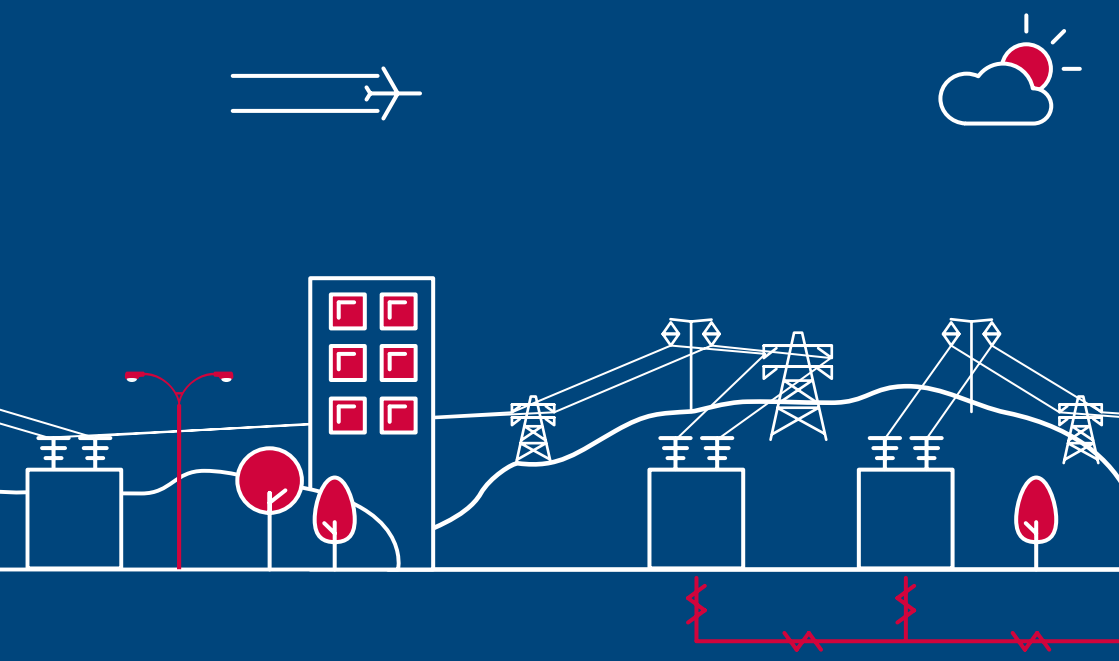
nationalgrid

Product Roadmap

For Reactive Power



May 2018

Foreword

Today we are publishing a roadmap of actions to shape the future of Reactive Power services.

This is the next step in our ongoing work to develop a more flexible and efficient electricity network fit for the future. It follows last year's publication of our *System Needs and Product Strategy* document, where we asked for your feedback on how we could simplify and improve our balancing services.

Our intention is to make sure the market is performing efficiently, and prioritise future development work.

Which brings us to today and our plans for the Reactive Power markets. Essentially, our aim is to provide greater clarity and certainty on our needs and actions, and we also share our plans to work more closely with our industry partners to improve the market for Reactive Power.

As always, we are keen to hear your views and feedback on what you read in this publication. We'll be holding engagement events later this year, but you can also send us your thoughts and comments via our Future of Balancing Services email address: box.futureofbalancingservices@nationalgrid.com

Cathy McClay
Head of Commercial, Electricity

Contents

Executive summary

As System Operator (SO) our vision is for a more flexible electricity system which makes the most economic and effective use of all available resources to meet the continuing needs of the electricity network.

We aim to be flexible to a changing environment, more efficient at procuring and better at talking to our partners and customers.

To do this, we are creating balancing services that allow all providers, new and existing, to participate in markets which complement, or act as an alternative to, network asset investment. We are working with our colleagues in the distribution networks, incorporating the work of the Energy Networks Association (ENA) Open Networks Project[1] in our products and redefining our ways of working. This document sets out our actions in the Reactive Power service area. The proposed milestones are shown in Figure 0.1.

The highlights include:

- reviewing current products and methods for procuring Reactive Power and working with industry to develop a better, shorter-term market
- being more transparent about our products and what we need from industry
- publishing an invitation for Expressions of Interest in the provision of Reactive Power services in South Wales
- continuing to build on our transparency commitments across our balancing services, ensuring data is presented in a coherent manner and improving Balancing Services Use of System (BSUoS)[2] charges information and the Monthly Balancing Services Summary (MBSS)[3].

