Operability Strategy Report

2019

Summer update

nationalgridESO

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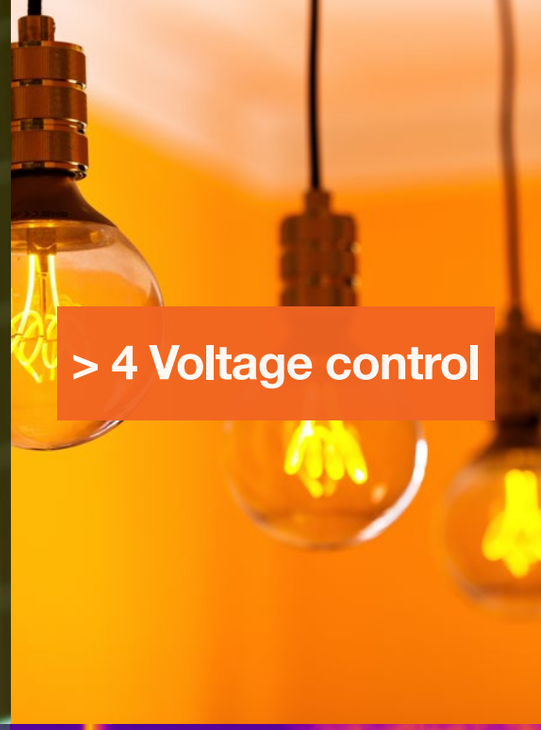
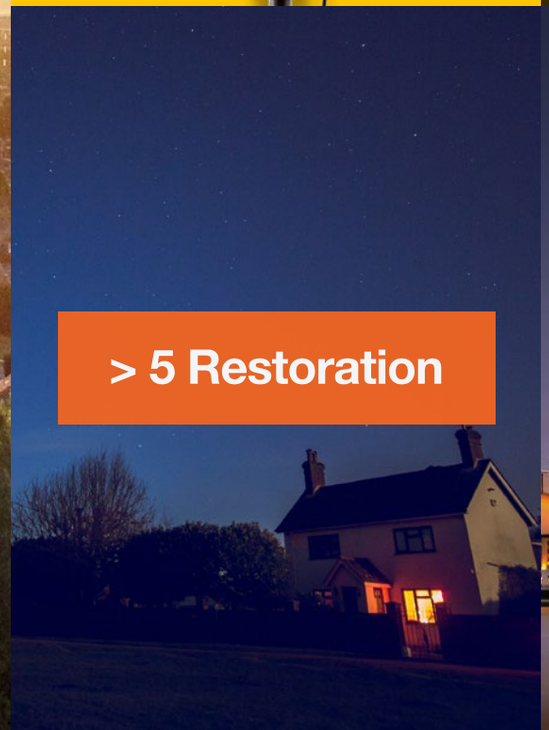


> 4 Voltage control



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1 Executive summary

Executive summary

This update to our Operability Strategy Report outlines the future challenges we face in maintaining an operable electricity system and what we are doing about them. It sets out what needs to be done to reach our zero carbon 2025 ambition and highlights how stakeholders can engage to help us meet these challenges.

Decarbonisation, decentralisation and digitalisation are driving significant change across the electricity network. These changes are impacting how we operate the system now and into the future. We facilitate these changes while ensuring system operability in a way that delivers the biggest benefits to end consumers.

By 2025, we will have transformed the operation of Great Britain's electricity system and put in place the innovative systems, products and services to ensure that the network is ready to handle zero carbon energy. This means a fundamental change in how our system is operated – integrating newer technologies right across the system – from large scale off-shore wind, to domestic scale solar panels, to increased demand side participation.

Our Operability Strategy is key to ensuring system operability while dealing with these future challenges. It will also enable us to deliver other benefits. It will improve safety and reliability of the network by ensuring it is secure in different scenarios. It will drive lower bills by changing the way we operate the network and seek out better solutions. It will minimise environmental damage while promoting overall societal benefits by reducing our reliance on services from carbon emitting sources.

This report sits across other publications from National Grid ESO and provides an operability overview. It gives an update on progress over the last six months and sets out our ambitions for the future. It provides a clear link to where more information can be found and highlights opportunities for stakeholders to get involved to help meet the challenges. This is summarised in the table on the next page.

Lastly, this is an update that builds from the previous report. Therefore more information on the detail of the technical operability challenges can be found **here**[1].

Opportunities to get involved

Topic	Opportunities to get involved
Frequency control	• Visit our **Future of Balancing Services**[2] website to participate in the development of new services.
Voltage control	• If appropriate, we will tender for long-term reactive power provision in the Mersey region during summer 2019. The tender will be published **here**[3]. • We expect to run tenders for short-term reactive power provision and these will be published **here**[4]. • A request for information will be published in June for the Pennine region on our **website**[5]. We invite all views on long-term reactive power provision.
Restoration	• **The distributed restoration innovation project**[6] project – This project will enable us to understand how DER can contribute to our restoration strategy. You can subscribe for updates using this **link**[7]. • A tender is currently underway for restoration services in the Southwest and Midlands zones. This process will inform how we procure black start services in other areas. • If you think you could offer a service, please let us know at **commercial.operations@nationalgrideso.com**.
Stability	• Relevant generators will be able to apply for payment to change their loss of mains protection. Applications will be invited via the **Electricity Networks Association Website**[8]. • Later this summer we will publish a request for information on our approach for developing stability services as part of the stability pathfinder project under the **network development roadmap**[9]. This will be an opportunity to share your views on the development of stability services.
Thermal	• We invite **your views**[10] on the probabilistic approach we are intending to adopt for the 2019/20 NOA process. • We will be publishing a request for information on constraint management in Q3 2019/20; we invite your views on service provision and commercial aspects.

We are keen to hear your comments and feedback on our approach to these operability challenges.
You can get in touch with us at **SOF@nationalgridESO.com**.

Upcoming reports and engagement

What can I expect this year?

Throughout the year, we will be releasing our operability publications.

These will be published through our System Operability Framework.

How can I get involved?

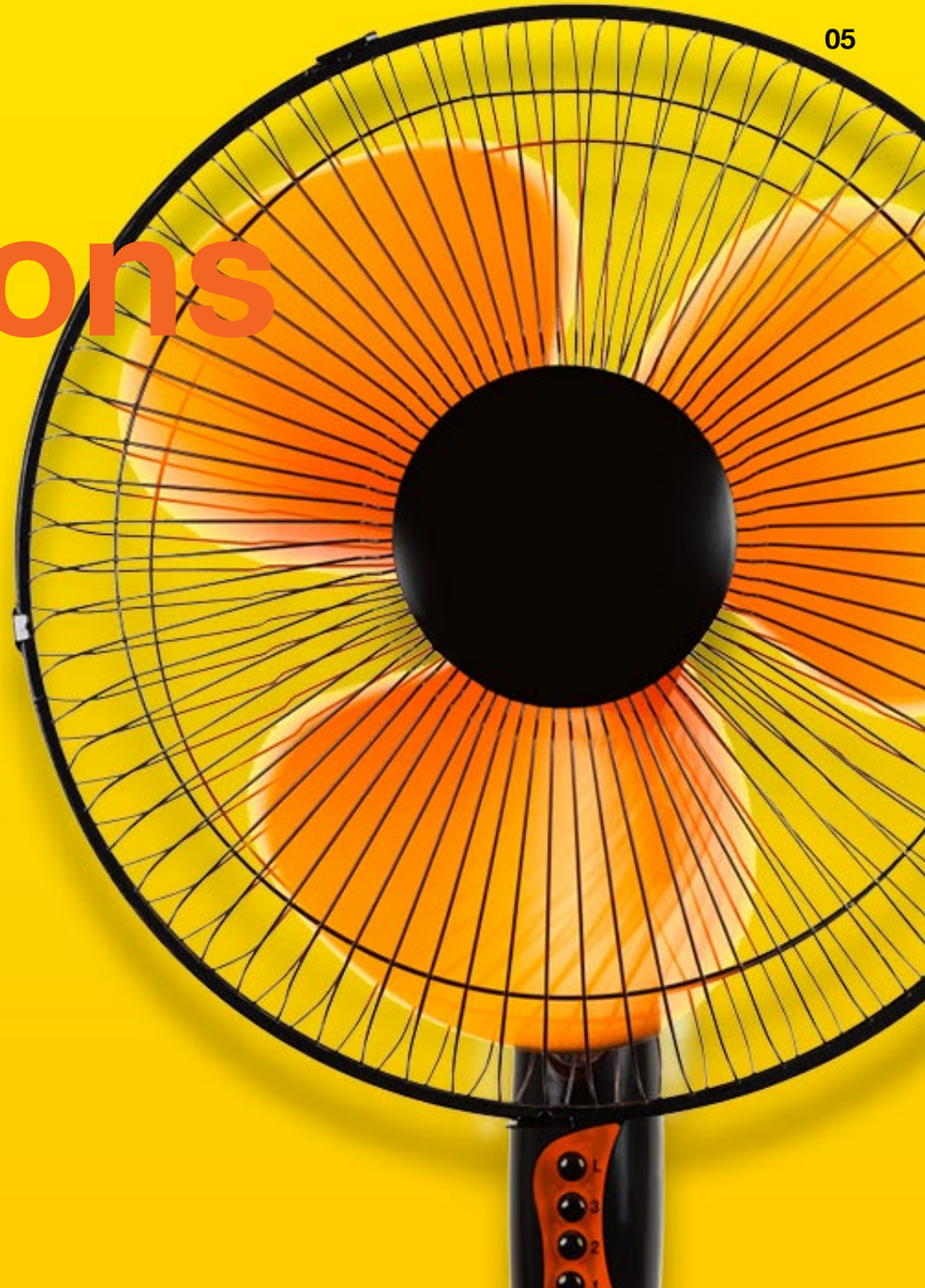
We are keen to hear your comments and feedback on our approach to these operability challenges. You can get in touch with us at **SOF@nationalgridESO.com**.

All our past publications, plus the option to sign up to our mailing list can be found on our **webpage**[11].

Reports	Overview	When to expect
Operability Strategy Report	An overview of the operability challenges and projects currently underway within National Grid ESO.	Winter 19/20
Operating a low inertia system	In this report, we will describe the technical challenges associated with operating a low inertia system.	Summer 19
Past system events	This report will publish data for past system events and how they impacted the system. To accompany this data, we will add a commentary about the operability challenges of frequency.	Summer 19
Herding behaviour of storage and electric vehicles	Here we will look at the impact of generation and demand responding to price or other signals and moving their output. Does this behaviour help or hinder operability?	Autumn 19
Virtual synchronous machines (VSM)	An update from the VSM work groups, VSM Battery project and some analysis and case studies of the benefits of VSM.	Autumn 19
Trends and insights	A look at the operability impact of the latest FES scenarios.	Winter 19/20

2 Key publications relating to this report

> 06 Our publications



Our publications

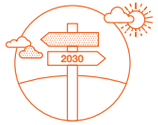
Future Energy Scenarios
July
A range of credible pathways for the future of energy from today to 2050. Scenarios are unconstrained by network issues.

The operability publications consider the unconstrained scenarios in *FES* to explore operability risks and associated requirements of the transmission networks and services.

Future of the whole energy system

Our Towards 2030 document sets the scene with a high level long-term view of the energy landscape in 2050 and the whole energy system and its enablers for 2030.

Our RIIO-2 Ambition is a consultation that sets out our ambition for the ESO and a first proposal of our activities for the next price control (from 2021 onwards).



Our 2019-21 ESO Forward Plan sets out our immediate steps until the start of RIIO-2 to achieve our ambitions as set out in the Towards 2030 document. It details our deliverables, performance metrics and how the outcomes we drive deliver consumer benefit.

System Operability Framework
How the changing energy landscape will impact the operability of the electricity system.

Electricity Ten Year Statement
Describes the likely future transmission requirements for bulk power transfers across the national transmission system over the next decade.

Publish the Operabilty Strategy Report and update every 6 months.

Operability Strategy Report
Overviews the challenges we face in maintaining an operable system, summarises the work we are doing to meet those challenges and highlights how stakeholders can get involved.

Each year we publish reports that explore future operational challenges.

Winter Review and Consultation
June
A review of last winter's forecasts versus actuals and an opportunity to share your views on the winter ahead.

Summer Outlook Report
April
Our view of the gas and electricity systems for the summer ahead.

Winter Outlook Report
October
Our view of the gas and electricity systems for the winter ahead.

Network Options Assessment
January
Recommends investment options for the TOs which meet the requirements as set out in the Electricity Ten Year Statement.

We also produce ad-hoc reports that develop shorter-term plans for more specific elements of the operational challenges, where the need arises.

Capacity report
Capacity Market auctions for delivery in 2019/20 and 2022/23.

System Needs and Product Strategy
Our view of future electricity system needs and potential improvements to balancing services markets.

Product Roadmap for Restoration
Our plan to develop restoration products.

Wider Access to the Balancing Mechanism Roadmap
Our plan to widen access to the balancing mechanism.

Product Roadmap for Reactive Power
Our plan to develop reactive power products.

Transmission Thermal Constraints Management
Our plan for the management of thermal constraints.

Network Development Roadmap
Describes the direction of travel for the ESO's network planning activities over the next three years.

