Ancillary services report 2017

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Energy UK

The voice of the energy industry

Contents

Executive summary

The electricity network system in GB is undergoing significant reforms. There are a number of large thermal transmission connected generation assets which have either closed or will be coming off the system in the next few years, due to economic and environmental constraints. Some of this retiring capacity is being replaced by smaller distribution connected thermal generation, renewable sources and nascent alternative technologies. In addition, new ways of optimising and operating existing transmission connected assets will be required as load factors fall and the need to provide reliable flexibility increases.

Ancillary services are services and functions provided to the System Operator (SO) that facilitate and support the continuous flow of electricity so that supply will continually meet demand. The term ancillary services is used to refer to a variety of operations beyond generation and transmission that are required to maintain grid stability and security. In GB, this occurs after gate closure, when the SO will issue instructions that maintain the system's stability. Historically, these services have predominantly been provided by transmission connected generation, but more recently this provision has diversified, reflecting the changing plant mix and participation of the demand side within the GB electricity system.

As load factors of larger transmission connected power stations change, driven predominantly by economic and environmental pressures, we now see the need to reform the current ancillary services framework to enable users of existing and new technology to drive innovation within the sector. With a greater emphasis on a smarter, more flexible electricity system, Energy UK considers that changes to the ancillary services market are required to deliver a stable electricity system at least cost to consumers while facilitating decarbonisation.

In order to facilitate changes to the future system framework, it is important that the system adapts to deal with the flexibility and operability issues now emerging. The recommendations highlighted by Energy UK are set out on page 4.

Recommendations

Energy UK's Ancillary Services Working Group proposes the following recommendations are taken forward:

Priority	Issue	Solution
Short Term issues to be completed in the next 12 months	The ancillary services framework is in need of reform and a complete review of the current system should be undertaken to ensure it is fit for purpose.	National Grid to engage with industry groups, the investment community and new technology developers through workshops, consultations and webinars to review how ancillary services are procured in GB with the aim of consulting on proposals which should lead to the design of new more efficient and economical solutions to balance the network.
Short Term	The ancillary services market is largely designed around the current plant mix and does not fully utilise the potential range of services operating on the GB system today.	National Grid should: • Consider how new technologies and existing technologies used in new ways can actively participate in the ancillary services market and how effective competition between all participants can be facilitated. • Establish a set of non-discriminatory principles to benchmark future changes to the ancillary services market to ensure the market develops appropriately.
Short Term	The future vision for the ancillary services market is not clear.	National Grid to formally consult on future changes to the market in the System Needs & Product Strategy report and how ancillary services will need to evolve to ensure the market is aware of changes. Specifically, National Grid should: • Publish the System Needs & Product Strategy report. • Ensure there is a suitable forum to address areas highlighted in the report and discuss future changes to ancillary services with service providers.
Short Term	Transmission Connected Generators and suppliers are liable for (Balancing Services Use of System) BSUoS charges, which are calculated daily as a MWh tariff for each settlement period, which can vary considerably.	Energy UK to review the current charging base for BSUoS and agree an industry position to improve the cost reflectivity of the BSUoS.
Short Term	A new SO incentive framework (from April 2018) is needed to meet future challenges.	Energy UK to influence Ofgem's work on the new SO incentive framework and co-ordinate an agreed industry view on its future development.
Medium Term issues to be completed in the next 12 - 24 months	The accessibility and transparency of ancillary services information is currently limited with market information spread across the National Grid website, and some not available at all.	Following a review of the short term priority issues National Grid should: • Develop an updated website where ancillary service data can be accessed easily by all market participants. This should coincide with the separation of the SO function within the National Grid group. • Publish details of expenditure with regards to bilateral trades, all non-locational services, trial services and where it is possible, locational services (constraints) should be also visible to the market.