Our proposed milestones shown in Figure 0.1 should be considered alongside the corresponding milestones in our Product Roadmaps[4] on Frequency Response and Reserve, and Restoration.

[1] http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-overview/

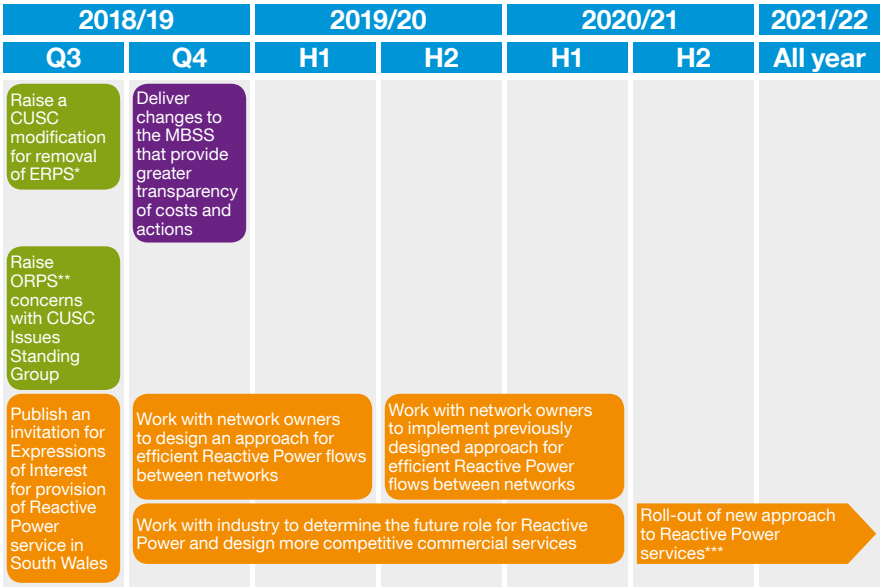
[2] https://www.nationalgrid.com/uk/electricity/charging-and-methodology/balancing-services-use-system-bsuos-charges

[3] https://www.nationalgrid.com/uk/electricity/market-operations-and-data/system-balancing-reports

[4] https://www.nationalgrid.com/uk/electricity/balancing-services/future-balancing-services

Executive summary

Figure 0.1
Roadmap of actions



Key

- Rationalisation
- Simplification
- Improvement

* Enhanced Reactive Power Service
** Obligatory Reactive Power Service
*** This is an agile project which will retain flexibility on which features to deliver and in which order, depending on service priorities and technical considerations.

Chapter one

Principles

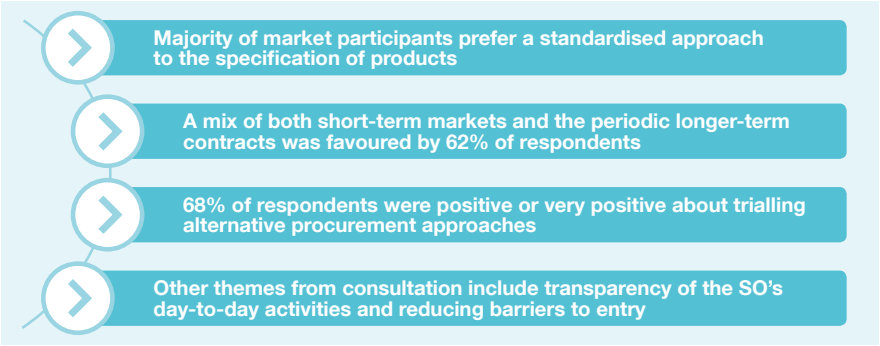
You asked the SO to operate differently

A few years ago we dealt with around 20 providers of balancing services. Today, that number is more than 350. We now handle more than 250 queries every year from new parties looking to provide services. The majority of this growth has been in frequency response and reserve but there is increasing interest in Reactive Power and voltage management.

This growth is coupled with a change in providers, from large transmission-connected plant to small distribution-connected renewable, thermal, storage and load aggregation. This change has thrown the design of our products and markets into sharp focus. We need to find ways to get these new energy providers onto the system while continuing to balance the system economically and efficiently. This is discussed in the *System Needs and Product Strategy (SNAPS)* document and a detailed overview of the responses from market participants can be downloaded here: *https://www.nationalgrid.com/uk/electricity/balancing-services/future-balancing-services*.