3 Frequency control

Vision – Frequency

Mission statement

Frequency control encompasses response, reserve, balancing markets and services and the wholesale energy market structure. National Grid ESO will facilitate zero carbon operation by 2025. We will enable the participation of new sources of flexibility, and open and simplify our range of balancing services.

Frequency control

Frequency control is the capability to respond to sudden change in demand or generation and maintain the balance between supply and demand. Frequency control is more than just frequency response services alone and covers processes from the wholesale energy market, the balancing mechanism (BM) and balancing services. Frequency control is important to maintain secure and stable operation of the transmission system. As ESO we need access to flexibility to change generation and consumption, refining the half-hourly energy position from the market to keep supply and demand balanced and frequency stable. To ensure that we have sufficient frequency control capability available we calculate reserve and frequency response requirements and take actions to ensure there is sufficient flexibility available to meet those requirements.

Zero carbon 2025

Decarbonisation has produced high levels of renewable generation which has different operating characteristics, plant dynamics, data quality, flexibility and inertia contribution. This has increased reserve and response requirements and the nature of intermittent renewable generation means that the requirements are more volatile and less predictable. As we move towards delivering zero carbon operation by 2025 these challenges will continue to grow. We must facilitate markets across a range of provider types, sizes and technologies to ensure we have access to the response and reserve products that are required to meet our 2025 zero carbon ambition.

We are already seeing promising market developments with significant interest in our proposed new products. There is increasing deployment of new technologies that are capable of providing the faster response and increased flexibility required to maintain operability and meet our zero carbon ambition.

Key messages

Over the last six months we have:

- published and consulted on our **Future of Frequency Response**[1]
- delivered improvements to our existing reserve products and improved access to these markets
- put in place the systems, driven forward the code modifications and managed the developments necessary to deliver replacement reserve via project TERRE
- taken learnings from innovation projects and published our **Innovation Strategy**[2].

Over the next six months we will:

- develop our new response products and the methods through which we procure them
- continue the rationalisation, simplification and reform of our reserve services
- continue the development of Power Available as an operational signal into our control room to increase visibility of power park modules
- expand the capabilities of our platform for ancillary services (PAS) for non-BM providers
- evaluate the risks and costs associated with meeting the criteria currently specified in the codes and licence documents for the application of frequency control standards, to inform the need for review
- improve our operational forecasting capabilities guided by our Energy Forecasting Strategy Roadmap.

Opportunities to get involved
Visit our **Future of Balancing Services**[3] website to participate in the development of new services.

Review of previous six months

Frequency response

In February, we published our **Future of Frequency Response**[4] document. This explains how the auction trial will work and describes the four new frequency response products that we propose to develop.

In March 2019, we completed a mock auction for a standardised frequency response product, low frequency static. Full details can be found on the **Future of Balancing Services**[5] website. We have chosen EpexSpot as our external supplier to develop an auction platform with additional functionality and features for phase two of the trial.

Auction trial

Phase one of the auction trial is up and running. We have successfully procured volumes of low frequency static response via a weekly auction, full details can be found on our Future of Balancing Services website. Later this year, in phase two, we hope to increase the range of products procured and expand participation as much as possible.

Review of previous six months

Reserve

In addition to response we have also been looking in detail at our reserve requirements and products. The process of rationalisation, standardisation and improvement as promised in our **System Needs and Product Strategy**[6] document has continued apace.

Two of our key firm reserve services, short term operating reserve (STOR) and fast reserve (FR) have undergone a consultation process to update the standard contract terms. The changes aim to simplify the product offering by removing barriers to entry whilst ensuring that the products continue to meet our operational needs.

As we study what our future requirements might be, we have also reviewed our existing operational guidance. In November 2018, we issued an **update**[7] for STOR market participants which clarified how STOR can be used to meet our reserve requirement and how we intend to utilise STOR volumes.

Also, in November 2018, we successfully launched fast reserve via the platform for ancillary services (PAS). Providers not in the balancing mechanism are now able to compete in this market and our control room can monitor and dispatch them via tools developed for PAS. Since then the platform development has continued and we intend to offer the same service to non-BM providers of STOR.

Review of previous six months

Reserve

In December 2018, the **Electricity Balancing Guideline (EBGL)**[8] entered into force. This was a major achievement and milestone shared between European transmission system operators (TSOs), regulators and industry. The obligations described within EBGL will shape the future of balancing in Great Britain. The most obvious impact in the last six months has been the huge amount of work undertaken to deliver the replacement reserve product, via **project TERRE**[9] (Trans European Replacement Reserve Exchange), into the GB market by December 2019.

The work for TERRE sits alongside our programme for wider access into the balancing mechanism, both of which create opportunities for new revenue streams. A significant number of code modifications have been proposed, consulted on and approved to help deliver these twin prongs of improved access to balancing markets.

VLPs

A new type of market participant has been created, the virtual lead party (VLP). VLPs can create secondary balancing mechanism units (BMUs) which may be aggregated units within a grid supply point (GSP). **These**[10] developments facilitate greater access to the BM and to new markets via project TERRE.

Review of previous six months

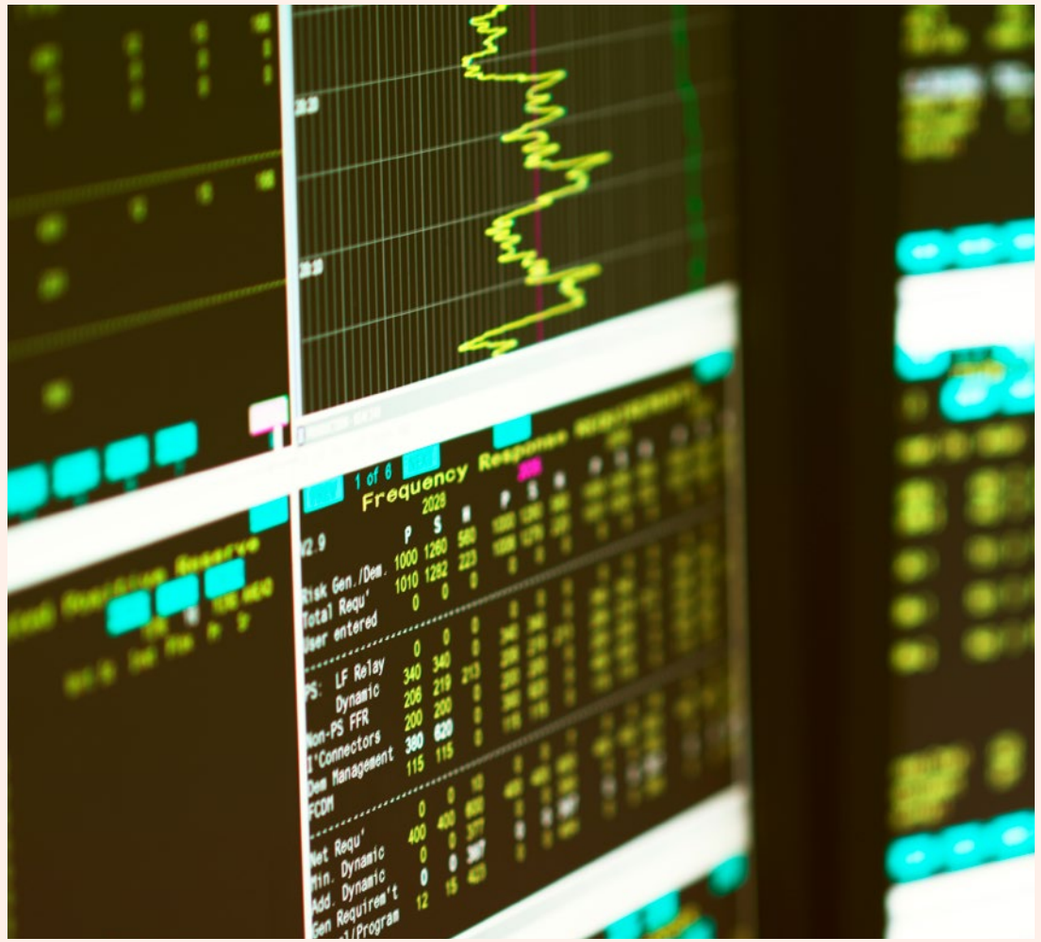
Innovation

The National Grid ESO Innovation Strategy **document**[11] has highlighted a number of priority areas, notably system stability at #1 and future markets at #3. Both are areas crucial to realising an operable system. Alongside many highly innovative partners, we have had success with a wide range of projects including:

- unlocking flexibility right across the whole-system
- improving our understanding of the impacts of **embedded storage**[12]
- improving our solar forecasting capability
- facilitating residential assets to provide response services.

EFCC

The **enhanced frequency control capability (EFCC)**[13] project has reported its findings and successfully tested a number of hypotheses. The project was able to determine the technical capability of different service providers to deliver faster acting frequency response, a key requirement for future operability. These learnings and improved modelling abilities will be useful as we design and test new response products.



Plan for future work

Frequency response

To ensure operability, we must open frequency response markets to as many providers as possible. In system needs and product strategy (SNaPS), we detailed how we expect the scale of our requirement to increase whilst at the same time the number and availability of our traditional providers will fall.

Our dedicated **Future of Balancing Services**[14] website has the latest details on the progress of phase one and two of our auction trial for frequency response products. Alongside this we will continue to design and model the new response products.

Reserve

Throughout 2019 we will continue to develop the IT systems and complete the parallel run testing that is required to deliver the replacement reserve product via project TERRE. Please see the recent **industry update**[15]. Our programme to deliver wider access to the balancing mechanism will continue, opening a key operability tool, the balancing mechanism, to a much wider range of flexibility providers.

Understanding the interactions of an expanded BM, via wider access, and an entirely new product, via project TERRE, will be crucial to designing the future reserve products and systems required to ensure operability.

Building on work that started with SNaPS, we will continue to rationalise, standardise and improve our reserve products.

In that document, we detailed our likely future requirements for reserve services. In 2019 we will expand and refresh this work, utilising our modelling capability to inform our reform of reserve services.

PAS
Our platform for ancillary services, already capable of dispatching fast reserve, will be expanded to facilitate non-BM providers of STOR.

Plan for future work

Codes and regulation

The SQSS **(Security & Quality of Supply Standards)**[16] defines how we must operate the system to meet frequency control standards. The SQSS must strike a careful balance between security and cost. As the whole-system has evolved at a rapid pace in recent years, we believe that some changes to the SQSS may be necessary to provide the end consumer with security at an appropriate level of risk and cost.

In 2019 we will continue our assessment of options under a review of how frequency control standards are applied. Any change will require significant industry consultation and input to ensure the outcome delivers benefit for the end consumer.

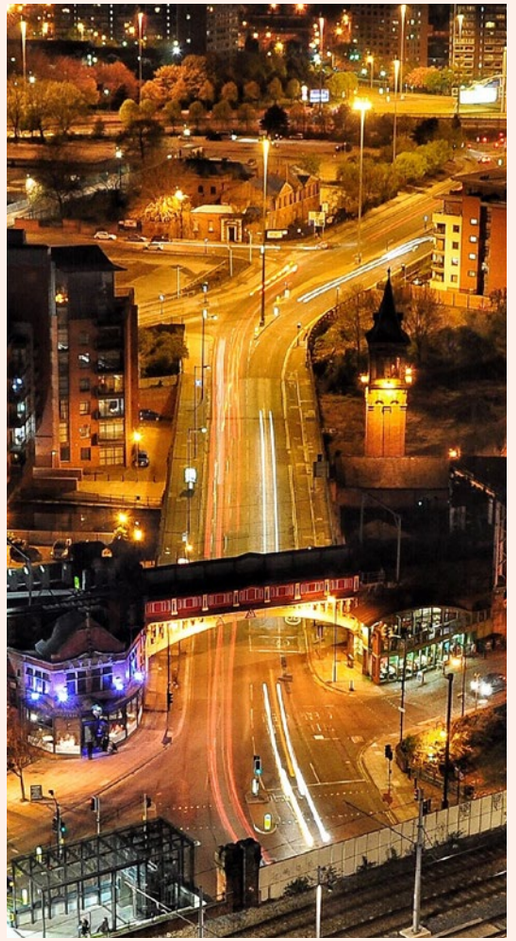
Forecasting

In 2019 we will publish our Energy Forecasting Strategy Project Roadmap, in it we will outline how we intend to build future-proof and world leading energy forecasting capabilities. The Platform for Energy Forecasting will be revolutionary for our capabilities in managing large volumes of data, applying innovative machine learning and AI forecasting methods and making the inputs and outputs readily available to the market, thus facilitating improved market balancing.