Recommendations (continued)

Priority	Issue	Solution
Medium Term	The ancillary services framework is in need of reform and a complete review of the current system should be undertaken to ensure it is fit for purpose.	National Grid to begin implementation of the recommendations coming out of the engagement with industry groups and stakeholders by the start of 2018.
Medium Term	Services and power provided via interconnectors is treated differently from GB counterparts creating an un-level playing field.	Ofgem and the UK Government should ensure that: • Participation in the GB ancillary services market by overseas providers and interconnectors is consistent with European regulations and the Clean Energy Package. • Service providers in GB compete on a level playing field with service providers in other countries by ensuring that GB generators (and other providers) are not exposed to higher network charges and policy costs.
Medium Term	It is desirable to optimise market revenue streams so that these markets complement each other, allowing service providers to factor in other revenue streams when competing for contracts.	Energy UK to lead the debate on future power market design. This will include the interactions of the Capacity Market, low-carbon support mechanisms, and the ancillary services market to ensure least cost options for balancing the system are identified and developed. However, this must be achieved without undermining the creation of a level playing field.
Medium Term	Local balancing and ancillary services need to be considered with an appropriate framework established to facilitate greater independence of the SO as well as the Transmission/Distribution interface.	Future structure of system balancing arrangements to be developed between National Grid, industry and the Electricity Networks Association TSO-DSO project and ensure its timely implementation. It is crucial that the scheme allows more long term development, rather than focusing on short term priorities while ensuring BSUoS volatility is minimised.
Medium Term	Ofgem has proposed a legal separation of the SO to ensure that there is sufficient focus on its increasingly complex role and to address any actual or perceived conflicts of interest between National Grid's SO functions, TO functions and other business interests.	To support the legal separation of the SO and ensure that the current and future proposals for the governance of the SO provide value for GB consumers.
Long Term issues to be 24–48 months	Local balancing and ancillary services need to be considered, with an appropriate framework established to facilitate greater independence of the SO as well as the Transmission/Distribution interface.	Optimal structure for DSO/SO interface to be fully implemented.

Who decides what's needed to manage the system and how?

System operability

System operability is the ability to maintain system stability and operate within pre-defined limits safely. Changing demand and supply patterns, combined with the location and performance of generators, affect the operability of the system. The increasing volume of non-synchronous generation connected to the system is creating challenges for the current operation of the system. With the forecast increase in generation connected at distribution network level, this is expected to have a larger impact in the future. In recent years, several issues have begun to affect the operability of the system such as increased intermittent generation, falling levels of inertia, system constraints and the loss of traditional service providers. We consider that the situation will only become more complex and expensive to manage if not addressed proactively.

It is the responsibility of National Grid as the SO to maintain the stability and operation of the system, which requires it to consider how to address the changes that are now manifest. National Grid publishes the System Operability Framework[1] (SOF) annually, outlining the future system requirements. The SO has developed various procurement processes and tenders over time in order to incentivise market participants to provide the extra capabilities that are required to maintain system security.

National Grid 2016 System Operability Framework

The November 2016 SOF outlined the changes in system parameters and performance that are forecast as a consequence of the changes in the generation mix, demand characteristics, new technologies, and new market and industry governance arrangements. It uses National Grid's Future Energy Scenarios to inform the analysis of different potential scenarios that could impact on system operability. The SOF identified three key messages around:

1. Balancing and flexibility;
2. Frequency and voltage management; and
3. Co-ordination for the whole system[2].

A summary of the 2016 SOF can be found in the Annex of this report.

Key principles that an ancillary services market should uphold

Since 2000, the SO has managed the stability of the GB electricity system largely by procuring services via bilateral contracts and tenders. There has been significant change in the contracting process used by National Grid with a move away from bilateral contracts to tendered services for the majority of energy based products. Location based services (constraints and black start) are agreed on a bilateral basis where there are potentially insufficient volumes of competition.

This issue was highlighted in 2016 when National Grid signed additional contracts with Drax and Fiddler's Ferry for black start services. National Grid considered that the contracts were required due to the non-forecast announcements of closure or mothballing by a number of thermal power stations in February 2016 as a result of unfavourable market conditions. This process highlighted that there has not been adequate development of a long-term market for ancillary services such as black start contracts. Should future contract negotiations continue to be agreed bilaterally, without reform, this approach could have a significant impact on the Government's policy position on ensuring all unabated coal plant should close by 2025 and longer term impact on affordability for customers.

It should be noted that the growth of distribution connected generation and demand providing services are included in procurement methodologies and have a significant presence in several services (e.g. Fast Frequency Response (FFR) and Short Term Operating Reserve (STOR)) providing significant value for customers.