Figure 1.1 provides a view of the key highlights which underpin our conclusions and proposed actions.

Figure 1.1
High level summary of SNAPS responses

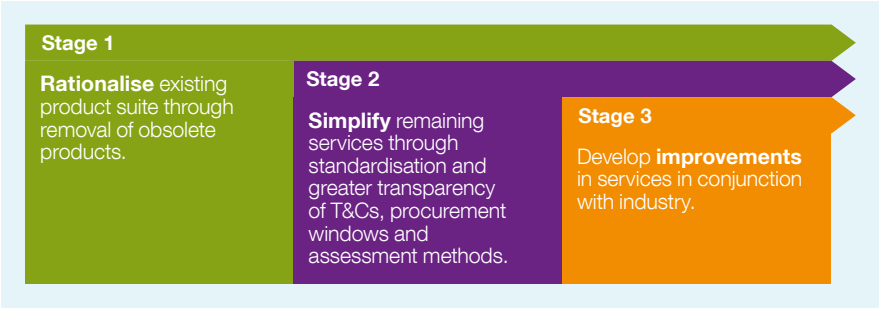


What are we delivering as part of this product roadmap?

In the SNAPS consultation, we set out a three-stage process to improve and develop our products and markets (Figure 1.2).

The Reactive Power market is less mature than either the response or reserve markets, so all three stages of the process will be covered in the roadmap.

Figure 1.2
Three-stage process in evolution of SO's products



Principles which will govern how the SO procures in the future

This product roadmap aims to reduce uncertainty by providing a set of principles for our future procurement activities and backing those principles with actions in relevant service areas.

Our three principles are broadly in line with the feedback we received from our October 2017 consultation.

Principles

Principle 1

Our procurement decisions will be transparent and our methodology and needs will be clear to the market ahead of time.

In practice, this means:

- we provide information on our needs and methodology ahead of each procurement event
- we help parties to understand why their procurement submissions were successful or rejected
- we avoid bundling together products where possible, e.g. not procuring frequency response, headroom and reactive capability at a single price
- where bundled procurement is justified on economic or operational grounds, we are clear on the value of each part of the bundle
- we separate the cost categories in the MBSS by the end of Q4 2018/19
- we make all underlying data for tendered balancing services and the MBSS available in one place in a simple format (Q4 2018/19)
- we produce YouTube videos explaining how products are procured and used.

Principle 2

The design of our products, the way we procure, and the contractual arrangements will increase competition in provision of services to the SO.

In practice, this means:

- where possible, our products will facilitate stacking of revenues through a review of contracts and exclusivity clauses and we will work with the ENA to achieve this
- our products will support different types of assets
- following overwhelming feedback from providers, we will develop a mix of short-term markets and long-term contracting opportunities.

Principle 3

Our products will be designed to balance both operational requirements and the technical ability of provider assets while maintaining system security.

In practice, this means:

- we will ensure products are designed to meet full operational requirements
- our products are designed to allow full market entry to current and emerging technologies as far as practicable.

