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National Grid System Operator Innovation Strategy

National Grid System Operator Innovation Strategy 2018

As Great Britain's System Operator (SO), we sit at the heart of the nation's energy system and are tackling pressing energy challenges. We must continually work to ensure we can provide secure supplies of energy in a fast-changing world in a way that is both sustainable and affordable.

This is the first ever System Operator Innovation Strategy. It sets out our innovation priorities for 2018 and how we plan to work together with industry partners to solve the challenges facing Britain's energy system.

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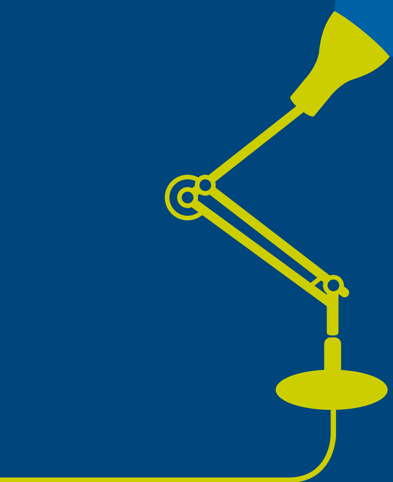


Innovate with us!

More details on how you can get involved with innovation at the System Operator can be found in 'Innovating with the System Operator' at www.nationalgrid.com/soinnovation

A changing landscape

The launch of this Strategy comes at a timely moment. If we pause for a moment to think about the pace of change in the energy industry, it's quite extraordinary.

In 2017 alone, we saw several energy firsts. Britain witnessed its first coal-free day since the Industrial Revolution. There was also the first instance of renewable generation providing more than half of Great Britain's electricity demand.

We are witnessing new sources of energy, emerging technologies and changing consumer behavior. Within the System Operator (SO) we recognise the vital role we must play in leading and facilitating innovation. It's our job to manage the network every day and that places us at the heart of the industry.

The work we do also enables other stakeholders in the industry to move ahead with their own innovations. For example, planning how the grid will support the widespread roll-out of electric vehicles is an essential part of planning a sustainable future for decarbonised transport.

Our Innovation Strategy brings together all of our thinking in one place but the fact is that we don't hold all the answers – it's vital that we have an open dialogue with stakeholders on where our innovation priorities lie and how we can work together in the future.

