOS/TNUOS, TOTEX savings, etc	**Frequency Response Auction Trial** Closer-to-real-time procurement will facilitate entry of non-traditional providers, increasing liquidity. Conservative estimate: £360k p.a. savings
Reduced environmental damage Enabling a low-carbon future, fostering technologies that will support the energy transformation	**Short-Term Inertia Forecast** Through an advanced inertia forecast, we will be able to manage increased penetrations of non-synchronous low-carbon generation
Improved safety & reliability Ensuring robustness and resilience of networks and systems	**Hybrid Grid Forming Converter** Enables renewable generation to behave in similar manner to conventional generation, enhancing stability of the system
Improved quality of service Delivering for stakeholders and creating more seamless value chain interactions	**Residential Response** Transforming prequalification, testing, performance monitoring and management of large numbers of residential DSR assets (current frameworks are barrier to entry)
Benefits for society as a whole Securing the wellbeing of the GB consumers, empowering our communities and our role within them	**Black Start from DER** Designing and testing frameworks for procuring Black Start from distribution networks, reducing reliance on dwindling large fossil-fired generation, lowering costs and increasing reliability
Best practice Making us fit for the future, providing information and data to make us better at our job	**RecorDER** Providing ‘one version of the truth’ visibility of flexibility and generation assets across transmission and distribution, to optimise whole electricity system outcomes



Success and failure

Our innovation projects can have 3 broad categories of outcomes:

1. **Hypothesis proven correct** – learnings disseminated and results moved to implementation
2. **Hypothesis proven incorrect** – learnings disseminated and taken on by the business
3. **Project failed** – due to poor management, supplier failure etc.

Given that one of the purposes of innovation funding is to create a safe space to try and test high-risk solutions, being proven wrong is to be considered a correct usage of funding, for it avoids finding out the hard (and expensive) way further down the road. For this reason, the first two of these three categories are considered a successful outcome for us, as long as we implement the results of the project.

Below we describe some of our projects whose outcomes fall within one of these three categories.

Hypothesis proven correct

SIM - Samuel Inertia Element: The project tested the assumption that system inertia could be directly measured, as opposed to simply estimated, with the aim of reducing balancing costs associated with inaccuracies in the inertia estimation. The project verified its assumption with laboratory tests supported by a small set of real-time measurements. The Electricity System Operator is currently negotiating for real-time inertia monitoring to improve visibility of the network inertia.

Optimisation of Energy Forecasting: The project explored whether solar PV forecasting could be improved using much larger data sets combined with deep learning and machine learning techniques. It was found that a particular approach of machine learning called ‘random forest’ was very effective at reducing solar generation forecast error by as much as 10%. Following completion of the project, the Electricity System Operator Agile Delivery Team took the new output model, validated, tested and combined it with many other types of machine learning to create a multi-ensemble forecast, which resulted in solar forecast error being cut by more than 30%.