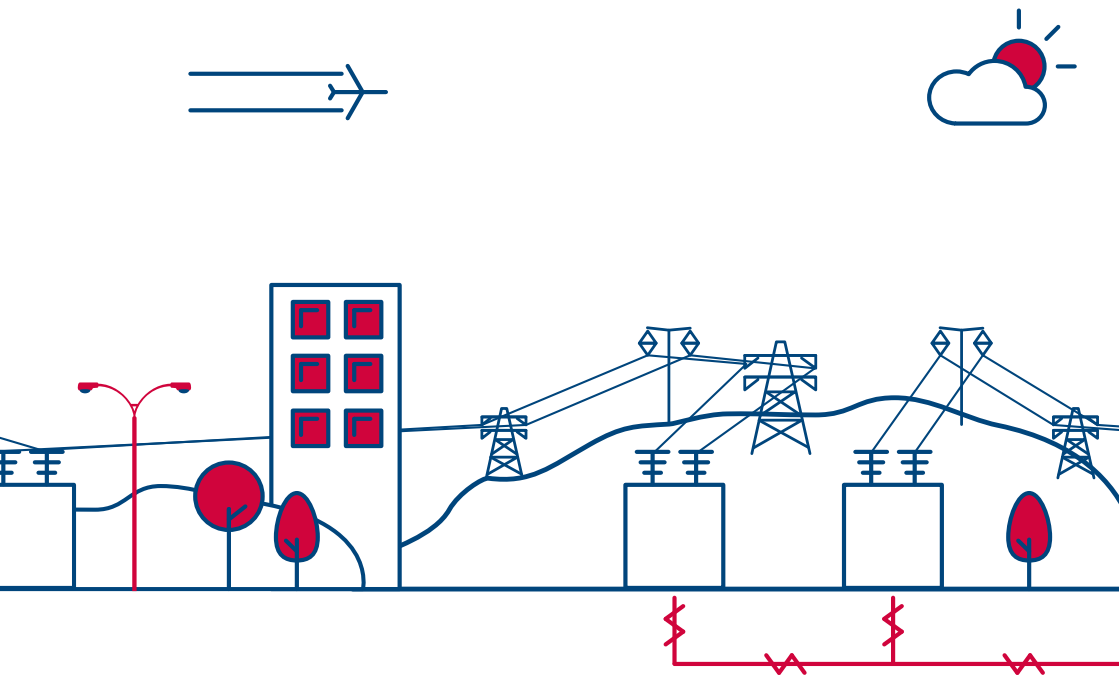
We will also take into account European guidelines in future designs to future-proof our balancing services products.

SO–DSO interactions

Many parties agreed the interactions between the SO and DSOs are critical to the future evolution of balancing services.

As distribution networks become smarter, more participants will want to offer a greater range of services to an increasing number of customers (e.g. SO, DSOs, suppliers etc.). That is our challenge and, working closely with DSOs, we aim to drive consumer value by making the most effective use of transmission and distribution assets across the whole electricity system.

The ENA Open Networks Project is a key driver for this and we are working with all DNOs to bring this project to fruition.



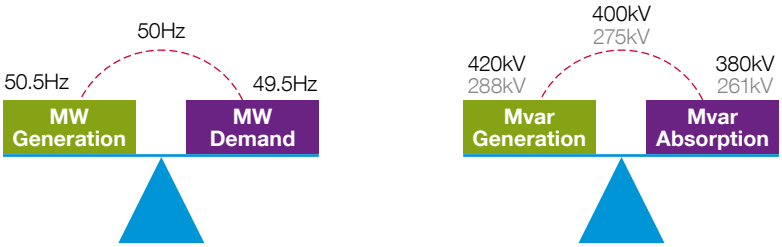
Chapter two

Reactive Power

Reactive Power (measured in Mvar) is used to control voltage levels across the electricity system, keeping them at a safe and efficient level for electricity transportation and consumption. This Reactive Power can be either generated if more is needed, or absorbed if there is too much in the system. This keeps the voltage balanced at the right level.

This is effectively how we keep active power (measured in MW) in balance to control the frequency of the electricity system as per Figure 2.1 below.

Figure 2.1
Active power balance and Reactive Power balance



When active power (MW) generation is greater than active power demand, the frequency increases, and when active power generation is lower than active power demand the frequency decreases. Similarly, when Reactive Power (Mvar) generation is greater than Reactive Power absorption, the voltage increases, and when Reactive Power generation is lower than Reactive Power absorption the voltage decreases. However, unlike active power for frequency control, Reactive Power generation and absorption requirements for voltage control are regional and vary significantly across the electricity system (Figure 2.2). For example, demand for active power in one region of the electricity system could be met by active power generation by any other region. This is not true for Reactive Power. Absorption of Reactive Power within a region of the electricity system needs to be met by generation of Reactive Power from that region.

Figure 2.2
National frequency balance and regional reactive balance

The regions marked are for illustrative purposes only and do not reflect actual regional reactive requirements