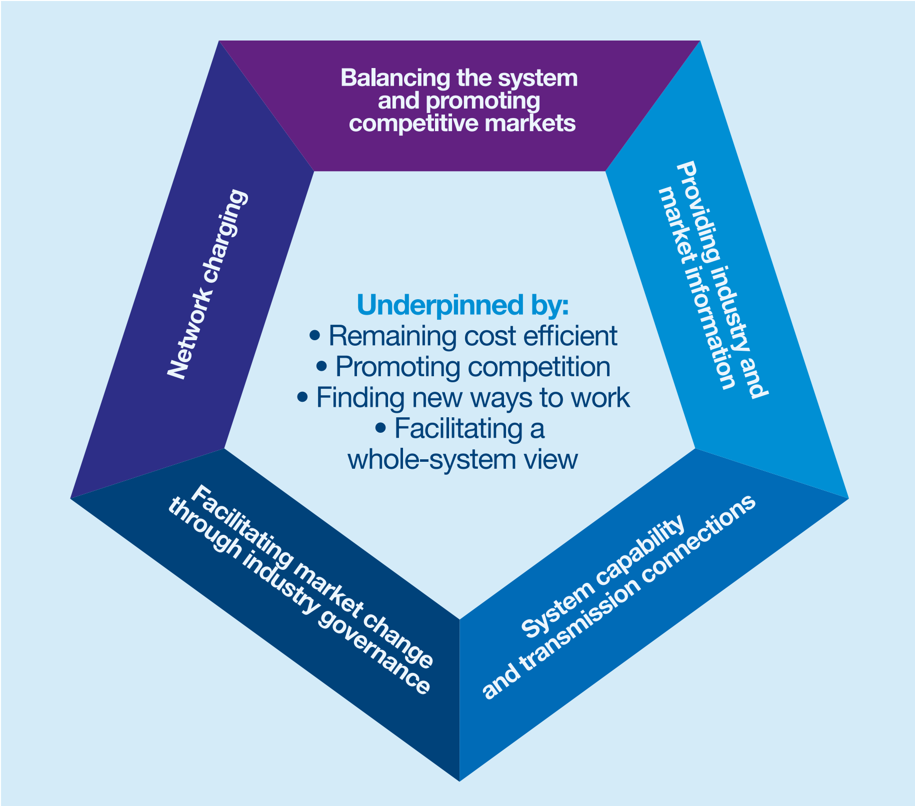
Roisin Quinn
Head of SO Strategy

Figure 1:
The SO's innovation priorities

The current and future roles of the SO

The SO's activities are adapting to reflect and enable the changing energy industry. Innovation plays an important part in building the SO of the future.

Figure 2:
The current roles of the SO



NGSO performs a number of critical roles (Figure 2) which need to adapt to the rapidly changing environment we find ourselves in. To do this, we have been working alongside customers and stakeholders to understand the changes required. We know that new tools and approaches are needed to operate the future energy system and meet the future requirements of our customers and stakeholders. New, more open marketplaces are required to facilitate new technology and innovation, allowing value to be delivered to our customers. We must adopt a whole-system view, changing the way we see the energy system and market by looking across gas and electricity, transmission and distribution. We are also working to shape the debate and help align national policy across heat, power, transport and industry to support emission reductions.

These new roles and themes covering gas and electricity require new ways of thinking, from the SO and across the industry. Innovation – particularly open and collaborative innovation – will play an important role if we are to successfully transform the gas and electricity systems and markets to support the transition to a low-carbon economy at minimal cost to the consumer.

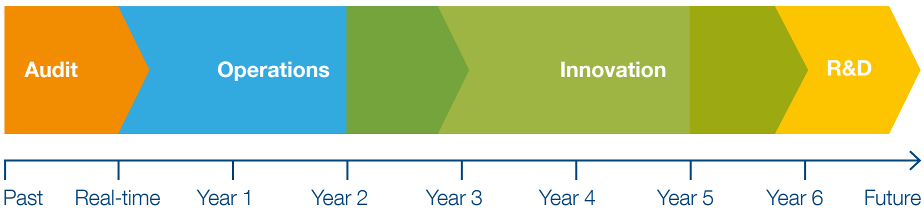
How we define innovation

Innovation is about exploring and developing novel solutions to valuable problems.

Innovation is about finding new ways to create value. We use two other criteria – the first is time. We look for innovation projects that will begin delivering value within two to six years.

The second measure is how mature each solution is. We focus our efforts where we know there's a problem, but an innovative solution is needed. We don't tackle the very early stages of research and development or work on projects that are more about the incremental improvement of day-to-day operations.

Figure 3:
The innovation timeframe, as distinct from R&D and operations



Value for consumers

Of course, the true measure of any innovation project is the outcome. What difference does it make? The projects we work on help us to achieve cost savings that can be passed on to consumers. They also enable us to work in a smarter way.

This could include reduced system operating costs, lower carbon emissions, or increasing system capacity so that new sources of generation and demand can be connected to the grid.

Sometimes, it's also about knowing what not to do. For example, quickly understanding that a proposed solution is not viable helps us to avoid unnecessary costs in the future.

How the SO supports innovation

The System Operator will lead innovation projects, partner with other organisations on projects, or support projects through contributing our perspective and expertise to addressing challenges in the system. Our involvement in innovation projects can take various forms:

1. We can provide funding – our primary sources of funding are:
   - Ofgem's 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
   - Ofgem's Network Innovation Competition (NIC)[2], a competition that is open to all Network Licensees. This is funding for larger-scale projects.
2. We can support projects by providing our time, expertise, and data, or by offering our problems for third parties to solve.
3. We can provide Letters of Support for third parties' bids for grant funding, e.g. Innovate UK or Research Council funding competitions. This will always include a commitment to offer one or more of the support mechanisms outlined in point 2.

[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/network-innovation/electricity-network-innovation-competition

Our methodology

We've developed our Innovation Strategy by building on the work done already in National Grid's Future of Energy publications. We've also consulted stakeholders and customers.