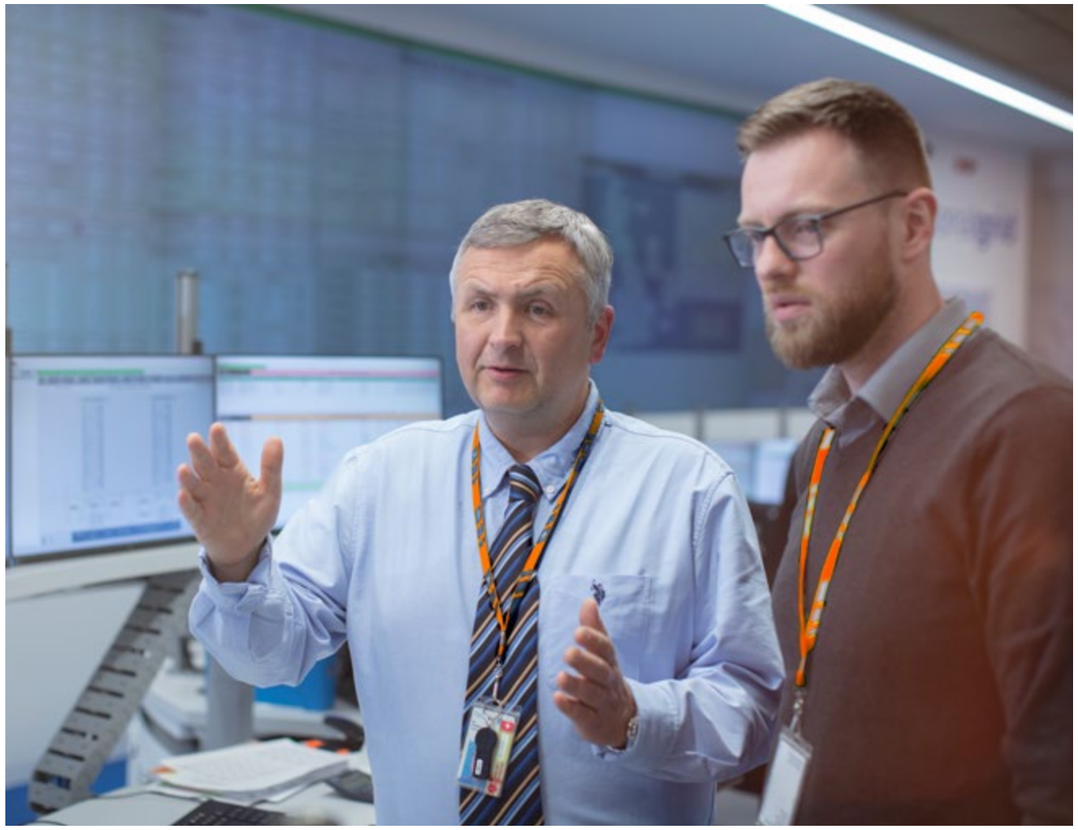
Vector Shift Initial Performance Assessment: This project set out to explore and review Vector Shift settings used in Great Britain for protecting distribution-connected customers from “Loss of Mains”. It evaluated whether Vector Shift protection was more effective than RoCoF (Rate of Change of Frequency) technique at detecting an islanding condition. The project concluded that Vector Shift was less effective than RoCoF, and resulted in a Distribution Code Modification (DC0079) to prohibit the use of Vector Shift as a “Loss of Mains” protection technique. The DC0079 workgroup is investigating whether the new requirement can be retrospectively applied to existing embedded generators. The savings estimated from these changes to protection settings are estimated at £240m NPV by 2024.

Hypothesis proven incorrect

Clustering Effects of Major Offshore Wind Developments: The project aimed to investigate the variability of wind resource for a cluster of windfarms planned at Dogger Bank, North Sea. This was tested by analysing several meteorological conditions derived from established models. One of its main hypotheses was disproven (that clustering large wind farms together would cause increased power swings in a 30-min window due to wind farm wake effects). Based on this learning, we know that if short-term power swings do occur in areas of wind farm clustering, they are unexpected and suggest an issue on the network.

Failed Projects

Granular Voltage Control (GVC): The project aimed to develop a working prototype to test the GVC concept, leading to a small-scale trial of the GVC to determine whether dynamic voltage control is a viable primary frequency response solution. The company which set out to develop the proof of concept entered administration and were not able to complete the work. This project demonstrates the risk of working with early stage technologies and companies.