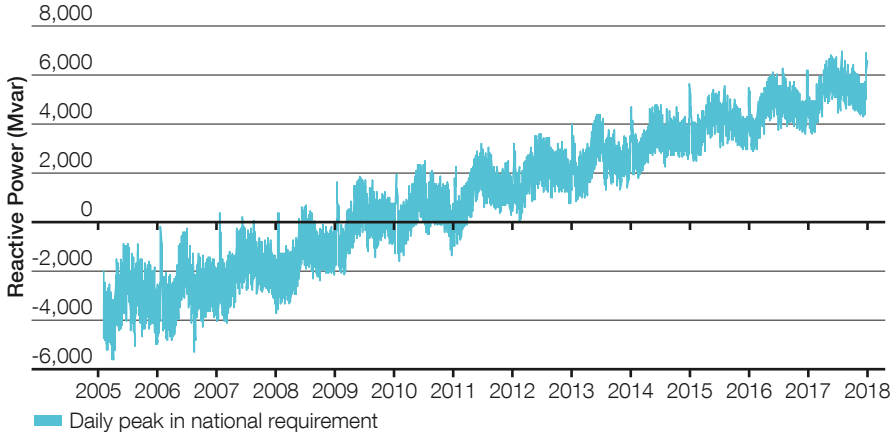
The way we manage Reactive Power also differs to active power in that generators and many of the network assets (such as transformers, overhead lines and cables) are able to both generate or absorb Reactive Power.

Reactive Power

When the demand for active power is low, power flow through the network is also low, and the network assets generate Reactive Power. This means our greatest requirement for Reactive Power absorption is when active power demand is low. This is usually overnight and during the summer and so the volume we procure varies both across the day and across seasons.

Figure 2.3 below shows how the Reactive Power absorption requirement on the transmission system has evolved over time, as well as demonstrating the seasonal variation.

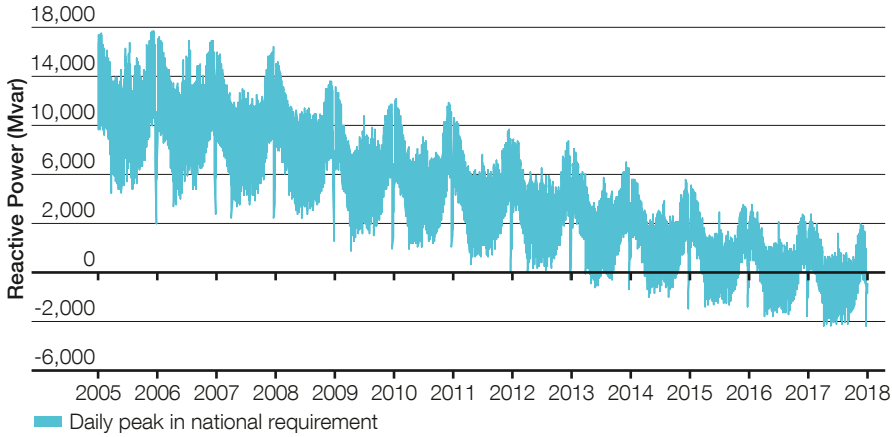
Figure 2.3
Daily peak Reactive Power absorption requirement



As you can see, the requirement for Reactive Power absorption has consistently increased for the last 10 years and our forecasts show this will continue.

Figure 2.4 below shows how the need for Reactive Power generation has evolved over time, and shows the seasonal variation.

Figure 2.4
Daily peak Reactive Power generation requirement



When the demand for active power is high, network assets absorb Reactive Power. This is usually across the peaks during the winter. However, the requirement for Reactive Power generation has consistently decreased for the last 10 years and we expect this trend to continue.

Our requirements for both Reactive Power generation and absorption are currently met through a combination of balancing services and network asset investment. Network assets for Reactive Power (capacitors, reactors) which have historically provided the majority of our baseload Reactive Power are very cost-effective. They are built by transmission and distribution network owners, as required to comply with the system's security standards, or to meet Reactive Power requirements.

We rely on balancing services to fill the gap when network assets are not available.

Reactive Power

In recent years the pace and scale of changing Reactive Power flows, combined with the lead times involved in the investment of network assets, has created an increased reliance on balancing services. We currently spend over £150m per annum on these services and to reduce this exposure we are working closely with the network owners and now optimise the network configuration much more than ever before.

We can procure Reactive Power generation and absorption through two routes, however we can only use these if the provider is running when we have a Reactive Power requirement. They do not enable us to ensure a provider is available:

1. The Obligatory Reactive Power Service (ORPS)[5], which is outlined in the Connection and use of System Code (CUSC)[6], and must be provided by all generators with a Mandatory Services Agreement. Generally, all power stations connected to the transmission network with a generation capacity of over 50MW must be able to provide this service, as set out in the Grid Code CC 6.3.2[7]. Service payments are based on a fixed methodology that is specified in the CUSC. We currently spend £100m per annum using this service.
2. The Enhanced Reactive Power Service (ERPS)[8] is a tendered commercial service as outlined in the CUSC. It is for providers who can go beyond the obligatory Reactive Power requirements. It is also for providers who do not have to offer ORPS but can meet or exceed the ORPS performance standard. We have not had a contract for this service since October 2009 and have received no tenders since January 2011.