Figure 4:
The SO's Future of Energy suite of documents and analysis

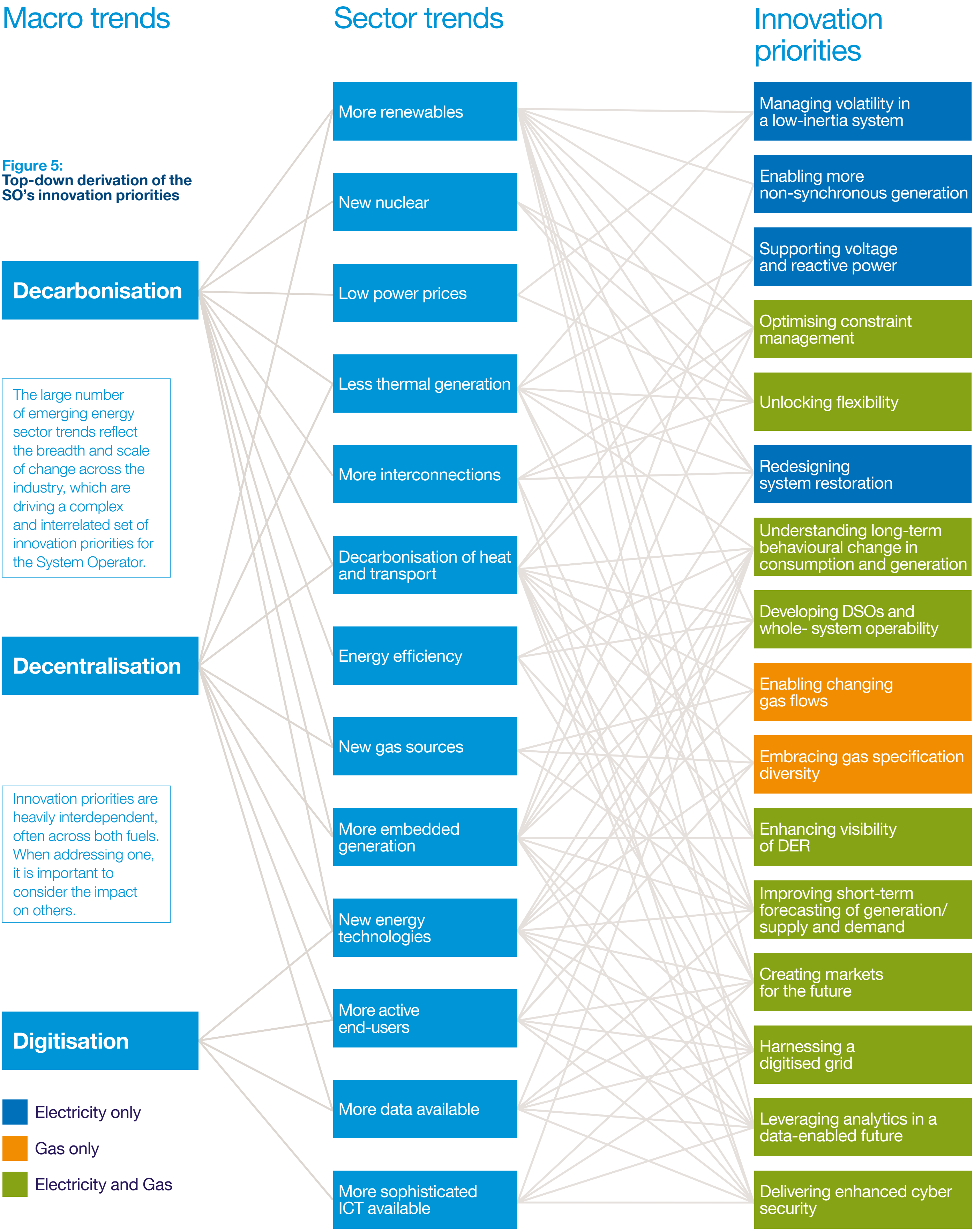
Our methodology begins with the three macro trends that are transforming the energy sector – decarbonisation, decentralisation and digitisation. We've linked these trends into challenges facing the sector as a whole and the SO in particular, as shown in Figure 5.

These issues were assessed both by operational, commercial and policy specialists across the SO, as well as external customers, against the criteria of:

- Efficiency – operating the system in the most cost-effective way, resulting in the lowest cost to the end consumer. Focusing both on costs that are currently high, and on those that are projected to increase if not addressed
- Security of supply and of system – ensuring that supply and demand are balanced and the system is stable
- Customer value – delivering value to our customers (generators and gas supply points, networks, suppliers, transmission-connected demand)
- Urgency – Ascribing higher urgency to issues that will materially impact the system in the period 2018-2021.