Further increases in distributed generation, flexibility, smarter networks, and opportunities for Demand Side Response (DSR) and storage mean that a review of the future framework for an ancillary services market would be timely. A review should aim to reflect benefits captured by the changing energy mix and provide system stability at least cost to consumers.

The wholesale energy market should be capable of providing the bulk of energy balancing through forward trading ahead of gate closure with the SO only procuring ancillary services required within the settlement period. The SO should avoid procurement mechanisms that unnecessarily dampen or otherwise interfere with the efficient operation of the wholesale market.

We therefore consider that the following key principles should form the basis for the current and future ancillary services market:

Competitive and market based – The procurement of ancillary services must be market based to maximise inclusiveness. This will ensure that services are procured at least cost, so as to maximise the benefit to consumers. Services should be procured through optimal market structures which could include tendering for long term contracts, or shorter term auctions/markets. Where possible, long term bilateral contracts are to be avoided. A tender which bundles multiple flexibility services has some advantages through revenue stacking, but there is a risk of introducing complexity to the tendering process.

Transparent - Ensuring that markets are transparent, that future demand requirements are clear and quantified and that procurement is rationalised will allow developers to take account of the value of ancillary services when new projects are at the design stage, as well as when securing finance. There should be equal visibility of all non-location services from procurement to instructed and delivered energy to facilitate competition.

Level playing field – All technologies and services should be able to compete for ancillary services on a level playing field, with consistent rewards and obligations for all providers to ensure the least cost options are developed and allow all technologies to compete, regardless of size or type. The framework should deliver the service that is required at a competitive cost from both existing participants and new entrants.

Fit for the future – The ancillary services market should be designed to facilitate the evolution of the energy system and should be constantly evolving to meet this challenge. This should include the potential for innovation by offering the ability for new technologies, as well as existing technologies used in new ways, to participate in the market without undue barriers to entry. This can be achieved by keeping service design as simple as possible, to avoid incorporating into the design assumptions about the technologies used to provide them[3].

Areas of concern for Energy UK with the current ancillary services market

Transparency

National Grid states that 'In contracting for the provision of Balancing Services we will purchase from the most economical sources available to us having regard to the quality, quantity and nature of such services at that time available for purchase.' There is, however, a variation in the level of transparency regarding the process by which National Grid selects the service providers offered contracts for ancillary services provision.

National Grid provides regular market reports relating to the procurement of all non-locational services (STOR, FR and FFR). In addition, for locational services, information about the provider and the services contracted is published on the relevant web site. All instructions for energy relating to Balancing Market (BM) plant are available in real time via the BM Reporting systems and post event delivered volumes are available. There is limited market visibility of instruction or delivered energy relating to non-BM, bilateral agreements and aggregation services that needs to be addressed, with data made available in a standard way to inform the market of the delivery of services, including instructed and delivered energy, and to facilitate competition in this market segment, given it is not subject to central settlement metering. There should be full transparency of all non-locational services and, where it is possible, locational services should be also visible to the market.

Regulatory codes and standards relating to what capabilities National Grid expects the service provider to have and what capabilities it will ultimately procure could be improved to provide clarity to the market. Information such as this is essential for market participants to make informed choices regarding which aspects of the ancillary services market are best pursued. Inefficient decision-making by market participants arising from this lack of transparency risks driving up costs for the end consumer. In addition to this lack of transparency, there is a range of differing procurement procedures for different services, with National Grid's Procurement policy for ancillary services[4] offering contracts over varying timescales either by competitive tender or bilaterally.

It is not clear that the range of services, and the criteria for providing them, are fully reflective of the needs of the system, as opposed to simply having evolved from whichever services may more easily be provided by large-scale, transmission connected, thermal plant. National Grid is currently reviewing the range and scope of services that it will need going forward and that will be appropriate for the change in market conditions.

Any new ancillary services framework should seek to capitalise on the value which all potential providers of services can bring, including new entrants, distributed plant, existing providers used in new innovative ways, demand response providers and nascent technologies such as battery storage, as well as the benefits provided by existing assets. A fair and level playing field should be in place to ensure effective competition between all balancing service providers; the resulting cost to the end consumer of energy delivered from aggregators, distributed connected generation or transmission connected generation should be the same.