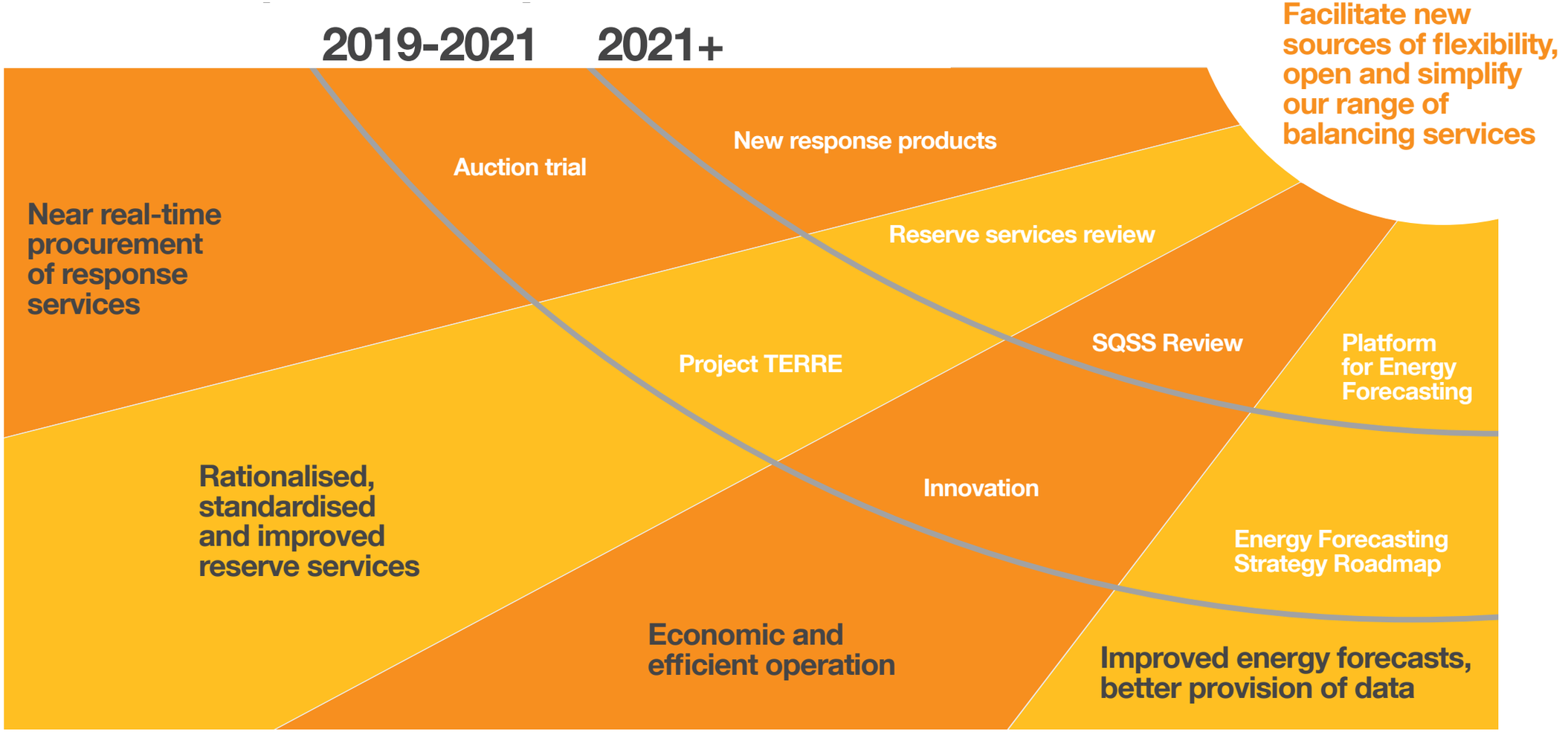
Better forecasts mean less market imbalance and subsequently allow our control room to hold more efficient volumes of response and reserve, thus reducing overall costs.

Intermittent generation

The growth in intermittent generation has provided challenges but also opportunities. In 2019 we will continue our work, often led by the Wind Advisory Group (with the support of RenewableUK), to facilitate the provision of Power Available (PA) as an operational signal into our control room. We will publish a Power Available signal quality standard guideline to ensure robustness of data. Integrating PA into control room systems is a key step to achieving the visibility required to manage an increasing proportion of intermittent generation.



Milestones and ambitions



4 Voltage control

Vision – Voltage

Mission statement

As our requirement for reactive power grows and its provision from traditional sources of large synchronous generation becomes less certain, we must find new sources of voltage control and enable wider participation in reactive power commercial services.

Voltage control

Maintaining the electricity system at the correct voltages enables safe and efficient power transfer within the performance limits of the network, generation and consumer devices. This requires the right balance of reactive power injection and absorption to be maintained in real time. Reactive power can come from network assets, generation or demand. High voltages occur more often throughout the summer months, overnight and at weekends because demand is generally lower at these times and the network is less heavily loaded. The amount of power flowing through the network affects voltage. Heavily loaded overhead lines absorb reactive power which lowers voltage. Cables and lightly loaded overhead lines inject reactive power which increases voltage.

Zero carbon 2025

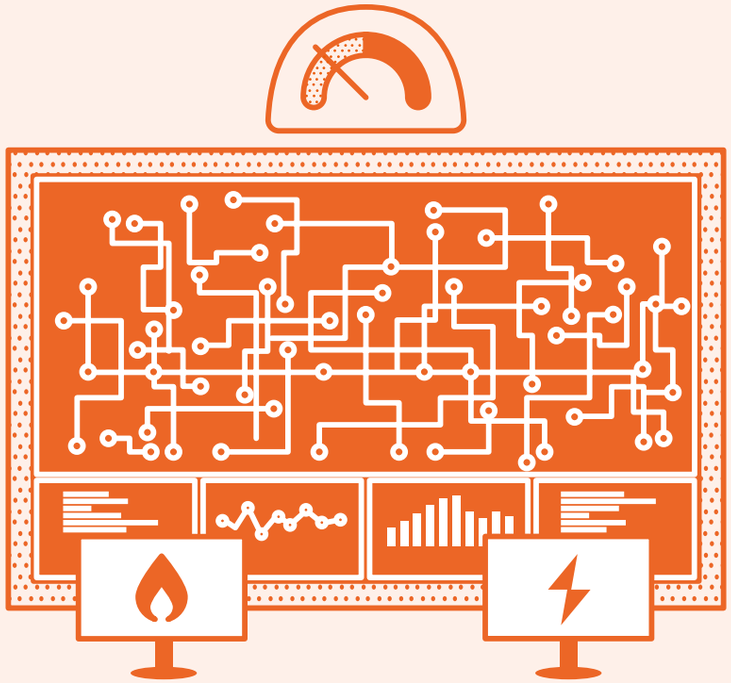
A traditional operational solution to manage high voltages during periods of low demand involves the synchronisation, via the balancing mechanism or bilateral trades, of traditional thermal plant (CCGT and coal) as these can provide the required dynamic MVAr response. The additional power delivered onto the network because of these voltage control actions can mean that balancing actions in the opposite direction are required to ensure supply and demand are kept in equilibrium. Often this means reducing the output or desynchronisation of renewables. To operate with zero carbon in 2025 we need to find alternative solutions to economically and efficiently manage voltage on our network. We have already begun adapting our strategy to reduce reliance on large thermal power stations for voltage control, as seen in our recent request for information in the Mersey region.

We have received a very positive market response to a number of requests for information and tenders relating to providing reactive power. New potential providers have been identified and we expect this trend to continue as we work to increase the transparency of our requirements and collaborate with wider industry on new solutions.

Key messages

Over the last six months:

- we completed a competitive tender process and awarded contracts for voltage constraint management in the South Wales and Mersey regions
- we signed contracts for an enhanced reactive service in Scotland. This was a first in providing effectiveness ratings to areas during the tender process, and individual effectiveness ratings post-tender
- we published our first long-term request for information (RFI) for high voltage needs in the Mersey region, inviting industry to provide their thoughts on long-term service provision and contract structures
- we have held our first workshops with transmission and distribution owners on the efficient transfer of reactive power.



Key messages

Over the next six months:

- we will further develop our strategy for review and reform of reactive services in light of our zero carbon by 2025 ambition
- in collaboration with distribution and transmission network owners, we will investigate short and long-term solutions to efficient reactive power transfer between transmission and distribution networks
- following a consultation with industry in May 2019, we will develop our methodology for applying a NOA type approach to regional voltage challenges. This is likely to create more opportunities for participants to provide reactive power services, both in the short and long term
- the first trials for Power Potential start in summer 2019
- we will publish a long-term request for information for the Pennine region (in Q1) to invite industry views on long-term service provision to meet high voltage challenges in this area.

Opportunities to get involved

- If appropriate, we will tender for long-term reactive power provision in the Mersey region during summer 2019. The tender will be published **here**[1].
- We expect to run tenders for short-term reactive power provision and these will be published **here**[2].
- A request for information will be published in June for the Pennine region on our **website**[3]. We invite all views on long-term reactive power provision.

Review of previous six months

Commercial and operational tools

Tenders, contracts and transparency

- For the South Wales and Mersey regions, we published invitations to tender in January followed by the results in February. We agreed three optional contracts; a 12-month contract for South Wales and two consecutive 6-month contracts for Mersey. The full results are available on our **website**[4].

- During February, we tendered for the provision of enhanced reactive power in Scotland for April 2019 to March 2020. The focus was on accessing reactive capability when active power output is below 20% of the rated active power output. In total, 36 tenders were received, and 11 were accepted. The full results are available on our **website**[5].

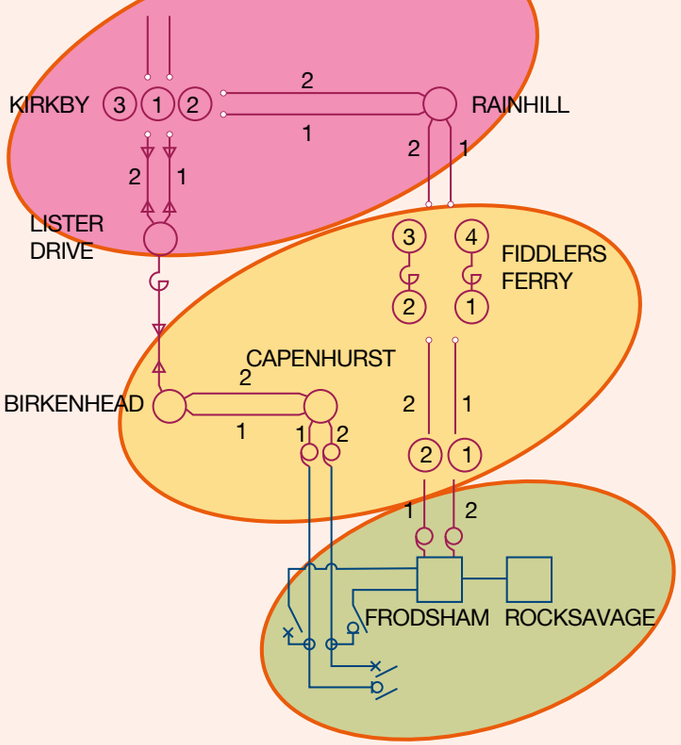
- We have increased transparency of reactive costs by separating out voltage constraint contract costs within the **Monthly Balancing Services summary**[6] document. We have also started to publish details of likely effectiveness by location in our tender and request for information publications.

Industry announcement

Following an **announcement**[7] from SSE Generation regarding the immediate closure of Fiddlers Ferry Unit 1, we are working with the distribution network (SP Energy Networks) to investigate the possibility of utilising distributed resources to manage a high voltage issue on the transmission system.

Mersey RFI effectiveness map

Least effective



Most effective

Review of previous six months

Innovation

Power Potential

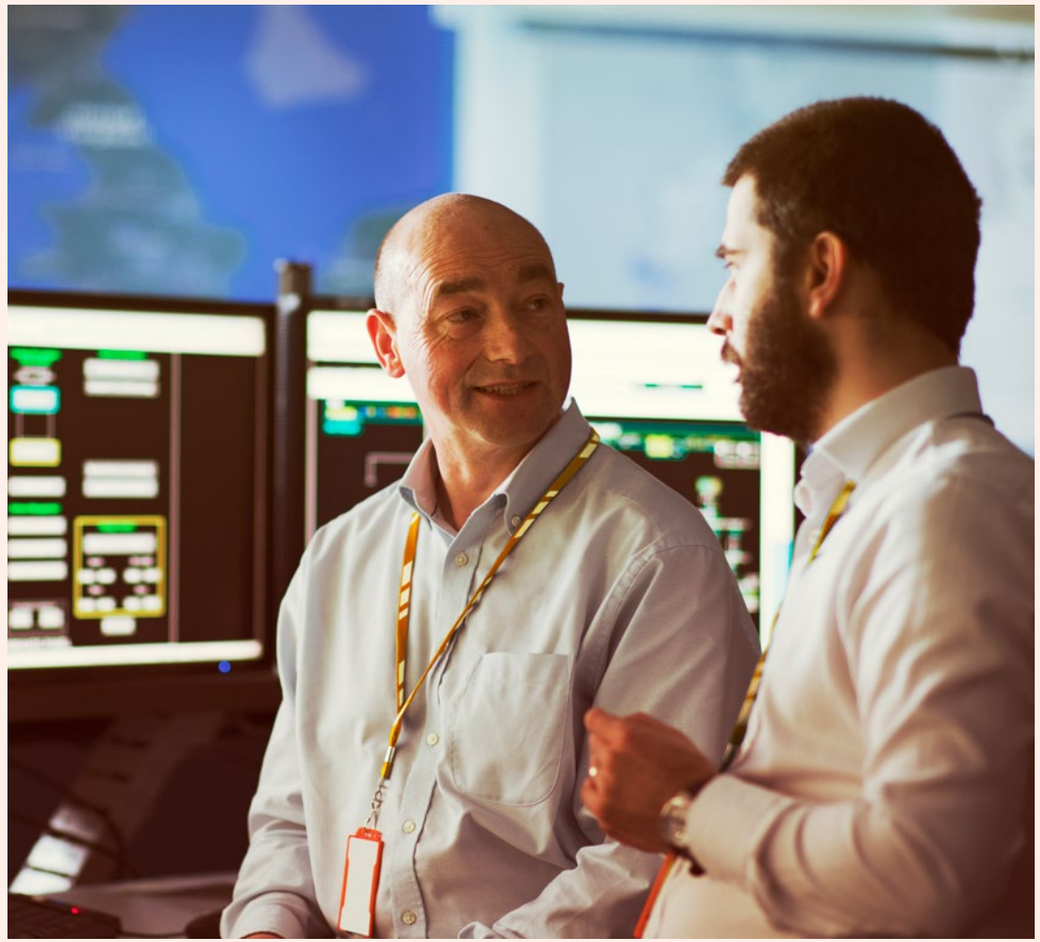
- Through the **Power Potential**[8] project we have teamed up with UK Power Networks for a world first trial of dynamic voltage support to the transmission network from distributed energy resources (DER). The project has been preparing for the trials, which start in the summer, by completing the build stage and finalising the testing stage.