These criteria are designed to lead to the best possible outcome for consumers.

Figure 5:
Top-down derivation of the SO's innovation priorities



The large number of emerging energy sector trends reflect the breadth and scale of change across the industry, which are driving a complex and interrelated set of innovation priorities for the System Operator.

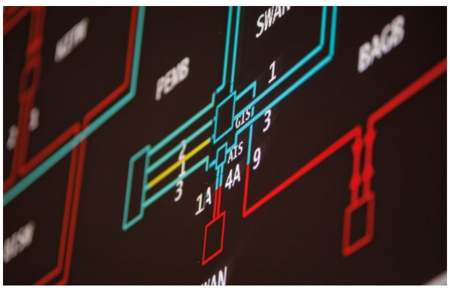
Innovation priorities are heavily interdependent, often across both fuels. When addressing one, it is important to consider the impact on others.

Our innovation priorities

The SO is looking to collaboratively explore and develop solutions that address our innovation priorities.

Figure 6: Our innovation priorities

Our innovation priorities are shown in Figure 6, and a brief description of each priority is given below.



Developing DSOs and whole-system operability

As an increasing amount of energy resource connects to the distribution networks, and as consumers gain the ability to actively manage demand, network operators are changing their behaviours to support and enable this. Joined-up approaches across transmission and distribution, and across energy vectors, need to be developed to meet these challenges.

Improving short-term forecasting of generation/supply and demand

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. On the gas network, supply patterns are becoming more difficult to predict as sources shift between UK and imported gas. Also gas-fired generation is increasingly being used for system balancing and operability, which is shifting electricity variability to the gas transmission and distribution networks. We need to understand the changing drivers of supply and demand, and deploy novel ways of forecasting them.

Managing volatility in a low-inertia system

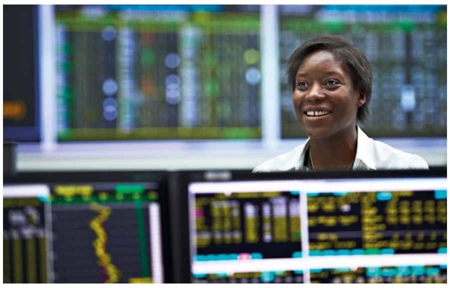
Electricity system inertia is decreasing as we transition from conventional (e.g. synchronous spinning plant) to inverter connected (e.g. wind and solar) generation, leading to faster changes in system frequency. New methods of controlling frequency need to be developed to manage this volatility.

Analytics in a data-enabled future

A more complex energy system and the huge increase in data available through the Internet of Things, smart meters and third party technologies requires enhanced capabilities to process, analyse and use this information.

Delivering enhanced cyber security

The digitisation and decentralisation of energy assets requires new and enhanced security measures to mitigate the risk of cyber attack.



Enabling more non-synchronous connections
Inverter-connected power generation is sensitive to rates of change of frequency (RoCoF), meaning that more actions are required to manage the electricity system and mitigate the risk of generator disconnection, which increases operating costs. We need to better understand the system impacts of high penetration of inverter-connected power generation, and find efficient approaches to integrating this technology.

Supporting voltage and reactive power
On the electricity network, requirements have moved from generating to absorbing reactive power, driven by lower transmission demands and increased reactive power contribution from distribution networks. We will explore how new technologies and commercial approaches can help support voltage across networks.

Optimising constraint management
Increased penetration of non-dispatchable power generation, often geographically concentrated, is exacerbating instances of having to constrain electricity generation. Capacity restrictions and compression limitations are also leading to constraints on the gas network. We will explore how new technologies and commercial approaches can better prepare for, manage and minimise constraint costs.

Redesigning system restoration
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.

Creating markets for the future
As electricity and gas markets change, it's increasingly important to create markets for services that can meet our changing system needs and to work with distribution networks to facilitate a whole-system approach.

Harnessing the digitised grid
We need to harness the capabilities of new technologies such as artificial intelligence, cloud computing and blockchain, while maintaining the highest standards of security and resilience which are required by the CNI (Critical National Infrastructure) status of our systems.