As patterns of generation and demand have changed on the system, the availability of ORPS providers at the times when they are needed most has become more challenging. This is most frequently seen during low active power demand periods in the summer, when conventional thermal plant that provides ORPS is less likely to run. This leads to some regions of the country not having enough ORPS providers available when needed, making those areas more challenging to manage and potentially giving rise to a voltage constraint.

A voltage constraint occurs when we don't have enough Reactive Power generation or absorption regionally. This means that voltage levels will go outside of secure limits unless we change the level of Reactive Power. When this happens, we first must ensure that sufficient ORPS providers are available within that region. We currently spend £50m per annum achieving this by using the following services:

1. Regional voltage constraint contracts (Constraint Management Services). These are tendered commercial services in regions where there is a voltage constraint to synchronise ORPS providers.
2. Forward energy trades under a Grid Trade Master Agreement (GTMA) to synchronise ORPS providers.
3. Accepting offers from participants in the Balancing Mechanism (BM) to synchronise ORPS providers.

In all of these cases we are using services designed to procure active power, often when active power is not needed, to ensure the availability of ORPS providers. We then procure the Reactive Power generation or absorption through ORPS.

The spend associated with Reactive Power can be found in our MBSS reports[9], or the annual C16 Procurement Report[10].

[5] https://www.nationalgrid.com/uk/electricity/balancing-services/reactive-power-services/obligatory-reactive-power-service

[6] https://www.nationalgrid.com/uk/electricity/codes/connection-and-use-system-code

[7] https://www.nationalgrid.com/uk/electricity/codes/grid-code

[8] https://www.nationalgrid.com/uk/electricity/balancing-services/reactive-power-services/enhanced-reactive-power-service

[9] https://www.nationalgrid.com/uk/electricity/market-operations-and-data/system-balancing-reports

[10] https://www.nationalgrid.com/uk/electricity/market-operations-and-data/transmission-licence-c16-statements-and-consultations

Stage 1: Rationalisation

We will review our current services for procuring Reactive Power, including our use of services for active power to ensure the availability of ORPS providers. This process will begin with ERPS.

We want to work with providers to replace this service with a better-functioning market for Reactive Power. Our vision is to be able to tailor our requirements area by area, procure from the most cost-effective providers, and broadcast the broad value of reactive solutions in each area. In the medium term, this could spur new providers, or help build the case for new asset-based solutions.

Our next steps will involve:

- setting out in more detail our concerns about ERPS to the relevant CUSC groups in Q3 2018/19, with a proposal to remove the service
- holding an initial information workshop in Q4 2018/19 with interested parties to outline the issues with current arrangements in more detail and set out a programme to improve Reactive Power market solutions.

Stage 2: Simplification

The aim of this phase is to simplify our procurement methods and break down barriers to entry where possible.

The majority of the feedback from the consultation highlighted issues with the complexity of both our balancing service products and how we procure services. This is acting as a barrier to new entrants and technologies, but also making it difficult for current parties to identify the best tendering strategy to deliver best value to the end consumer.

To support this goal, it is essential we provide the market with clear information on the cost of our actions in the Balancing Mechanism and the cost of services procurement.

Providers have told us that it is not clear how Reactive Power and voltage constraint costs are reported in our online MBSS. At present, the MBSS reports the costs of the ORPS separately. However, it does not make clear that the costs of procuring active power to access ORPS are because of a Reactive Power requirement. The growing costs of synchronising plant for the provision of Reactive Power are grouped into a general ‘Constraints’ cost category that covers both thermal (active power) and voltage constraints.

Reactive Power

This is because historically plant synchronisation would primarily have been for thermal constraints. It was not envisaged that plant would have to be regularly synchronised by the System Operator for the provision of Reactive Power.

To make both the reason for our actions and the breakdown of our spend transparent, we will separate out the costs within the MBSS and make it clear when we are procuring active power to access Reactive Power. We will complete this work by the end of Q4 2018/19.