Networks

Long-term provision

- We have been furthering our voltage pathfinder projects which are focused on comparing network and non-network solutions for regional voltage challenges. In March, we published a **request for information**[9] on long-term voltage control in the Mersey region inviting industry and potential providers to feed back on the assessment criteria, principles, and contract options. This request for information closed on 24 May.

- In the South Wales region, our most recent analysis concluded there is **no longer a high priority need**[10], so we will not be pursuing a long-term reactive service at this time.



Review of previous six months

Codes and regulation

Whole-system solutions

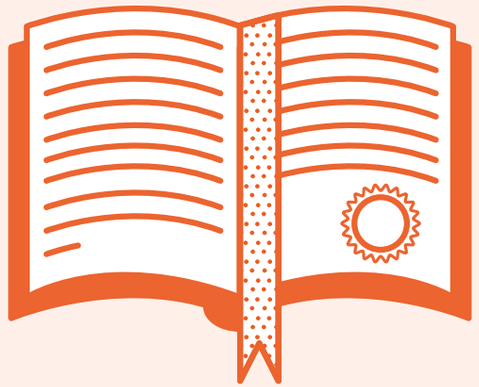
- In April 2019, as part of our commitment to a whole-system approach, we held our first meeting with distribution and transmission network owners with the aim of better understanding the considerations and challenges of setting and meeting an efficient level of reactive transfer between networks.

Enhanced reactive power service (ERPS)

- Our proposal to remove ERPS from the connection and use of system code (CUSC) was returned by Ofgem, requesting additional information; they also indicated they wish to make a decision alongside a third-party proposal to improve ERPS. The ERPS workgroup is currently considering the criteria that could be used for setting up an improved ERPS product, and planning a consultation on what this process might look like. You can find out more via our **code administrator webpage**[11].

Obligatory reactive power service (ORPS)

- We have recently considered the voltage/reactive space, and there are numerous projects which could all significantly impact on how we develop voltage/reactive solutions in future. Our conclusion is that the next step is to develop our internal strategy and appropriately prioritise our deliverables.



Plan for future work

Commercial and operational tools

Commercial opportunities

- The Mersey request for information (RFI) for long-term provision closed on 24 May. We have committed to **publishing our decision**[12] on next steps by the end of June. This will include a decision on whether a tender for the region is appropriate at this stage.

- We intend to run further short-term tenders this year, providing greater opportunity for participants to provide reactive power services. Tenders will be published **here**[13].

- We will continue to increase the transparency of reactive power costs, volumes and locations where possible. We will also further break down costs by region and publish historic costs by region.

Plan for future work

Innovation

Power Potential

- The next stage for Power Potential starts in the summer and is delivered in two waves. The first wave trials the technical aspects of the service, starting with mandatory technical trials for all participants. Wave one also covers a range of network configurations and operating conditions. The innovation fund for the project will allow participants to recover most of their upgrade costs through a participation payment.

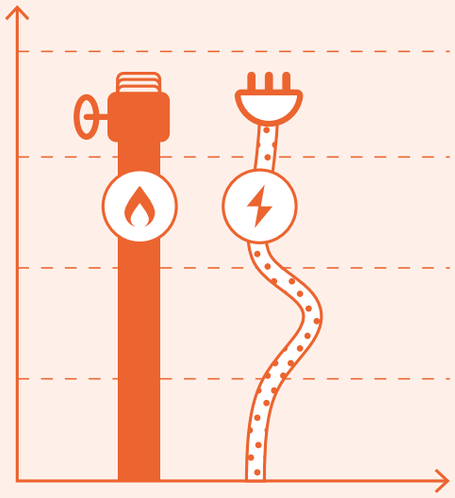
Wave two introduces competitive bidding between distributed energy resources (DER), with the volumes accepted by National Grid ESO in line with actual system need. The purpose of wave two is to facilitate 'price discovery' from DER, i.e. allowing DERs to freely bid on both availability and utilisation under a competitive environment, allowing them to reflect any risk or cost associated with the provision of the service in the most efficient way.

Networks

Whole-system solutions

- We will be publishing a **request for information**[14] for the Pennines region in June. This will follow the same format as that of the Mersey publication and invite industry participants to provide thoughts on long-term reactive service provision.

- In our **Network Development Roadmap**[15], we outlined how we would apply a NOA type approach to regional voltage challenges on the transmission network. Following a consultation on our proposed **methodology**[16] to identify economically efficient options for managing high voltages in May, we will apply this approach to compare network and market based options, once approved by Ofgem.



Plan for future work

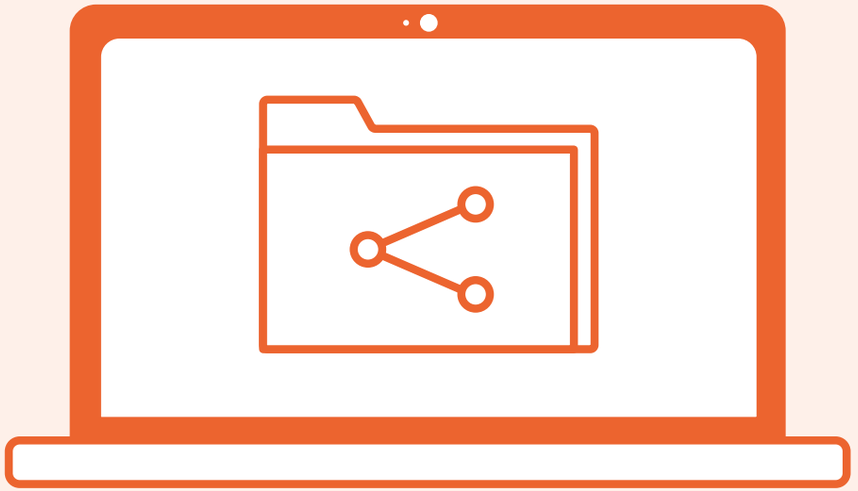
Codes and regulation

Whole-system solutions

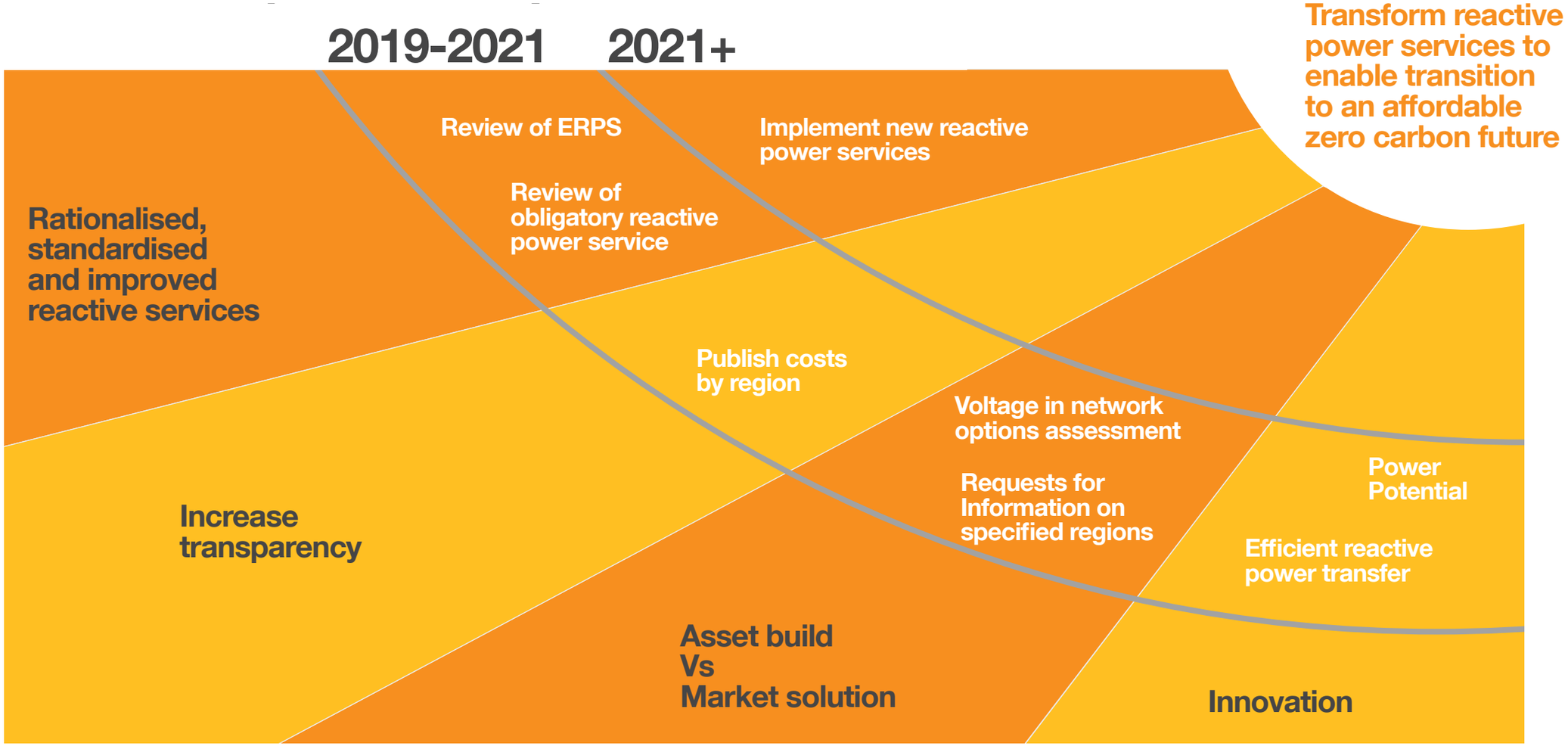
- Following our cooperation with DNOs and TOs to discuss efficient reactive power transfer, the next steps are to conduct further analysis of reactive power transfer at grid supply points and undertake some international benchmarking to see how our counterparts in Europe and the US manage reactive power transfers. Ensuring efficient transfers of reactive power will help decrease consumer costs.

Obligatory and enhanced reactive power services

- Whilst we develop our strategy to further the review of the obligatory and enhanced reactive power services, we will continue to work with industry on the future role of these services.



Milestones and ambitions



5 Restoration

Vision – Restoration

Mission statement

In the unlikely event of a partial or total system shutdown, we need the capability to restore the system. In the past, this capability has been provided by large synchronous transmission connected generation. The future energy mix will be more diverse and generation is becoming less centralised. These changes provide an opportunity and a necessity to develop new approaches to restoration.

Restoration

In the unlikely event that the electricity system fails and the lights go out, the ESO has a robust plan to restore power to the country as quickly as possible. If you would like to know more about our strategy for restoration and our current methodology for procuring services to support restoration, you can find more information on the black start **page**[1] of our website. The role of the ESO in a restoration event is to provide coordination between generators, to energise and export power, and network owners, to ensure energy reaches homes and businesses who need their power supply restored.

Zero carbon 2025

As we move towards a zero carbon system, the number of large, transmission connected fossil fuel generators that have traditionally provided our black start capability will necessarily decline. In this future, we will have a more diverse range of technology types with more generation connected to the distribution system. Therefore the type of contribution a service will have towards restoration will be more varied. Maintaining black start capability at all times is of course a priority. To meet our zero carbon 2025 ambition we must enable a range of new providers to participate in this service.

The wider industry has been assisting our move away from reliance on traditional thermal sources of restoration capability. This has been demonstrated by the ability of providers to maintain black start capability without warming and synchronisation to the grid.