Understanding long-term behavioural change in consumption and generation
Long-term supply and demand forecasting is becoming increasingly difficult as new technologies rapidly emerge in power, heating, transport and in other sectors. These new technologies, and the business models they enable, could lead to dramatically changed end-user behaviour. We need to understand and model the underlying policy, technical, economic and consumer assumptions and outcomes.

Enabling changing gas flows
The National Transmission System is designed for north to south flows and transmission to distribution flows, but this will change as North Sea gas supplies decline and more low-carbon gas is produced at distribution level. We need to understand possible future flows and how to enable them.

Enhancing visibility of DER
We have varying degrees of visibility around the connection, capacity and output of distributed energy resources. Their growing prominence will affect our ability to maintain a balanced system and procure and settle firm, cost-effective balancing services. We will explore novel new approaches to sharing more real-time data with network operators and other market participants.

Unlocking flexibility
Flexibility on the electricity system has traditionally been supplied by a combination of dispatchable generation and large-scale storage (pumped hydroelectric). However, as the proportion of conventional flexible generation declines, the SO has fewer options available to carry out our role in managing system balance and operability. Flexibility will also become progressively more important for the gas network, as gas fired power stations are increasingly used to provide backup and flexibility for intermittent electricity generation, as well as more volatile energy sources and other demands for gas. We will test new technologies and markets for flexibility.

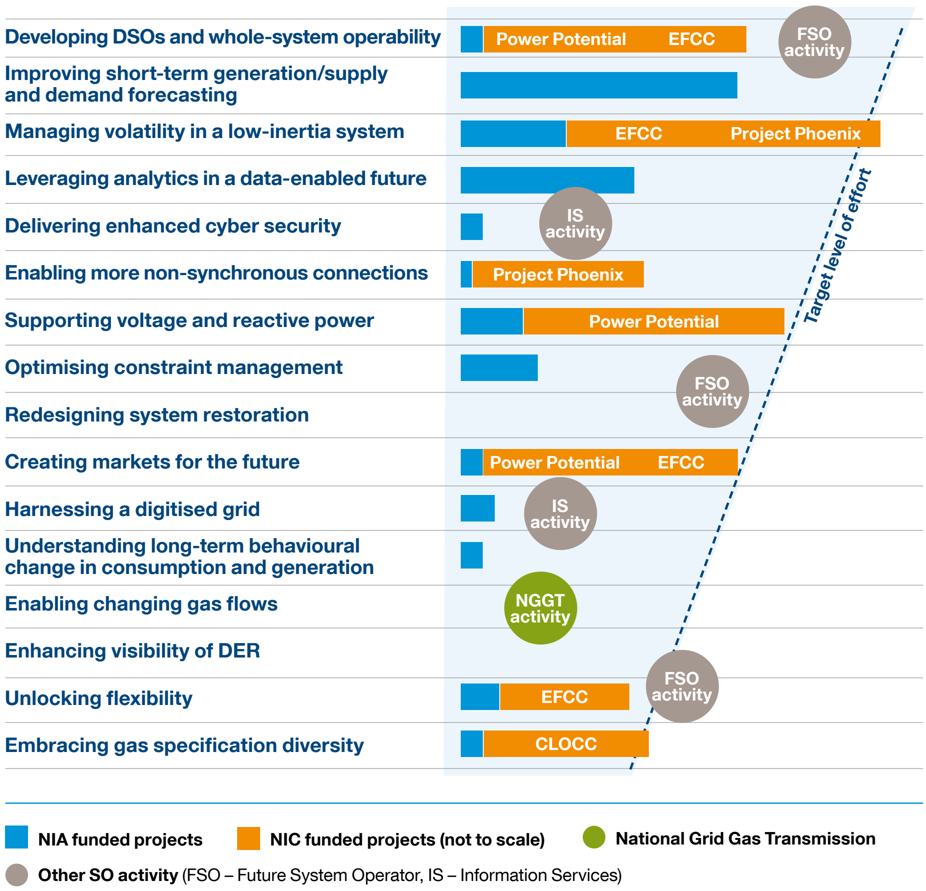
Embracing gas specification diversity
The current gas quality standards needed to enter the National Transmission System are based on North Sea gas; however, Great Britain is becoming increasingly reliant on imported gas which does not meet these standards. This requires work to ensure gas quality does not become a barrier to trade or to new sources of gas.