Interconnectors' participation in the ancillary services market

Some of the future interconnector projects will connect GB to mainland Europe and the size of these proposed links means that a large and fast change in interconnector flows driven by wholesale market price swings could have an impact on the GB system, but would be negligible to the European system due to the different characteristics of the mainland Europe network compared to the GB system. Overseas generators pay network charges according to the rules in their native country and are not necessarily liable to pay exactly the same charges that GB transmission users are subject to.

When ancillary services that result in a change in MW flows are provided via an interconnector, payments are made to an interconnector owner and also to overseas generators through payments to remedy the imbalance caused in those markets by the provision of the ancillary service. Project TERRE[5] will provide a "shared platform" such that overseas generators may compete and be remunerated for ancillary services more directly, however, while the network charging regimes, for example (TNUoS and BSUoS charges) and carbon costs differ between GB and European service providers, GB service providers could be disadvantaged as they may be unable to compete on equal terms.

Interconnectors can also provide other ancillary services such as reactive power that do not require a change in MW power flows across the interconnector. The emphasis should be to ensure that GB service providers pay an equivalent level of system charges with European service providers. The overall aim should be to ensure the least cost options for consumers are secured once all costs for providing the services have been taken into account.

Optimisation of value streams

There are two areas where it could be beneficial to optimise value streams for the ancillary services market:

- Revenue stacking products within the ancillary services market give service providers the ability to factor in revenue from multiple services to potentially reduce the overall cost of providing services. The SO will need to ensure in the procurement methodology that mutually exclusive services cannot be stacked.

- The design of the future energy market needs to ensure that the main electricity revenue streams which make up the GB electricity market (capacity, low carbon, ancillary and wholesale) complement each other and allow market participants to factor in revenue from across these markets when competing to provide different services.

- The length of ancillary service contracts is another important consideration; longer contracts do help to support new investment but may carry the risk of locking in high costs to be borne by customers, although high costs can occur if provision is left to the spot markets too. A balanced approach of both long and short term contracting is required. A simple, stable, and transparent short-term market for services may also help to support certainty among investors, as occurs in the New Zealand market[6].

It is essential that any such optimisation of revenue streams does not lead to unintended consequences, such as undermining the level playing field between service providers.

Nascent technologies

Intermittent renewable energy, storage and DSR as well as other nascent technologies have significant potential to provide ancillary services. These include frequency response with varying degrees of response time, from the standard Primary, Secondary and High response to very fast response such as synthetic inertia. It is important to ensure that the technical capability of these technologies is recognised, if the SO is to make full use of them to balance the network at least cost. The changes needed to facilitate this market include reforming procurement arrangements, engineering standards and the length of contracts.

As an example, historically, inertia has been a characteristic of the system that defines how much energy is available in the rotating masses of all machines that are directly coupled to the system to instantaneously balance a small surplus or deficit in power. There will be a continued need for some level of inertia on the power system for the foreseeable future, whether this be through traditional thermal plant or other technologies such as flywheels.

There are, however, increasingly opportunities for the delivery of so called ‘synthetic inertia’ by batteries, loads, and non-synchronous generators such as renewables. Synthetic inertia is the delivery of power by the ultra-fast response of power electronics associated with non-synchronous generation, load or storage, rapidly adjusting the net power provided to the system in response to sudden frequency changes.

Synthetic inertia can minimise the quantity of inertia required to be held by the system (although this cannot currently replace the requirement). There is ongoing academic interest in the development of theoretical methods, but a practical solution is yet to be demonstrated. Measurement and processing times could be reduced, but it is necessary to ensure that any response would not be erroneously triggered by local or transient conditions.

The provision of synthetic inertia is likely to be in greatest demand at times when few traditional large generators are running. With this in mind, it is essential that barriers to entry are removed for providers of synthetic inertia and other fast frequency response services, and that steps are taken to maximise the value that can be offered by these providers. As part of this process, the SO will need to determine what are the technical and commercial trade-offs between holding inertia and fast frequency response (including synthetic inertia), as well as determining what is the minimum quantity of inertia required to safely and securely operate the system.