We will also continue to build on our transparency commitments across our balancing services, ensuring data is presented in a coherent manner and improving BSUoS charges information and the MBSS. As part of this we will be considering wider feedback on avoiding unnecessary fragmentation around the publication of information by working closely with other industry partners such as Elexon.

Stage 3: Improvement

As previously stated, Reactive Power generation and absorption requirements are currently addressed through a combination of network asset investment and balancing services. So we aim to look at how we can improve both of these areas.

Network asset investment

We have recently published our Network Development Roadmap Consultation[11] with our proposals for developing our network planning tools. This describes how we are developing a longer-term approach to tackling voltage constraints, that considers a range of transmission network, distribution network and market solutions.

In the medium term we will work with DNOs to optimise the use of transmission and distribution network assets (transformers, overhead lines, cables, capacitors and reactors) across the system.

The increase in renewable and small-scale generation connected to the distribution network is coinciding with the reduction of traditional providers of Reactive Power services. To efficiently manage the flows of Reactive Power on both systems, we believe that better coordination is needed between the transmission network and the distribution networks. This is likely to involve agreeing how much Reactive Power should be transferred between the distribution and transmission networks and a more active role in managing these reactive exchanges.

Our next steps include:

- working with DNOs to understand what's involved with setting and operating efficient exchanges of Reactive Power by Q1 2019/20
- agreeing common practice by the end of September 2019 and implementing any quick wins
- implementing new practice from October 2019.

[11] https://www.nationalgrid.com/uk/documents/113896-network-development-roadmap-consultation

Balancing services

We will continue our review of services for procuring Reactive Power, including our use of services for active power to ensure the availability of ORPS providers.

We will work with providers to design a better-functioning market for Reactive Power, starting with an initial information workshop in Q4 2018/19.

We will need to consider the following aspects:

- How we communicate our requirements for Reactive Power.
- How the product is defined
  - what the requirement is: absorption, generation, availability, utilisation
  - the separate reactive regions
  - the timeslots in which we need availability of the service
  - how the requirement for the service may evolve due to asset investment, and
  - whether generating or absorbing, or both.
- What the pricing mechanism for the product should be (i.e. a pay-as-bid tender or cleared price auction).
- Whether we procure our requirements through separate regional markets.
- Where there are limited providers in regions, whether any price controls need to be in place, such as caps on pricing, or indexing prices to other better equipped regions.
- How to ensure barriers to entry are minimised and the market is as open as possible.
- Lessons learned from the Power Potential project.

Reactive Power

Case study: Power Potential Innovation Project

Power Potential is a Network Innovation Competition project we are running in partnership with UK Power Networks. The purpose is to demonstrate that distributed energy resources can address transmission network voltage requirements.

We will explore if this can be achieved through a market-based solution with coordination between the System Operator and distribution networks.

Trials will take place in the south east throughout 2019 to demonstrate how network operators and distributed energy resources can work together to achieve the best outcome for the consumer.

Power Potential will provide more information on the technical solutions and supporting market arrangements. Information on how to take part can be found in the Power Potential 'Guide to Participating' document[12].

We are keen to hear providers' views, both at the initial information workshop and by contacting us via our Future of Balancing Services email address: *box.futureofbalancingservices@nationalgrid.com*.

We will also work with providers to investigate how we should include the additional value of synchronous providers as a relevant system requirement and the value interaction between this and Reactive Power.

Synchronous generators are those directly coupled to the electricity system and not through an inverter. Most thermal and hydro electricity generation is synchronous. Interconnection, solar and wind generation is typically non-synchronous.

While both synchronous and non-synchronous providers can provide Reactive Power, synchronous providers contribute to the overall stability of the network. In particular, synchronous generators provide resilience against faults and disturbances on the system and ensure control systems function correctly. These needs have previously been discussed in technical detail in our System Operability Framework publications[13].

As the number of synchronous generators continues to fall, we expect a growing requirement for synchronous (or similar) capabilities. Given the inherent link between sufficient regional synchronous capability and safe, stable voltages across the network, we believe this requirement should be considered in the future design of Reactive Power markets. This should also use the lessons learned from Project Phoenix.

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

[13] https://www.nationalgrid.com/uk/publications/system-operability-framework-sof

Case study: Phoenix Innovation Project

Phoenix[14] is a Network Innovation Competition project led by Scottish Power Transmission with a number of academic and industrial partners including National Grid. Phoenix will demonstrate the design, deployment and operation of a hybrid-synchronous compensator.