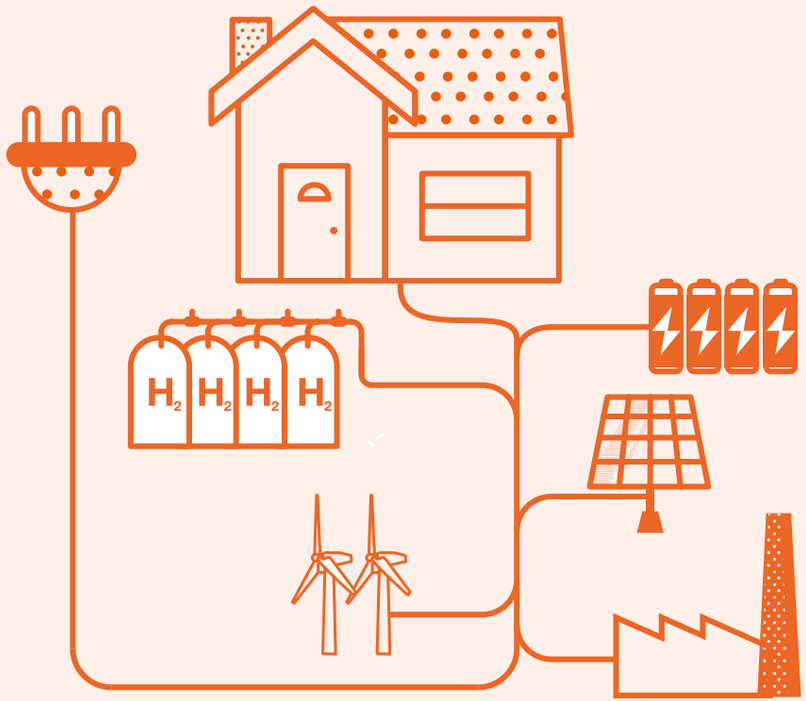
Key messages

Over the last six months:

- we have initiated two innovation projects looking at how we can broaden the range of providers able to support restoration
- we have begun a new competitive procurement event for black start services in the Southwest and Midlands.

Over the next six months:

- the output of our innovation project on non-traditional technologies will inform our innovation project looking at black start from distributed energy resources and case studies will proceed
- our competitive procurement event will move forward to the feasibility stage of the process.



Opportunities to get involved

- **The distributed restoration innovation project**[2] – This project will enable us to understand what part DER can play in our restoration strategy. You can subscribe for updates using this **link**[3].
- A tender is currently underway for restoration services in the Southwest and Midlands zones. This process will inform how we procure black start services in other areas. If you think you could offer a service, please let us know at **commercial.operations@nationalgrideso.com**.

Review of previous six months

Commercial and operational tools

The purpose of this work is to ensure that we are procuring and utilising black start capability economically and limiting the impact on balancing costs. These steps will make service provision more accessible and support new providers to offer the service.

Alternative approaches for procuring black start services

- **Competitive procurement event**[4] – Previously our black start procurement has typically been through bilateral negotiations. As promised in our **Restoration Roadmap**[5] National Grid ESO is trialling a competitive procurement event for black start services. This approach should enable greater participation and drive down the overall cost of this service to the consumer. The expression of interest (EOI) launched for the competitive event in the Southwest and Midlands received responses from 31 participants totalling 16 GW of capacity and more than ten different technology types.
- **Using transparent scoring criteria**[6] – In 2018, two potential providers in the South East zone were competitively assessed against a technical and commercial scoring matrix devised by National Grid ESO (the matrix has now evolved into the current EOI assessment criteria). One of these potential providers has progressed to the contracting phase for a black start service. This standardised and transparent scoring criteria will help potential providers understand what qualities we value from a service.

Review of previous six months

Commercial and operational tools

Improving transparency

- As part of the competitive procurement event we have published a **broad range of documentation**[7] including updated technical requirements, assessment criteria and more generic black start service terms.
- We have also consolidated our **Strategy and Procurement Methodology**[8] into a single document explaining how we determine our requirements for black start and how we procure that capability. The consolidated document will be published online once approved by Ofgem.

Expanding and improving participation

- **Combined service** – We have explored and identified combined service opportunities with various providers. Some of these options are now progressing through the feasibility process. Nine combined service approaches have been received in the competitive procurement event.
- **Trip to house load (Islanding)** – We have already procured a trip to house load (TTHL) service and have identified other opportunities for TTHL existing at various stages of feasibility assessment.
- **Interconnectors** – Interconnectors with suitable technology have proven to be black start capable and several have been progressed through various stages of feasibility study. We believe there is enough competition to procure restoration services from interconnectors.

Seasonal readiness strategy

- We now use the seasonal demand variation to adapt the number of providers in a state of readiness at any time whilst still maintaining the required restoration time and minimum service level. This reduces black start service costs without compromising on restoration delivery.

Review of previous six months

Innovation and networks

- We have reviewed the restoration procedures that we have in place with the transmission and distribution network owners. Further workshops are planned this year for training of network owner control staff on our simulator. This training is important to ensure preparedness if system restoration is required.
- In January 2019, we commenced the **The distributed restoration innovation project**[9]. This innovation project will study the technical capability of non-traditional technologies to contribute to restoration. The project will evaluate the operational impact that these technologies will have on the growth of a power island by reviewing international experience and performing detailed desktop analysis.

Codes and regulation

- EU Network Code on Emergency and Restoration – European code requirements are being integrated into GB codes through the grid code modification process. We have published our proposed **System Restoration Plan**[10]. This plan consists of the technical and organisational measures necessary for the restoration of the electricity system in GB. **Grid code modification GC0108**[11] has been implemented to update the black start testing requirements for generators.

Plan for future work

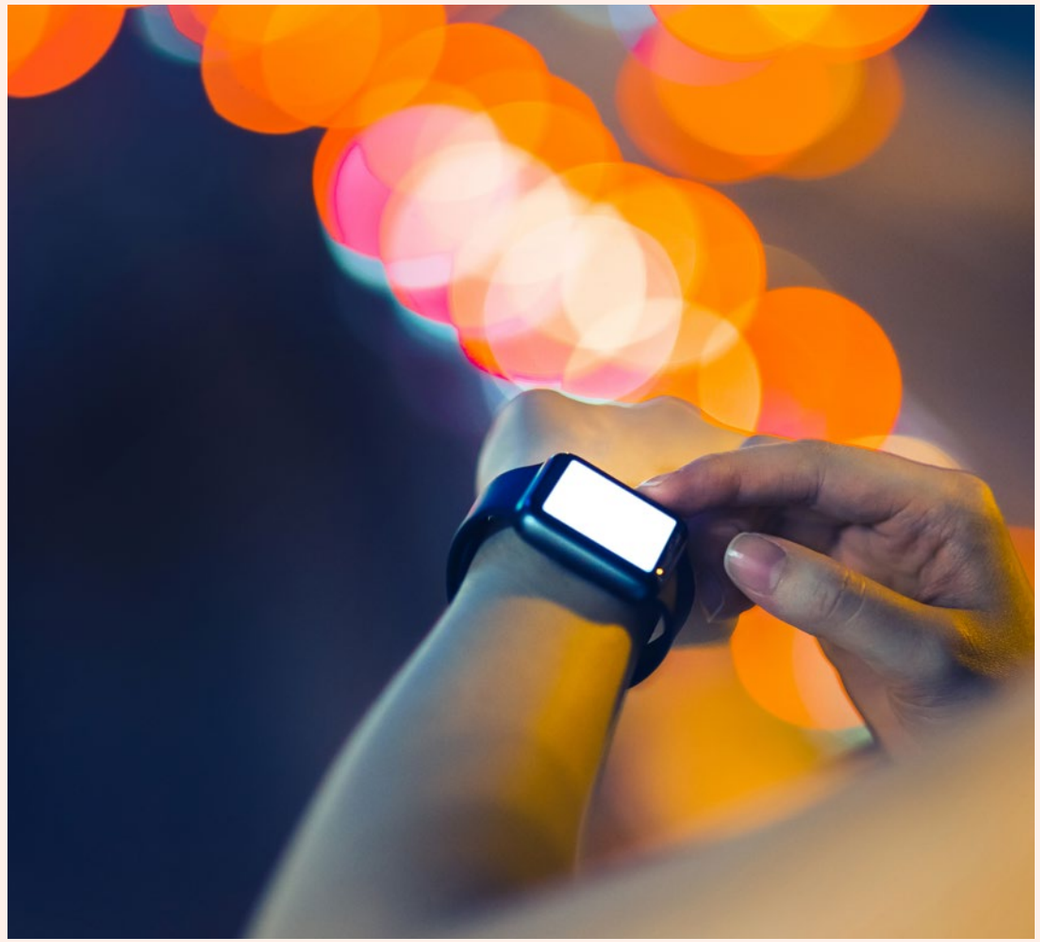
Commercial and operational tools

Alternative approaches for procuring black start services

- **Competitive procurement event**[12] – Parties who submitted an expression of interest in the Southwest and Midlands, and were eligible to proceed, have been invited to participate in the tender. The next step will be for all potential providers to complete a feasibility study to explain how the service can be delivered. The feasibility stage one report and scope for feasibility stage two are due to be submitted by 31 July 2019. We will use our learning from this trial to consider how we procure services in other areas of the country.

Expanding and improving participation

- Over the next six months, the **black start capabilities from non-traditional technologies innovation project**[13] will conclude. This project will offer insight and inform us which technologies are most promising and how best to proceed. The output will feed into the black start from distributed energy resources project and our broader strategy for restoration.



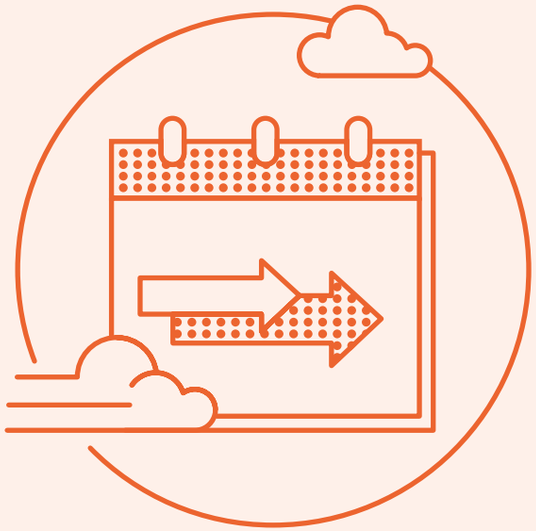
Plan for future work

Innovation and networks

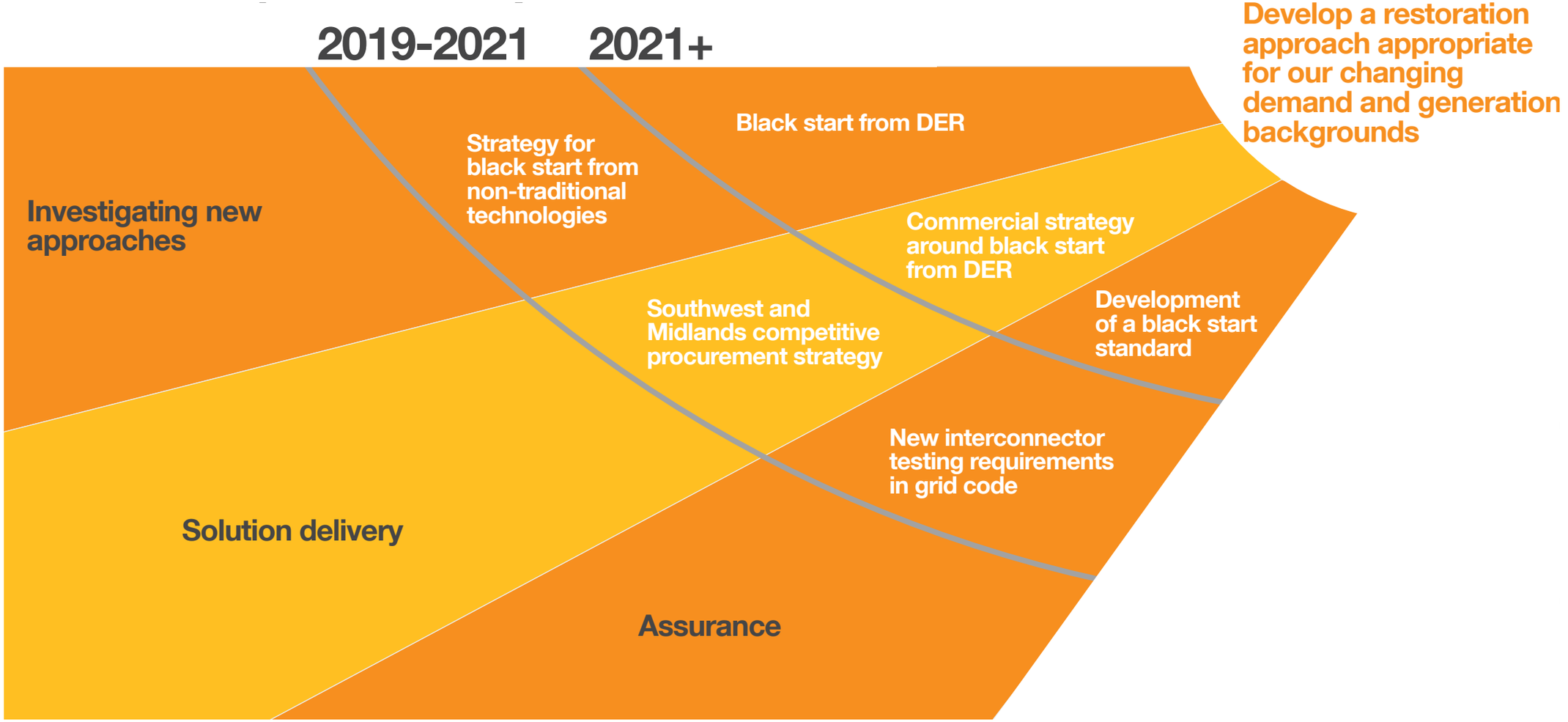
- The black start from DER innovation project is moving forward with our project partners, Scottish Power Energy Networks and TNEI. We will be investigating a wide range of case studies over the next year and then moving forward with a selection of these to the demonstration phase. The project will complete in 2021 and will enable us to understand what part DER can play in our restoration strategy. You can subscribe for updates on this project using this **link**[14].