Utilising existing technologies in new ways

Existing large scale generation is likely to be run at significantly reduced load factors and has the capacity to adapt in the ways it provides ancillary services. Large generators by their nature provide inertia as part of their operation, which is not a service that is rewarded. Large generators also have the ability to energise a significant length of transmission line following a black start event. Retrofitting steam injection to a CCGT to enable existing generation to deliver frequency response in faster time lines is typical of the innovation required in this sector. The SO procurement methodology should recognise that, in some cases, a cheaper cost effective solution would be to utilise existing generation in new ways and this would be a low cost option for the consumer.

Level Playing field

Creating a level playing field between all providers of ancillary services is important to ensure that least cost solutions for balancing the network are procured. This includes charging arrangements[7] for distribution and transmission connected services, the treatment of interconnectors, different non-delivery exposures and additional income when providing energy services through ‘spill’ payments. We note that work is already being taken forward through a Connection and Use of System Code (CUSC) modification under CMP275 to introduce a principle whereby units are not paid twice for providing the same service.

Balancing and Settlement Code modification P354 has been raised to give the SO the ability to remove the imbalance volumes that a supplier receives following the delivery of ancillary services energy by non-BM plant. This is seen as a key change required to facilitate completion between provider groups. Work will be needed to ensure the rules and metering are appropriate across all technologies and sizes.

Additionally, there are several barriers to entry that must be addressed such as constraints and congestion management that currently reduce competition across ancillary services. Connecting to the network is difficult, with numerous locations around the country now at full capacity on both the distribution and transmission networks. Work to build new infrastructure should be taken forward with DNOs and TOs sharing data on where connection capacity is impacted across network boundaries to ensure the investment case is clear.

System operation

Ofgem consulted on the future design of system operation in GB early in 2017, proposing a legal separation of the SO within National Grid to allow the SO to play a more proactive role in managing a more flexible electricity system. How this interacts with 'Distribution System Operators' (DSOs) performing local balancing will need careful consideration to ensure optimum value may be delivered from the different levels of the network, and that conflicts of interest are avoided. Clarity is needed regarding the future structure of the SO and its interaction with DSOs. Designing this structure will be important to ensure industry can provide the services and flexibility that future networks require. This process should be led by Ofgem/BEIS in full consultation with the SO and Distribution Network Operators (DNOs) as well as current and future service providers. The Electricity Networks Association (ENA) has set up a TSO – DSO project which is aimed at providing clarity at the interface between networks. There are four work streams which include:

1. Develop improved T-D processes around connections, planning, shared TSO/DSO services and operation;

2. Assess the gaps between the experience our customers currently receive and what they would like and identify any further changes to close the gaps within the context of 'level playing field' and common T & D approach;

3. Develop a more detailed view of the required transition from DNO to DSO including the impacts on existing organisation capability; and

4. Consider the charging requirements of enduring electricity transmission/distribution systems.

Engagement with industry and timely delivery of these work streams will benefit the future design of the system which will be important as the upcoming RIIO ED-2[8] and SO incentive schemes will set the reward structure for future DSOs and the SO in GB. Consideration is required to ensure local ancillary services can be implemented in a timely manner and ensure the SO facilitates and utilises such markets in conjunction with DSOs. Clarification is also required regarding the interaction, role and responsibility of the central body, which may be required to oversee the ultimate control of system security.

The SO must be provided with greater transparency of generation assets located on the distribution network to allow it to efficiently and securely manage the system (see the SOF for more details on the challenges posed by greater volumes of distribution connected generation). The method by which increased transparency is delivered should be proportionate and improve the means by which these assets can potentially compete for Balancing Services.

Engineering requirements

The engineering requirements for transmission and distribution networks are being updated as part of the EU Network Code implementation process. There are areas that require further investigation in terms of the treatment of new technologies and how system redundancy can be managed to take advantage of a smart, dynamic network that can actively manage changes to demand/generation without the need for physical reinforcement of the networks.

Cost of products

The costs for contracting and utilising ancillary services are recovered through Balancing Service Use of Systems (BSUoS) Charges. The BSUoS charge recovers the cost of day-to-day operation of the transmission system. BSUoS is set as an ex-post charge, on a half-hourly basis. National Grid provides a monthly forecast of BSUoS as part of the current Monthly Balancing Services Summary (MBSS) report and publishes historical charges. BSUoS charges are however highly volatile, with National Grid finding them difficult to forecast accurately. BSUoS costs are recovered on a half-hourly basis from both transmission connected generation, with the exception of interconnector flows, and demand (split 50:50) on the basis of metered volumes. BSUoS charges are billed on Settlement Final (SF) data and reconciled on Final Reconciliation Volume (FRV) data. Generators and suppliers are liable for these charges, which are calculated daily as a flat tariff for each settlement period across all users. Further work to improving the transparency of BSUoS needs to be taken forward.