Targeting our innovation priorities

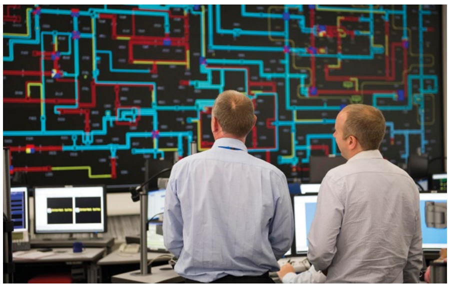
This Innovation Strategy outlines our prioritisation process and guides our investment decisions. It ensures the SO's innovation efforts are distributed according to areas of strategic importance.

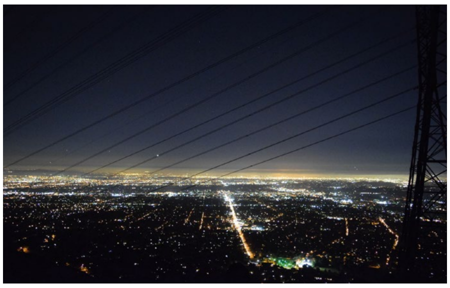
Figure 7 shows our current approximate level of effort and spend against each innovation priority for 2017–18, and the dotted line of "target level of effort" indicates the distribution of spend which we are aiming for. The more important priorities receive more innovation funding and effort than lower priorities. The current project portfolio addresses a number of our innovation priorities, and we will continue to pursue projects that target these.

Figure 7: Targeting investment and effort levels across our innovation priorities



We are targeting our innovation priorities through collaborative projects, internal change programmes, and utilising a variety of funding streams.





[1] https://www.nationalgrid.com/uk/investment-and-innovation/innovation/system-operator-innovation/power-potential

[2] https://www.nationalgrid.com/uk/investment-and-innovation/innovation/system-operator-innovation/enhanced-frequency-control

[3] http://nationalgridconnecting.com/connecting-renewables/

[4] https://www.nationalgrid.com/uk/investment-and-innovation/innovation/gas-transmission-innovation/project-clocc

Network Innovation Competition (NIC) projects

We have 4 active NIC projects in the System Operator:

1. **Power Potential**[1] is a £9.6m project, in partnership with UKPN, exploring how a new market could enable distributed energy resources to provide reactive power services to the SO. It directly targets our priorities of DSOs and whole system operability; supporting voltage and reactive power; and markets for the future.
2. **Enhanced Frequency Control Capability**[2] (EFCC) is a £9.5m project working with a number of partners to trial an innovative new monitoring and control system to obtain frequency response from non-conventional providers. It directly targets our priorities of: unlocking flexibility; markets for the future; managing volatility in a low-inertia system; and DSOs and whole-system operability.
3. **Project Phoenix**[3] is a £17.4m project, in partnership with Scottish Power Transmission and others, looking at how we can use the innovative Hybrid Synchronous Compensator, which may allow for greater penetration of renewable generation whilst maintaining security and stability of supply. It directly targets our priorities of: managing volatility in a low-inertia system and enabling more non-synchronous connections.
4. **Customer Low Cost of Connections**[4] **(CLoCC)** is a £4.8m project striving to reduce the time and cost of connecting to the gas NTS for new and existing customers. This includes unconventional gas producers such as biomethane, addressing our gas specification diversity priority. The NIA project Gas Quality 2020 is also targeting our gas specification diversity priority by assessing the likely impacts of legislative or supply changes on gas quality.

Network Innovation Allowance (NIA) projects

We have a number of NIA-funded innovation projects that are addressing our innovation priorities, for example:

- We are using new methods of data analysis and new sources of data to better forecast embedded generation and demand. Our project in partnership with Sheffield Solar has led to near real-time estimates of national solar output, based on third-party metered data from live sites.
- We are investigating the benefits of new technologies such as storage and synchronous compensators to address the challenge of managing volatility in a low-inertia system. Our project with Nottingham University aims to design, build and test a prototype of a Virtual Synchronous Machine, a technology that could allow renewable generators to provide inertia to the system.
- Our Vector Shift project is working with the University of Strathclyde to investigate if the current settings used to protect from ‘Loss of Mains’ are appropriate for non-synchronous connections.
- In 2015, we led a project which investigated the potential of alternative Black Start options. The results fed into the System Operability Framework (SOF) chapter on System Restoration and guided our future work in this area.