Codes and regulation

- **Grid code modification GC0125**[15] – This modification proposal seeks to align the grid code with the EU Network Code on Emergency and Restoration by setting out testing requirements for interconnectors offering black start.
- **Black start testing** – To ensure compliance with the recently updated black start testing requirements for generators, an increased programme of tests will be delivered over the course of the year. This will ensure greater assurance of our existing services.
- **Black start standard** – Collaboration with BEIS' black start Task Group is continuing to design and inform a black start standard and explore possible ways of implementation. This work is important to ensure the level of restoration capability required is clear and agreed.



Milestones and ambitions



6 Stability

Vision – Stability

Mission statement

We have relied on the inherent qualities of synchronous generators to help maintain a stable system. However, the availability of these traditional sources is declining. To deliver zero carbon capability by 2025 it is essential to find additional sources for these stabilising qualities and develop transparent procurement methods.

Stability

Stability is the inherent ability of the system to quickly return to acceptable operation following a disturbance. The term is used to describe a broad range of topics. If the system becomes unstable, it could lead to a partial or total system shutdown, leading to the disconnection of consumers. If you would like to know more about stability, we have described the key topics in more detail in the System Operability Framework **publications**[1].

Rotating generators which produce power at the same frequency as the system frequency are called synchronous generators. Coal, gas and nuclear generators are examples of synchronous generation. Wind and solar are examples of asynchronous generation. When a synchronous generator is running, it has an inherent stabilising effect on the system in most circumstances. Asynchronous generators do not have the same inherent stabilising effect.

Zero carbon 2025

As we move to a low carbon electricity system, more of our power is coming from renewable sources; at the same time, energy consumption is decreasing as we become more efficient. This means the amount of synchronous generation running at any time is reduced and, without intervention, the stability of the system reduces. To support the transition to a low carbon electricity system we need to both decrease our reliance on fossil fuel generation to stabilise the system and learn to operate with a more dynamic system.

The programme for relevant generators to change their loss of mains protection has received excellent support from the industry and will result in significant benefit to the end consumer. Finding alternative sources of inertia is crucial to our 2025 ambition and the stability pathfinder project will be looking for similar support from industry.

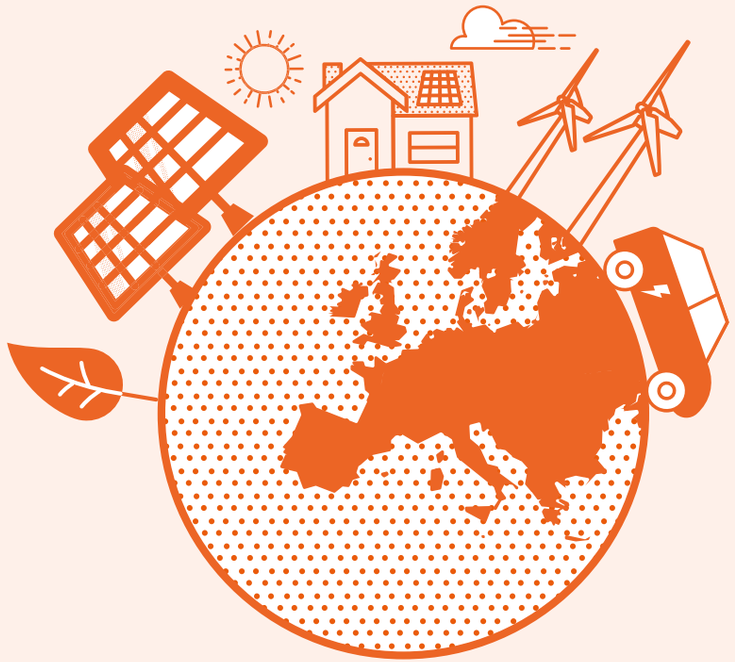
Key messages

Over the last six months:

- the volume of synchronous generation on the system has continued to decline. Some of the key factors influencing this decline are the connection of more asynchronous power sources; the increased capacity of transmission between Scotland and England allowing more asynchronous generation to run; and weather conditions favourable to high output of renewable generators
- managing the rate of change of frequency to prevent tripping of loss of mains protection continues to be the main stability challenge in the short term
- the cost of managing the system to prevent the tripping of loss of mains protection has risen from £60 million in 2017/18 to **£150 million in 2018/19**[2]
- to resolve this challenge, we have been working with distribution network owners to drive forward the implementation plan for accelerated loss of mains changes.

Over the next six months:

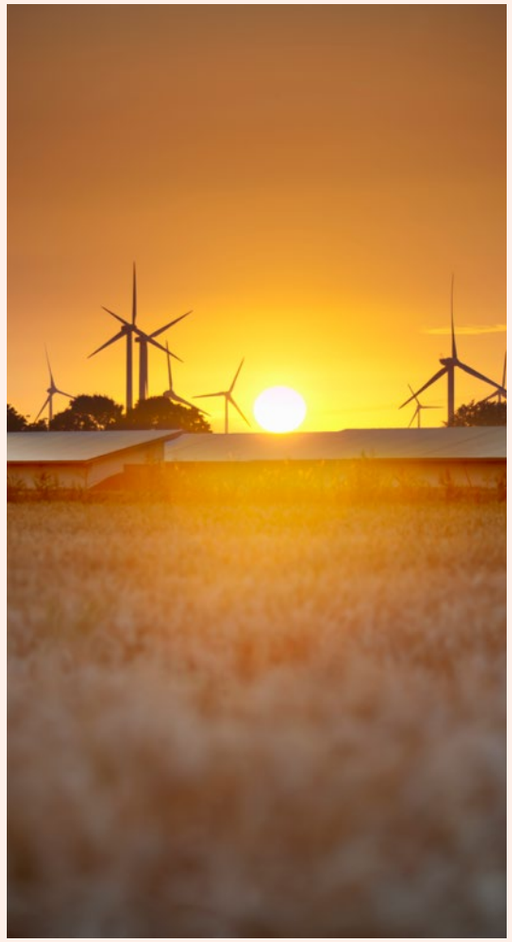
- we will continue working to better understand our future requirements for stability in preparation for publishing these to the market through the stability pathfinder
- the stability pathfinder is part of the **network development roadmap**[3] which is looking at how we can improve our network options assessment (NOA) methodology to consider more systems issues and propose wider range of solutions.



Key messages

Opportunities to get involved

- Relevant generators will be able to apply for payment to change their loss of mains protection. Applications will be invited via the **Electricity Networks Association website**[4].
- Later this summer we will publish a request for information on our approach for developing stability services as part of the stability pathfinder project under the **network development roadmap**[5]. This will be an opportunity to share your views on the development of stability services.
- We are continuing to use our engineering expertise to identify the operability challenges we see in the future energy scenarios. The topics which we are prioritising for 2019 are: review of past system events, operating a low inertia system, virtual synchronous machine, herding behaviour of storage and EV, trends and insights. If you have any views on what topics should be included in future System Operability Framework documents, please contact us at **sof@nationalgrideso.com**.



Review of previous six months

Loss of mains protection relays

Reducing the number of generators with inappropriate loss of mains protection settings will reduce the volume of generation at risk of disconnecting in response to a large loss (and subsequent high rate of change of frequency) on the system. This change will alleviate the RoCoF constraint, which is now the dominant factor when managing system inertia, and reduce the cost of balancing the system. This will also allow us to operate the system with lower levels of inertia which is a key step to enable operation with zero carbon in 2025.

Following previous changes to loss of mains protection requirements for generators above 5MW and new generators, a distribution code modification recommending retrospective changes to loss of mains protection settings for smaller generators was submitted to Ofgem in February. This code change will mean that less sensitive standards for loss of mains protection settings will apply to both new and existing stations.

As part of a broader programme looking at payment, assistance and enforcement, we have worked with the distribution network operators to develop a new constraint management service to pay small generator owners to change their protection settings. This aims to expedite the setting changes and hence allow us to reduce the number of actions and cost when managing this issue.

Review of previous six months

Development of stability requirements

We have published two reports outlining the impact of declining short circuit levels.

- **Whole-system short circuit level**[6].
- **Impact of declining short circuit levels**[7].

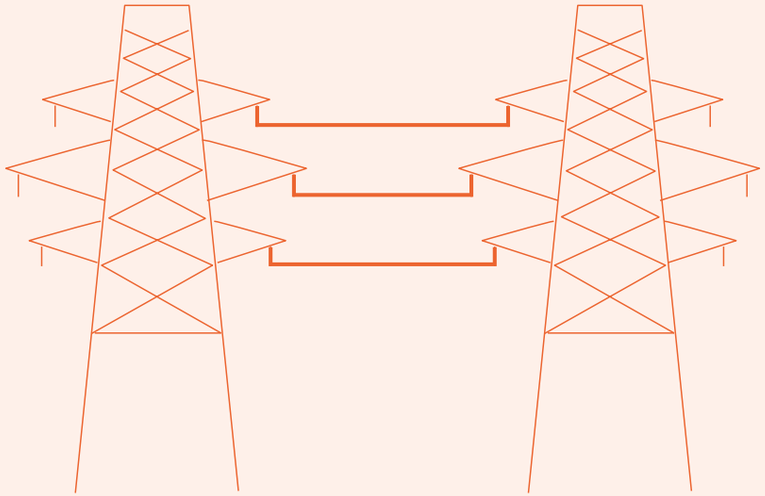
The reports outline the challenges we face due to the decline in short circuit level as a result of falling synchronous generation running on the network. The reports concluded that:

- the decline in short circuit level will present risks for network protection and generators with phase lock loop convertors
- increasing short circuit level at transmission will be more effective than at distribution to resolve transmission issues
- National Grid ESO will define requirements and seek solutions through our stability pathfinder projects.

The stability pathfinder is part of the **network development roadmap**[8] which is looking at how we can improve our network options assessment methodology to consider more systems issues and a wider range of possible solutions.

The stability pathfinder aims to better define our requirements for stability and develop an approach for requesting and comparing market-based solutions with network solutions. This should enable us to assess a variety of different solutions on a technical and commercial basis to establish the most economic approach to meeting our stability requirements.

The initial focus of the stability pathfinder has been on Scotland as this was identified as a priority area through our investigations into short circuit levels. Understanding the requirements will enable us to start developing services and markets.



Review of previous six months

Commercial and operational tools

- **Demand inertia**
  We have used data from events on the system to develop a better way to calculate the contribution that demand has towards our system inertia. We have now integrated this approach into our control processes. This will mean that we are operating the system more securely and economically.

- **Review of operational policy**
  The decision to secure some faults is based on a comparison of the likelihood of the event and the cost of mitigation. Over time both these factors can change which can impact the original decision. As part of our regular review, we have been assessing the cost and likelihood of a range of different faults to update our assumptions and ensure that we have the correct balance of cost to the consumer and security of supply.

Codes and regulation

- **Fault ride through**
  As a greater volume of the generation on the network is made up of small generators, **new requirements**[9] to ensure generation can ride through a fault have been introduced which now apply to all new generators above 1 MW. Any generators who either: had not ordered their equipment before 17 May 2018, or connected to the network after 27 April 2019, must now follow these new requirements.

- **Fast fault current injection**
  The grid code is being updated to clarify the requirements for fast fault current injection for generators with convertors. The consultation has now closed and this **modification**[10] will be submitted to Ofgem for approval.

Review of previous six months

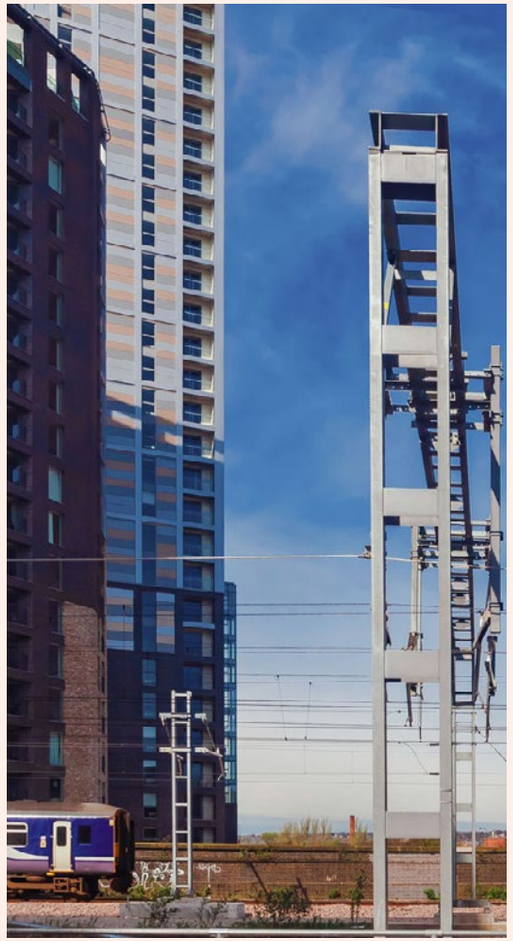
Innovation

- **Enhanced frequency control capability (EFCC)**[11]
  From a stability perspective, the project has confirmed our assumption that whilst response can be delivered in sub-second timescales, the timescales required to measure, communicate and deliver a response to a frequency event are not fast enough to prevent the tripping of loss of mains protection. Data received from the development of a wide area monitoring and control system would support our ability to be able to measure inertia in different locations across the country.