This is a synchronous device which can provide Reactive Power and enhance the stability and security of the system. It will be installed in 2019, with technical and commercial trials due to last for one year. A key deliverable for this project is to explore the commercial and regulatory approach towards ownership of a hybrid device by a regulated network business.

Our ambition is to minimise the use of regional voltage constraint contracts, forward energy trades and the Balancing Mechanism as a means of indirectly accessing Reactive Power, which will also increase the transparency of our Reactive Power needs.

To achieve this, we see benefits in market participants offering prices based on the total cost of providing Reactive Power generation or absorption in a particular area, including any cost for active power produced to provide the service, and would be keen to receive feedback on this approach. This would move away from our current approach of first procuring active power to ensure a provider is available, and then procuring Reactive Power through ORPS.

At some times of the year, such an approach would be likely to create a clear difference in prices between those providers who must provide active power to provide Reactive Power, and those who do not. This could encourage 'wattless vars', and reduce the need for significant repositioning of both thermal and renewable generation in the Balancing Mechanism, reducing the cost to the end consumer.

[14] https://www.spenergynetworks.co.uk/pages/phoenix

Reactive Power

Case study: Product Scalars on 'wattless vars' in Ireland[15]

The Transmission System Operators (TSOs) in Ireland (EirGrid and SONI) are finalising arrangements for their new suite of ancillary services, known as DS3, which have been specifically designed to manage large amounts of non-synchronous generation (from wind and interconnection in particular) on the system.

Payment mechanisms in DS3 are based on each ancillary service being given a unit price and an overall budget. To incentivise flexibility, value for money, reliability and performance, the TSOs will use a range of product scalars, which have the effect of changing the unit prices.

The new Steady State Reactive Power (SSRP) product features a product scalar, so any provider instructed to provide Reactive Power at zero MW output will receive a scalar of 2 – i.e. twice the unit price for delivery of Mvar. This should encourage the industry to deliver technologies capable of 'wattless' delivery, which in turn should reduce redispatch costs ultimately borne by consumers.

To ensure we are looking at the full range of potential solutions providers could offer, by Q3 2018/19 we will publish an invitation for Expressions of Interest in the provision of a Reactive Power service to meet a requirement within South Wales. This will look for providers who are able and interested to provide a Reactive Power service in that region for some or all of the period April 2019 to April 2021.

We are currently developing the detail which will form the invitation for Expressions of Interest, however it will include:

- definition of the region
- reactive generation and absorption requirement
- service windows
- current spend managing reactive power requirements.

[15] http://www.eirgridgroup.com/site-files/library/EirGrid/DS3-System-Services-Enduring-Scalar-Design-Consultation-Paper.pdf

Chapter three

Engagement and next steps

Our next steps in the area of Reactive Power are:

- sending our proposal to remove ERPS to the relevant CUSC groups in Q3 2018/19, and our intent to work with industry to identify alternatives in Q4 2018/19
- setting out our concerns about ORPS in more detail, to the relevant CUSC groups in Q3 2018/19, and our intent to work with industry to identify alternatives, in Q4 2018/19
- holding an information workshop with interested parties in Q4 2018/19
- modifying the CUSC once alternative arrangements are in place
- publishing an invitation for Expressions of Interest in the provision of a Reactive Power service to meet a requirement within South Wales in Q3 2018/19
- working with DNOs to understand the specific considerations involved with setting, and meeting an agreed level of efficient Reactive Power transfer
- agreeing an implementation plan for operating within these levels by September 2019
- operating within these levels, where this is agreed as the most cost-efficient action, from October 2019
- establishing the transparency initiative, and updating the market on our plans, by Q4 2018/19.

We are keen to hear your views and feedback on what you read in this publication. We'll be holding engagement events later this year, but you can also send us your thoughts and comments via our Future of Balancing Services email address: *box.futureofbalancingservices@nationalgrid.com*

Continuing the conversation

Email us with your views on the Future of Balancing Services on:
futureofbalancingservices@nationalgrid.com
and one of our experts will get in touch.

Access our current and past documents, data and multimedia at:
https://www.nationalgrid.com/uk/electricity/balancing-services/future-balancing-services

Get involved in the debate on the future of energy and join our LinkedIn group
Future of Energy by National Grid.

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