Future ancillary services market design

The future design of the ancillary services market will be essential to facilitating the transition to a low-carbon electricity system, in which variable renewables, storage and Demand Side Response (DSR) and other nascent technologies will play an increasingly significant role. As deployment increases, so will the need for flexibility to balance demand and supply whilst efficiently ensuring system security across all time horizons, from seconds, hours and days to seasons.

It is essential that all areas of the ancillary services market are open to all potential providers of services including new generation technologies and business models, to ensure that innovation can take place. This should complement the direction of travel highlighted through the BEIS/Ofgem flexible, smart energy system call for evidence.

Annex

Summary of the 2016 SOF

Balancing and flexibility

The SOF highlights that future growth of interconnection and continued growth of distributed generation are having an impact on the operation of the system in terms of balancing and flexibility.

- Transmission system demand is becoming more variable as distributed generation and weather-dependent output grows. Lower transmission system demands are experienced for more of the year and the lowest value decreases over the decade.

- Additional balancing actions are required to ensure sufficient flexibility when large generators are displaced by small generators. More flexibility is needed from small generators, demand, interconnectors and nuclear plant.

- Users of the power system must become more flexible in terms of synchronising, de-synchronising and load following throughout the day.

- Flexibility and operability must be considered holistically across active and reactive power requirements to determine efficient solutions, which illustrates the need for product bundling.

There are risks associated with simultaneous interconnector ramping capability and there is a need for flexibility to cope with future increases.

Frequency management

Frequency is the number of alternating current cycles per second of the power system; the optimum frequency for the system in Great Britain to run is 50.00Hz. The rate at which frequency changes following a loss of generation or demand depends on the total amount of energy stored in the inertia of rotating masses and the amount of 'synthetic inertia' being provided to the system, although it should be noted that SOF highlights that inertia is distinct from the fast injection of active power after a measurement delay (synthetic inertia).

The SOF highlighted several key messages with regard to system frequency

- Frequency is more volatile when system inertia is low, which occurs more often.

- System inertia must not fall below a specified limit to avoid the unwanted disconnection of distributed generation in the event of a frequency disturbance. The limit cannot be relaxed until generator protection settings are changed or relays are replaced, which needs to be coordinated across the industry.

- Inertia is distinct from the fast injection of active power after a measurement delay, often referred to as synthetic inertia.

- Static response cannot replace the dynamic response requirement.

- Flexible low Stable Export Limit (SEL) plant is highly valuable.

- A review of frequency response services would facilitate more efficient development of frequency management solutions.

Voltage management

Voltage management facilitates the transfer of active power economically, efficiently and safely across the transmission and distribution networks. Voltage levels must be controlled within an acceptable operational margin across the whole system. The transmission system is operated so that voltage levels remain within the normal operating ranges defined within the Grid Code. This is ±5% at 400kV and ±10% at lower transmission voltages. The ranges for distribution networks are similarly defined in the Distribution Code. Importantly, voltage is a localised property of the system and is affected by changes in the network itself, which means that requirements vary from one region to another. Active power (measured in MW) provides consumers with their energy needs (e.g. supplying a kettle heating element to boil water). Reactive power (measured in MVAr) is required to transfer active power across the network.
Regional system strength will be lower and more variable when limited synchronous generation is running. The greatest requirements for additional voltage control occur at these times:

- the largest decreases in system strength occur in regions where large plant closes or where it is unlikely to run when transmission demand is low;

- existing network protection approaches may not be able to identify faults when system strength is low;

- additional reactive power absorption is required in most regions to manage high volts. Additional reactive power generation is required in regions where power flows are large and volatile;

- of the growing requirement for voltage control resources, a greater proportion must be dynamic in order to follow the daily reactive load profile and ensure voltage containment and recovery after a disturbance.