- **Phoenix**[12]
  We are partners in Scottish Power Energy Networks' Phoenix innovation project investigating the use of a hybrid synchronous compensator (a technology which could help to resolve our stability requirements). National Grid ESO has been working on network analysis to review the impact and perform and cost-benefit analysis of a hybrid synchronous compensator on the operation of the network.

  The initial network analysis shows that, in the future years with the declining synchronous generation in Scotland, boundary transfer between Scotland to England and Wales could be limited by stability issues. With the addition of hybrid synchronous compensator (H-SC) or synchronous compensator (SC), stability of the system could be improved which also increases the boundary transfer levels.

- **Investigation and modelling of Fast Frequency Phenomena (F2P)**[13]
  This project aims to observe and predict frequency variations across the network to understand how rate of change of frequency differs at a range of points on the network and ultimately help us to better define our requirements. The first phase of the project concluded in April and we now have a tool which can visualise how frequency varies across the network following an event on the system based on a 36 node model. Phase two of the project will look at creating a whole-system model and understand the impacts across both transmission and distribution.



Plan for future work

Accelerated loss of mains change

Applications are now open for relevant generators to apply for payment to change their loss of mains protection. You can apply for payment by submitting your details via the **Electricity Networks Association website**[14].

The applications will offer an improved understanding of the existing protection settings on the system which will enable us to better understand the volume at risk. As protection is changed we will be able to update the volume at risk in our operational tools which will enable us to reduce the scale and frequency of our actions.

If approved by Ofgem, the changes will become a **compliance requirement**[15] in 2022.

This summer we will be publishing a report on operating a low inertia system which will improve transparency of the processes and methodologies we use to manage rate of change of frequency.

Once the loss of mains protection changes have been implemented, our need to manage the rate of change of frequency will be driven by frequency management rather than the possible tripping of protection. The development of faster frequency response products will support this. The value of inertia in this future scenario will be considered alongside other stability requirements through the stability pathfinder.

Plan for future work

Development of stability requirements

Later this summer we will publish a request for information on our approach to developing stability services as part of the stability pathfinder project under the **network development roadmap**[16]. This will be an opportunity to share your views on the development of stability services.

Our intention is to trial this approach based on our initial requirements in Scotland. This trial will inform how we roll out our requirements across the country, so we encourage all industry participants to respond to the request for information not just those with a focus on Scotland.

We will develop and test processes to define requirements of transmission system stability needs, focusing on dynamic volts, inertia and fault levels as an indication of system stability requirements.

We will also develop processes to assess and procure market options to meet requirements that have been identified through technical and economic assessment. This will enable us to assess a variety of different solutions on a technical and commercial basis to establish the most economic approach to meeting our stability requirements. We will develop a methodology for inclusion in the Network Options Assessment for 2020-21.

Plan for future work

Commercial and operational tools

- **Inertia measurement capability**
  We continue to work on ways of measuring inertia in real time, two differing approaches are being taken forward. If successful, these will give us world leading information on the dynamic characteristics of the system and further increase confidence that we are operating the system with the right balance of costs and risk.

  These approaches will be built and tested during 2019/20. Once there is sufficient confidence in the output of the measurement, the data will be used to inform our operational policy. By 2020/21, we aim to implement a first of a kind system to measure system inertia in real time and use it to optimise real-time operation, service procurement and network development.

Codes and regulation

- **Low frequency demand disconnection**[17]
  If the frequency drops very low, it may be necessary to disconnect some demand to ensure the integrity of the rest of the network. In the **System Operability Framework**[18] we indicated that this may not work effectively in the future. We have been working with the DNOs to identify locations at risk. Once the requirement has been clarified, changes to the grid code will be proposed and industry will be able to engage further with this through the code change process. These changes are also in line with the European code requirements to implement an effective system defence plan.

Plan for future work

Innovation

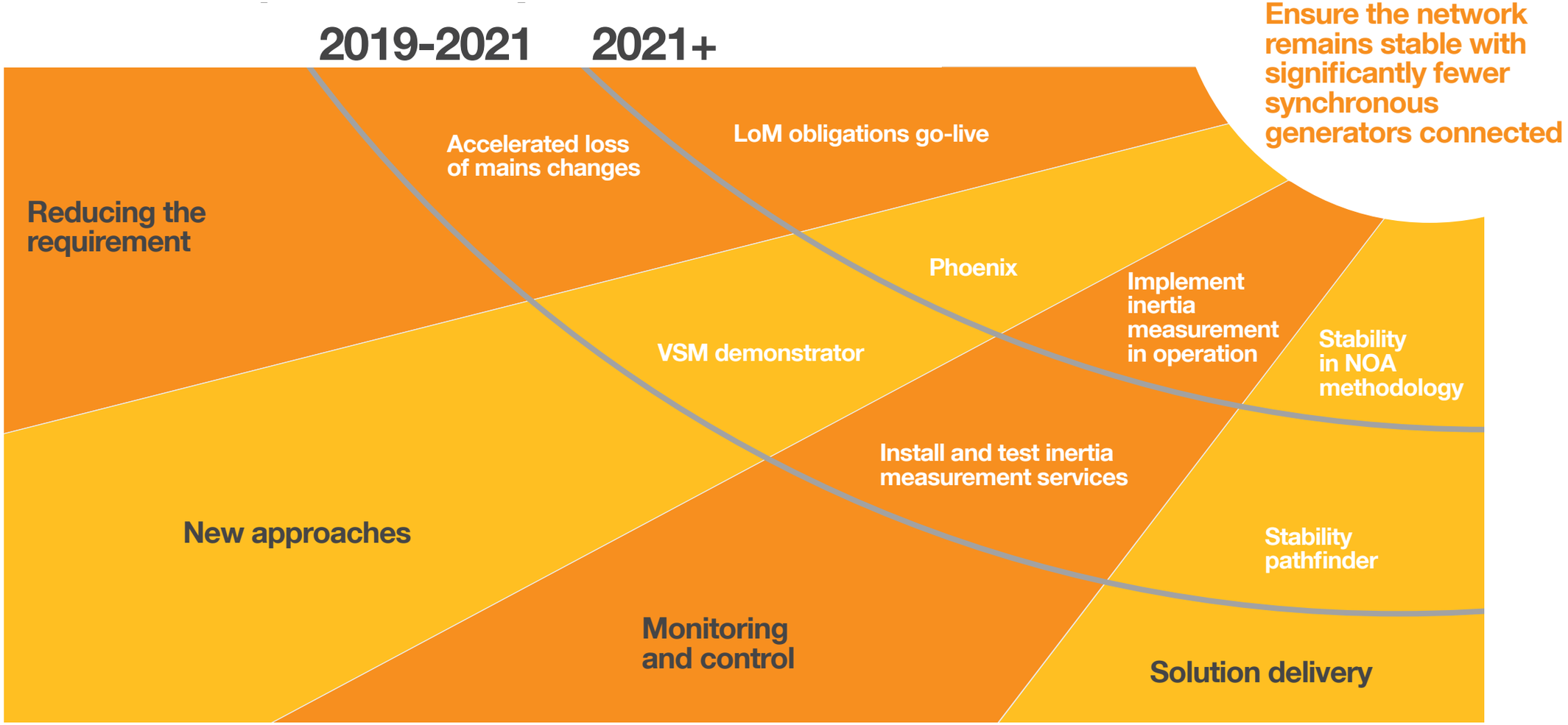
- **Phoenix**[19]
  We are partners in Scottish Power Energy Networks' Phoenix innovation project investigating the use of a hybrid synchronous compensator (a technology which could help to resolve our stability requirements). The initial network analysis under Phoenix has focused on Scotland as this is where the trial will be connected. Over the next six months, our network analysis will be expanded to other areas and will help to inform our approach for developing stability requirements.

- **Hybrid grid forming convertor**[20]
  Grid forming convertor technology enables renewable generation to behave in a similar manner to conventional generation and hence offers a method of achieving higher renewable penetration in the energy market. The project aims to understand the behaviour of grid forming convertors when applied across a wind farm as a whole rather than at each individual turbine. The results of the project will inform the development of balancing services or mandatory requirements.

- **Virtual synchronous machine (VSM) demonstrator**[21]
  A virtual synchronous machine is one type of grid forming convertor comprised of an asynchronous generator with a control system which mimics some of the stabilising qualities of a synchronous generator. This project will trial a virtual synchronous machine which will help us to better understand the capability of this potential solution and demonstrate the system benefit in the laboratory environment.

- **Short-term inertia forecasting**[22]
  In March 2019, we started our short-term inertia forecasting innovation project. This provides a proof of concept tool for an accurate day-ahead and intra-day inertia forecast with multi-time resolution, that can be used to support day-ahead requirements, procurement and real-time system operation.

Milestones and ambitions



7 Thermal

Vision – Thermal

Mission statement

The electricity network has physical limitations on how much power can be transmitted through every piece of equipment. To keep within these limits and operate a zero carbon network, we must deliver new tools, enhance current systems and create whole-system efficiencies to manage these constraints and reduce consumer costs.

Thermal

There is a physical limit to the amount of power which can be transmitted through any piece of equipment on the network. Often this limit is set to ensure that equipment does not overload and overheat. Whilst every piece of equipment on the network has this limit, we only have to take action if the generation and demand pattern mean that this limit will be exceeded. New forms of generation, at different locations on the network and of different sizes, are causing flows on the network to change. This is due to generation connecting in the distribution network or around the periphery of the transmission network to make best use of renewable energy. We do not always have the same level of visibility of, or commercial agreements with, these new forms of generation, especially in the distribution network. As a result, we are seeing more occasions when our options to manage transmission constraints are limited. We need to work with DNOs to take a whole electricity system approach to managing network constraints across transmission and distribution to ensure efficient outcomes are realised for the end consumer and so that system security is maintained.

Zero carbon 2025

Significant changes in the generation mix will be required as we transition to zero carbon operation in 2025. We are already seeing impacts of this, as thermal constraints and voltage levels change in response to new forms of generation connected at different locations on the network. We will not be able to rely on instructing large thermal generators in the future so our approach includes encouraging new providers to participate in our constraint management services. Close collaboration with DNOs and TOs will be crucial in facilitating services from a range of zero carbon providers.

Bringing in the views of industry and stakeholders is vital to developing the right network assets for the future. We have been pleased with the responses to our stakeholder events and regional development programmes (RDPs). Further interactions are planned and we are also keen for continued collaboration with DNOs and TOs.

Key messages

Over the last six months:

- we published the findings from our case study on the use of **thermal probabilistic analysis**[1], tested on a transmission network boundary in the south east as a way of developing our network planning tools, as described in our **network development roadmap**[2] publication
- we have run our first key stakeholder event, "Commercial Opportunities for Network Challenges", bringing together industry views to inform our future tender processes and network enhancements. We will publish the outputs from the session, on our **website**[3], by the end of June
- we have launched and progressed two new **regional development programmes**[4] (RDPs): 'Connecting storage in the West Midlands' and 'Heysham GSP'
- we have reviewed the scope of the post fault constraint management commercial solutions pathfinder following more detailed identification of the requirements to seek market interest in a year-round thermal constraint service
- we have also launched a new constraints pathfinder, which is focused on the constraints which remain after economic reinforcement, and have sought industry views on our initial analysis.

Over the next six months:

- we will further the work of the RDPs, collaborating and assisting DNOs and TOs, and engaging with industry where appropriate
- we will build on the successful "Commercial Opportunities for Network Challenges" industry event and identify next steps.

Opportunities to get involved

- We invite **your views**[5] on the probabilistic approach we are intending to adopt for the 2019/20 NOA process.
- We will be publishing a request for information on constraint management in Q3 2019/20; we invite your views on service provision and commercial aspects.

Review of previous six months

Networks

Probabilistic assessment approach

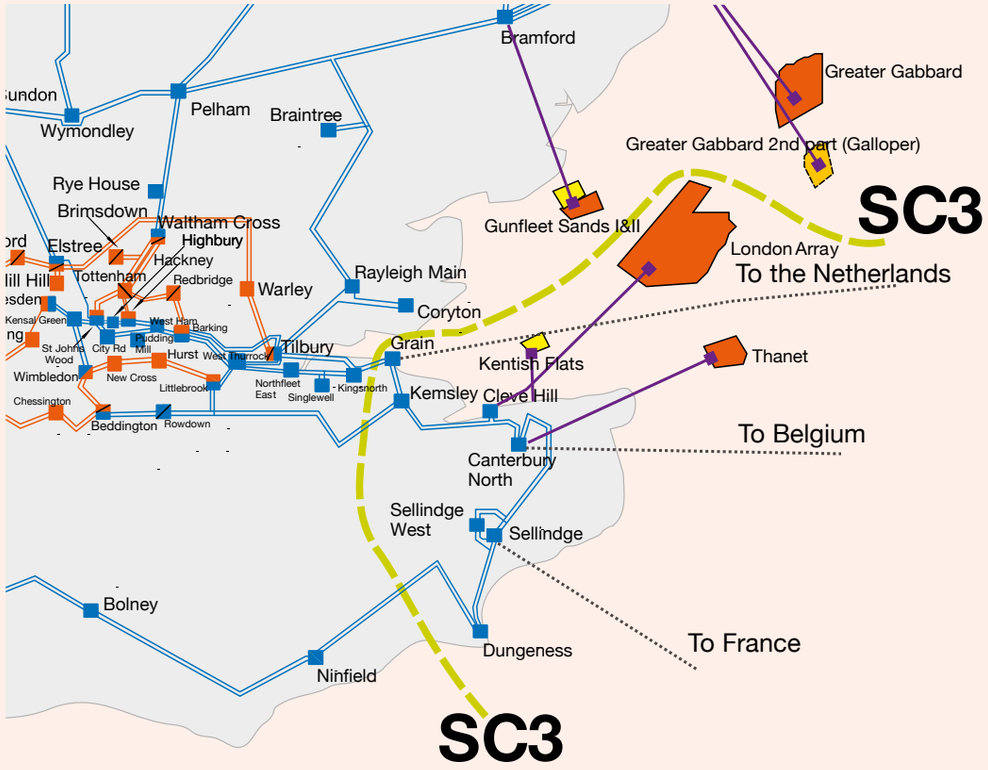
- One approach set out in our **network development roadmap**[6] is to take a probabilistic approach to assessing year-round thermal transmission network needs. In March 2019, we published the findings of a **case study**[7] where we tested a planning tool and analysis methodology on part of the South East coast network. Through the case study we have been able to show that, with further development of our tool and analysis, we can identify additional transmission network needs compared to our current deterministic planning approach.