Letters of Support

We have also issued Letters of Support for projects that target our innovation priorities. For example, we supported a bid by a consortium including Nissan and Nuuve which is trialling new Vehicle to-Grid (V2G) technology and commercial models. This will help us understand the impact of Electric Vehicles (EVs) on behavioural change in consumption and generation, as well as informing markets for the future for V2G.

Transformation programmes

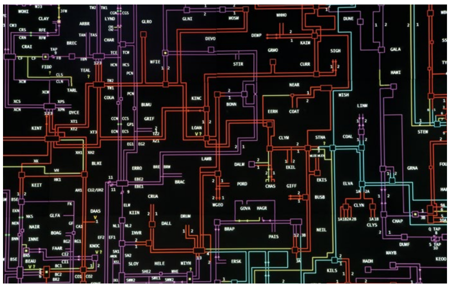
The SO’s Future System Operator (FSO) programme addresses a number of our innovation priorities. In particular, the Flexibility workstream is tackling the areas of unlocking flexibility and markets for the future, and the Whole-System workstream aims to address DSOs and whole-system operability through activities such as the Regional Development Plans with UKPN and WPD. There are a number of projects within National Grid’s Information Services (IS) function that address the areas of the digitised grid and enhanced cyber security, and we are also exploring several use cases of blockchain due to its security attributes.

Gas transmission activity

Our enabling changing gas flows priority is also being addressed through activity in our Future of Gas programme, and other work programmes are investigating how changing gas flows will affect the gas transmission network and what is required to safely allow these changes to come into force. We will continue to pursue projects that address our innovation priorities using the various tools and funding sources available (see the “Innovating with the System Operator” document for more information).

Balancing our portfolio

Our investment in innovation must continuously deliver value across a range of timescales, exploring and progressing solutions at various stages of maturity. We take risks that the core business isn't able to, and maintain a consistent focus on ensuring that all projects are asking the right questions.



Success, failure and risk

How we view success and failure is critical to fostering a culture that includes (and manages) the level of risk required for innovation. All of our projects test one or more hypotheses; we consider projects as 'successful' as long as they deliver valuable information that we can use to make better decisions in operating the system. Project success is therefore independent of the success of the original hypothesis. We work in an agile way, testing a series of hypotheses. If a hypothesis is disproven, we aim to quickly pivot to another approach, or to 'fail fast'. This ensures we do not use unnecessary time and resource, instead focusing our efforts on projects that will benefit the business and our customers.

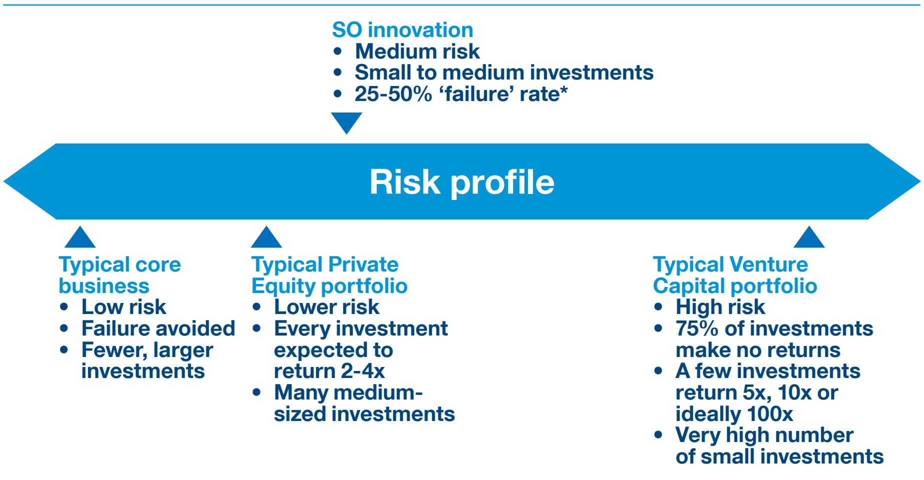
Innovation risk profile

Innovation investments, by definition, involve more uncertainty and risk than investment decisions of the core business of the same organisation. The System Operator expects between 25-50% of innovation projects and investments to "fail" and be discontinued; in comparison to typical risk profiles in other industries which invest in early stage and growth technologies and business models, this risk profile sits between typical profiles of Private Equity and Venture Capital (see Figure 8 below).