Whole system co-ordination

The SOF highlighted that the SO is finding it increasingly difficult to manage the system as the result of an increase in the number of 'moving parts'. Understanding the capabilities and behaviour of generation, demand and networks is key to operating the whole system and this is becoming more difficult to predict. In particular, the SOF isolates key concerns below:

There is uncertainty in balancing and operability, in planning timescales and in real-time as a result of SO's increasing lack of visibility of generation output across the system as a whole;

- Active network management facilitates quick and economic connection to constrained networks. If not coordinated, it can increase uncertainty and restrict market access for potential providers of flexibility;

- Distributed energy resources have the potential to deliver enhanced transmission system voltage control through the application of new control approaches;

- The function of low frequency demand disconnection is not guaranteed to be effective in the future due to changing power flows caused by distributed generation growth;

- There is an ongoing requirement for Black Start capability in light of recent closure of plant that traditionally provided this capability.

A whole systems approach and why it's important that ancillary services are included

Recent developments in the electricity industry have resulted in a market which consists of four main components:

- **wholesale market** - Electricity traded through power exchanges
- **capacity** - Capacity Market is the main tool for capacity payments in GB
- **low carbon** - Feed-in-Tariff, Renewable Obligation and Contracts for Difference.
- **ancillary services** - Costs of balancing the network.

Currently, each of these components is run independently, with policy and direction set by different parties, whether that be BEIS, Ofgem or National Grid. There is limited (no) overview looking at the cost of all of the components together and how they interact. We believe that this results in a less efficient power market, which in turn results in higher costs than necessary. This is against a backdrop of increased costs for balancing the system (as a result of growing ancillary services) which are forecast to rise significantly over the coming years. To keep up with the changing nature of the system, reforms will be required in all areas.

Bringing all of these markets together to view the system holistically will create an opportunity to produce and deliver electricity more efficiently, which will result in lower consumer costs. The value of each market should be realised to allow developers and operators to access the market at least cost. Ancillary services are one element of the system that needs to be reformed to allow the most efficient future power market design to be realised.

Overview of existing Ancillary Services

Ancillary Services refers to a range of functions which the SO uses to ensure system balancing, stability and security; for example, if the frequency of the system is dropping, National Grid has created numerous services that market participants can offer to compensate for the drop in frequency.
This section gives a broad overview of the different Ancillary Services contracted for by National Grid. Ancillary Services are increasingly playing an important role going forwards, both with regard to supporting system operability and managing decreasing capacity margins. This section is designed to offer a broad introduction to each of the Ancillary Services available. For a detailed explanation of each please follow the links to the relevant part of the National Grid website.

It must also be recognised that many of the service requirements met by the above products are also met by taking bids and offers in the BM including on forward 7A Trades[9]. Balancing services and the BM cannot be considered in isolation from one another.

Frequency Response

National Grid has a Licence Obligation to control frequency at a level of ±1% of nominal system frequency (set at 50.00Hz) except in exceptional circumstances. National Grid must therefore ensure that sufficient generation and or demand-side response is held in readiness to manage any events which may occur and lead to frequency variation. Maintaining frequency is essential to ensuring both demand and generation installations are able to operate within safe parameters.

Frequency Response is provided either on a Dynamic or Non-Dynamic basis. In the former, loads automatically regulate themselves in response to second by second changes in the system frequency. In the latter, the service is triggered at a defined frequency deviation. Frequency response products are provided either through the mandatory requirement, or through a commercial arrangement under 'firm frequency response', 'frequency control by demand management', 'enhanced frequency response', or bespoke bilateral deals:

- **Mandatory Frequency Response**
  Transmission-connected generators are generally required to be able to offer frequency response services to National Grid, as a condition of connection (although some sites are able to apply for derogation). Generators bid in to provide the service, and successful generators receive holding payments (made for making a unit available in frequency response mode) and response energy payments which remunerate for the amount of energy delivered to and from the system when providing frequency response. Although the majority of transmission-connected generators are technically able to provide frequency response, it may be technically or financially undesirable for some generators to offer the service. Therefore, some generators submit high holding prices with relative certainty that this will prevent them being called upon.