  We've also shown how the probabilistic approach can be used to define dynamic boundary capability requirements, enabling us to optimise our network reinforcement. We welcome **your feedback**[8] on this approach.

Constraint management pathfinder

- In the last Operability Strategy Report we committed to review the relationship between regulated network assets and market-based commercial solutions. We have since conducted feasibility studies which show that flexible solutions can show consumer benefit for northern boundaries and further studies have commenced following the new **NOA backgrounds**[9] published in January 2019. In May 2019, we engaged with industry on how best to articulate the system and technical requirements and recommendations for contract structures.

South East boundaries



Review of previous six months

Regional development programmes (RDP)

Since our last update in November 2018, we have published a **report**[10] for the UK Power Networks South East RDP. This report summarises how detailed collaborative analysis showed benefits in understanding network security issues under conditions not previously experienced. It also enables the investigation of a range of build and operational solutions to show under what conditions whole-system solutions could benefit both consumers and DER project developers.

We have also launched two new RDPs for 'Connecting storage in the West Midlands' and 'Heysham GSP'. For these, and the Southwest Scotland RDP, we have published high level plans which provide a timeline for the key project milestones.

Review of previous six months

Regional development programmes (RDP)

Connecting storage in the West Midlands – Western Power Distribution (WPD)

- **Our Future Energy Scenarios**[11] have highlighted a significant growth in energy storage within the UK. WPD currently has over 840 MW of energy storage either connected or accepted and this is beginning to impact on reinforcement requirements at the transmission-distribution boundary. The RDP seeks to allow energy storage, or other system flexibility providers, to receive the flexibility arrangements granted to generation and become part of the solution to network capacity issues. We have completed a large portion of this work (see high level plan on **website**[12]) and have been working with WPD on developing contractual documents and terms.

Heysham GSP – Electricity North West (ENW)

- The North West part of the electricity network has high potential for wind resources. By 2020, it is anticipated that 564 MW of DER will be connected behind the Heysham grid supply point (GSP). However, the GSP is at its limit in terms of thermal capacity and fault level limits. This RDP aims to deliver a more economic market solution than the installation of a new super-grid transformer (SGT) which is often a time consuming and expensive solution. We have completed phase one of this project (see high level plan on **website**[13]) and will be publishing a report into the cost-benefit analysis findings by end of Q3.

UK Power Networks South East

- The UK Power Networks Southeast RDP is currently going through IT assessment to identify the appropriate system to dispatch active power in the area, and the subsequent timeline to deliver the dispatch platform. The complexity of the project has caused delays in the IT project which has subsequently delayed the implementation phase of the RDP.

Western Power Distribution South West

- The WPD Southwest RDP is currently going through IT assessment to identify the appropriate system to dispatch active power in the area, and the subsequent timeline to deliver the dispatch platform. The complexity of the project has caused delays in the IT project which has subsequently delayed the implementation phase of the RDP.

South West Scotland

- The Southwest Scotland RDP is currently going through IT assessment to identify the appropriate system to dispatch active power in the area, and the subsequent timeline to deliver the dispatch platform.

Plan for future work

Networks

Post fault constraint management commercial solutions[14]

- As a result of the findings from reviewing requirements, we have changed the scope of the post-fault commercial solutions work and we are now going to be seeking industry views to help support the assumptions we made last year and confirm there are benefits for year-round commercial solutions.

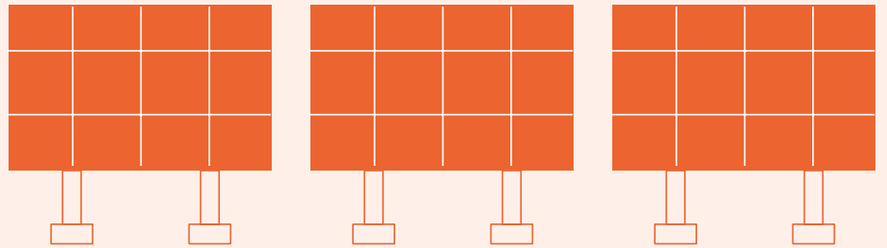
Constraint management pathfinder

- We will be developing and working on the next steps, borne out of our mid-May industry stakeholder event. We will also be working on the commercial aspects of what any future service may look like. We intend to publish a request for information later this year on **constraint management**[15].

Probabilistic methodology, tool and analysis

- For the 2019/20 Network Options Assessment (NOA), we intend to use the probabilistic tool and techniques to validate network assumptions used in the boundary analysis and results provided by the TOs when year-round conditions are considered.

To further develop our capability and experience in probabilistic network assessment, we intend to study all boundaries for the NOA year one thermal analysis. We will also select one or several boundaries on which to perform year-round analysis for all NOA study years.



Plan for future work

Regional development programmes (RDP)

Connecting storage in the West Midlands – Western Power Distribution (WPD)

- We will ensure that energy storage customers can participate in emerging whole-system energy markets, through the development of necessary distribution network owners and ESO processes, such that flexibility can be delivered in constrained areas. The ESO needs full visibility and control of all providers to effectively manage whole-system issues.

Heysham GSP – Electricity North West (ENW)

- We will be collaborating with Electricity North West to agree the most economic and efficient development of the transmission and distribution system to enable new connections in the Heysham group, whilst considering a whole-system approach.

UK Power Networks and Western Power Distribution

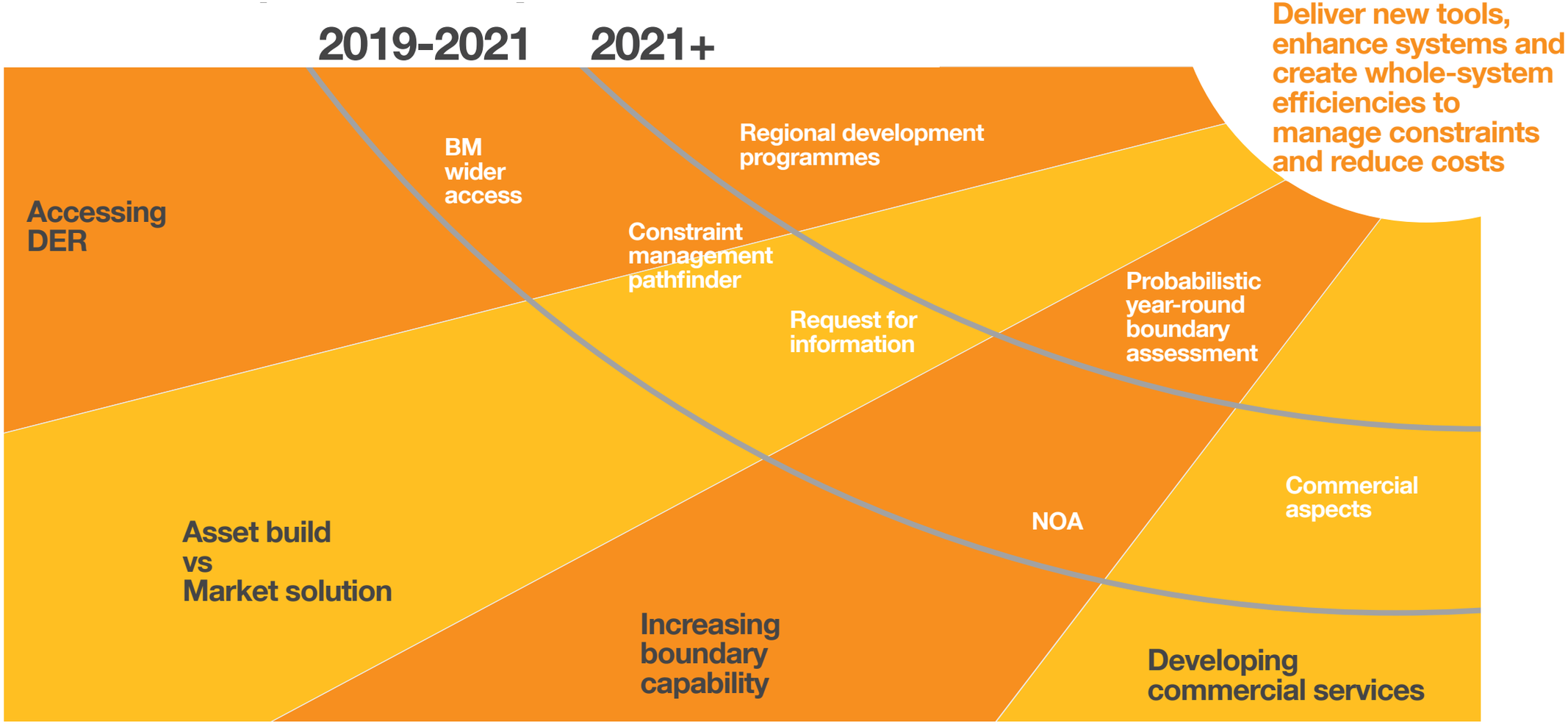
- We will be working with our partners to progress the internal IT project and develop a system capable of dispatching DER. Alongside this we will engage with stakeholders to develop an appropriate ancillary services commercial contract framework for DER.

South West Scotland

- We will continue to work with SP Distribution to aid their roll-out of a network-wide **ANM** and work with SP Transmission to develop the necessary technical requirements for **GEMS**.

In addition, we will be developing suitable commercial frameworks which ensure that transmission constraint management solutions can be provided by both transmission and distribution connected customers.

Milestones and ambitions



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[8] http://www.energynetworks.org/electricity/engineering/accelerated-loss-of-mains-change-programme.html
[9] https://www.nationalgrideso.com/insights/network-options-assessment-noa/network-development-roadmap
[10] mailto:transmission.etys@nationalgrid.com
[11] https://www.nationalgrideso.com/insights/system-operability-framework-sof

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[1] https://www.nationalgrideso.com/document/138861/download
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[1] https://www.nationalgrideso.com/insights/network-options-assessment-noa/network-development-roadmap
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Chapter 5 – Restoration

[1] https://www.nationalgrideso.com/balancing-services/system-security-services/black-start
[2] https://www.nationalgrideso.com/project-black-start-from-der
[3] https://mailchi.mp/db16788e123e/distributedrestoration
[4] https://www.nationalgrideso.com/balancing-services/system-security-services/black-start?overview
[5] https://www.nationalgrideso.com/sites/eso/files/documents/National%20Grid%20SO%20Product%20Roadmap%20for%20Restoration.pdf
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[8] https://www.nationalgrideso.com/balancing-services/system-security-services/black-start?overview
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[13] https://www.smarternetworks.org/project/nia_ngso0022
[14] https://mailchi.mp/db16788e123e/distributedrestoration
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[9] https://www.nationalgrideso.com/codes/grid-code/modifications/gc0062-fault-ride-through
[10] https://www.nationalgrideso.com/codes/grid-code/modifications/gc0111-fast-fault-current-injection-specification-text
[11] https://www.nationalgrideso.com/innovation/projects/enhanced-frequency-control-capability-efcc
[12] https://www.spenergynetworks.co.uk/pages/phoenix.aspx
[14] https://www.smarternetworks.org/project/nia_ngso0007
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[16] http://www.dcode.org.uk/current-areas-of-work/dc-0079.html
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[19] https://www.nationalgrideso.com/insights/system-operability-framework-sof
[20] https://www.spenergynetworks.co.uk/pages/phoenix.aspx
[21] https://www.smarternetworks.org/project/nia_ngso0019
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[1] https://www.nationalgrideso.com/document/140781/download
[2] https://www.nationalgrideso.com/sites/eso/files/documents/Network%20Development%20Roadmap%20-%20Confirming%20the%20direction%20July%202018.pdf
[3] https://www.nationalgrideso.com/insights/network-options-assessment-noa/network-development-roadmap
[4] https://www.nationalgrideso.com/insights/whole-electricity-system/regional-development-programmes
[5] transmission.etys@nationalgrid.com
[6] https://www.nationalgrideso.com/insights/network-options-assessment-noa/network-development-roadmap
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