Success from failure

Our completed project "Clustering Effects of Major Offshore Wind Developments" disproved one of its main hypotheses (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. Therefore, we consider this project to be a success.

Figure 8: A comparison of risk: SO innovation portfolio vs other common risk profiles



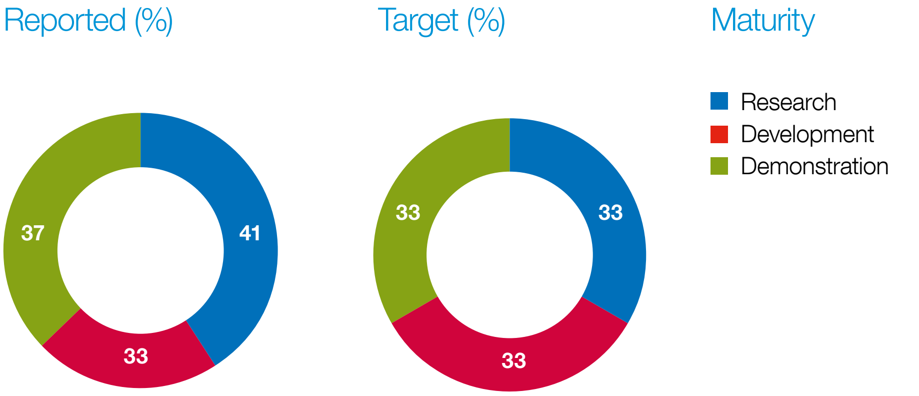
*In this context meaning a disproved hypothesis. We aim for 100% success in terms of a project delivering valuable information.

Our portfolio

We are also aiming to achieve a more balanced maturity level for our portfolio, allowing us to deliver value in the short term but also preparing for the future and longer-term innovation challenges and solutions. As Figure 9 shows, our focus has previously been more weighted towards earlier-stage research projects.

While research remains important, especially for novel project areas, we are focused on progressing the successes of these projects through the maturity stages of development and demonstration, and finally into core activities.

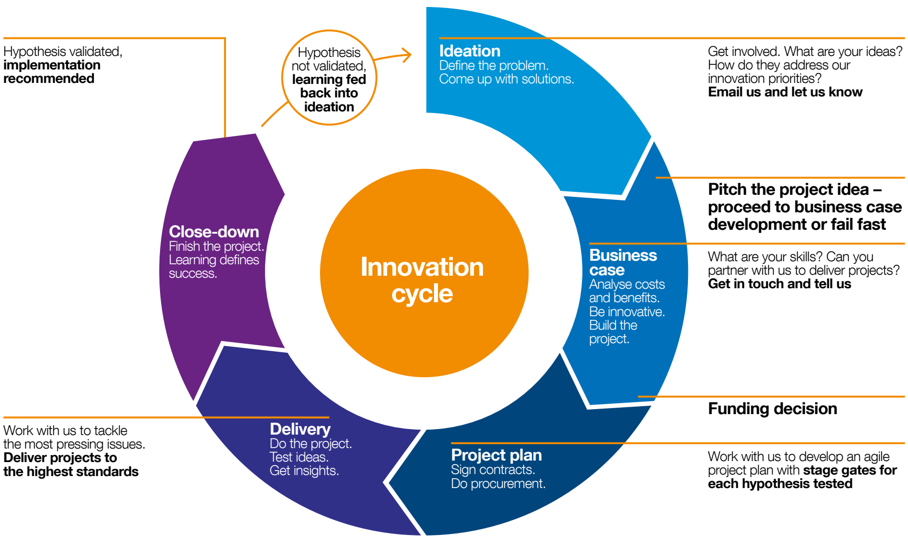
Figure 9: Maturity distribution of our ongoing NIA project portfolio for 2017-18 (as at November 2017) and our target portfolio maturity



Our process

To enable agility and to ensure strategic focus, we have developed a rigorous process to turn ideas into full projects, as shown in Figure 10. 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[1] document on our website. Going forward this process, combined with our strategy, will help us work with partners on innovation projects that will help us and the wider energy industry adapt to the challenges we face.

Figure 10: Our innovation process



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Innovate with us!

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