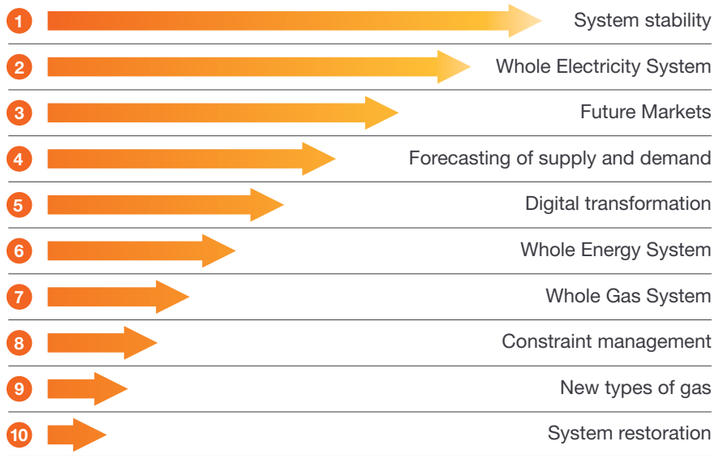
05

Our aims for the year ahead

Our planned effort vs new strategic priorities

For 2019/20, we will continue to strive to solve industry and System Operator challenges as per our refreshed Innovation Priorities, as shown in Figure 8.

Figure 8:
Our planned effort against the new innovation priorities, for 2019/2020.



Collaborations

We aim to continue our fruitful collaborations with third parties and to further focus on balancing the type of partners we engage with. We are especially keen to target Small and Medium Enterprises (SMEs) as well as more innovative start-ups going forward.

To drive this increased collaboration, we will create more opportunities and events where we look to co-create projects in an open manner with 3rd parties, and in the case of start-ups, by organising an ad hoc Venture Capital day that will provide first hand access to our internal experts.

We will continue to increase collaboration with other electricity and gas network companies, as funding partners or strategic advisors.

This year we have also worked more broadly with BEIS to align with their energy transformation ambitions. In the coming year, we will forge ever closer ties with BEIS, as well as with other institutional organisations such as Innovate UK and the Energy Systems Catapult.

06

Useful Information

How the System Operator supports innovation

The System Operator leads innovation projects, partners with other organisations on projects, or supports third party projects; through contributing our time, expertise, data, or our challenges for third parties to solve.

Our primary sources of funding from Ofgem are:

- Network Innovation Allowance (NIA)[1] – An annual allocation dedicated to innovation activities led by the SO. This is funding for earlier-stage research and development, or small-scale demonstration projects
- Network Innovation Competition (NIC)[2] – A competition that is open to all Network Licensees. This is funding for larger-scale projects.

We also provide Letters of Support for third party bids for grant funding, e.g. Innovate UK or Research Council funding

Our Process

To enable agility and to ensure strategic focus, we have developed a robust process to turn ideas into full projects, as shown in Figure 8. At the centre of the business case phase is a comprehensive Cost Benefit Analysis (CBA) that assesses how a project will deliver value against one or more of our innovation priorities, and weighs this against costs and unmitigated risks. For more information on this process, see our 'Innovating with the System Operator' document.

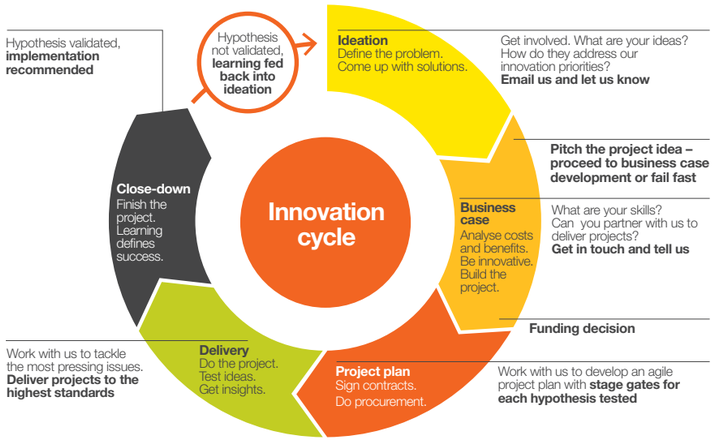


Figure 9:
Our innovation process.

1. https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-allowance
2. https://www.ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/network-innovation/electricity-network-innovation-competition

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