- **Firm Frequency Response (FFR)**
Firm Frequency Response (FFR) is the firm provision of Dynamic or Non-Dynamic response to changes in Frequency. Unlike Mandatory Frequency Response, FFR is open to BMU and non-BMU providers, existing Mandatory Frequency Response providers and new providers alike. National Grid procures the services through a monthly online tender process. Following a pre-qualification assessment, FFR providers can access the electronic tender platform where they may tender for single or multiple months. To provide FFR, a plant must choose to run part-loaded, the FFR payments cover the cost of making this choice. Payments are made on an availability basis, with additional payments for dispatch. As with mandatory frequency response, services are split into primary, secondary and high. National Grid currently has the greatest need for Secondary Firm Frequency Response.

National Grid will accept the most economical tenders, with reference to the 'quality, quantity, nature of the services'. There is little information regarding the criteria used to make such a decision however.

- **Firm Frequency Response Bridging**
A sub-category of FFR is FFR Bridging[10]. This allows smaller Demand Side Providers and other small parties to secure a contract within which to develop a portfolio of new FFR volume. The aim of the contract is to address the current arrangement that limits the entry into the FFR tendered market to parties who already have 10MW or more of contracted volume. It is clear that it is possible for Demand Side Providers to achieve this level of volume over time, however there is no route to market for this volume until 10MW has been achieved. This contract aims to bridge this gap and reduce the barrier to entry into the FFR market. The FFR Bridging contract is for a set term of one or two years, with a mandated price per MW that is dependent upon the type of service being provided (e.g. Secondary, Primary + High, etc.) and which increases as more MWs are aggregated.

- **Enhanced Frequency Response**
Enhanced Frequency Response is a new service which requires providers to deliver a dynamic response, reaching 100% of the proportionate active power output within 1 second of a frequency deviation. This is in contrast with existing frequency response services which can have timescales of up to 10 seconds, or 30 seconds (depending on the service). Results for the EFR tender were announced in August 2016, with 201MW of capacity procured from 8 storage sites. Bids were accepted on the basis of leading to minimum costs for National Grid.

For more information, see here: **www2.nationalgrid.com/UK/Services/Balancing-services/Frequency-response/Firm-Frequency-Response/**

- **Frequency Control by Demand Management (FCDM)** Frequency Control by Demand Management (FCDM) provides frequency response through interruption of supply to parts of consumer load which have contracted to offer this service. The demand customers that provide the service usually contract on the basis of supply being interrupted for a maximum of 30 minutes. Statistically, interruptions are likely to occur between approximately ten to thirty times per year. FCDM is required to manage large deviations in frequency which can be caused by, for example, the loss of significantly large generation. FCDM must have a minimum capacity of 3 MW (which may be the product of multiple aggregated sites). This service is procured through bilateral negotiation between providers and National Grid.

For more information, see here: **www2.nationalgrid.com/uk/services/balancing-services/frequency-response/frequency-control-by-demand-management/**

- **Reserve**
National Grid needs the ability to source extra power either in the form of increased generation or demand turndown, in order to deal with unforeseen demand increase and generation unavailability. The current range of reserve services is made up of products that require differing response times so that operating reserve levels can be maintained. There are a number of different reserve services:

- **Fast Reserve**
The service provides the rapid delivery of active power via increased generation or reduced demand within two minutes of instruction. Once instructed the provider needs to be able to sustain output for a minimum of 15 minutes. The minimum size of instruction is 50 MW for a single unit. Fast Reserve may be provided as either a Firm service or Optional service, with the Firm service subject to a tender process. Tenders are assessed with reference to expected costs, plant performance, and possibly constraint implications and interactions with other providers. There is limited clarity regarding how these assessments are made.

- **Short Term Operating Reserve (STOR)**
  The STOR service can be provided by either generation or demand assets. Those that are a BM unit, or part of a BM unit, can be dispatched through the balancing mechanism (BM STOR) and those which are not a BM unit are dispatched outside the balancing mechanism (non-BM STOR). BM STOR is predominantly offered by OCGT plant (with a small amount of pumped storage and CCGT participating). Non-BM STOR is offered by a wide range of different technologies including diesel generation, OCGT, and DSR. In 2014/15, the majority of STOR capacity was non-BM STOR[11] . The minimum volume required is 3 MW, which can be provided from either a single site or an aggregation of sites – approximately 20% of STOR volume is contracted via an aggregator. Delivery needs to be within 20 minutes of instruction and should be able, if needed, to maintain full output for at least two hours. Procurement is via a competitive tender process with services being provided on either a committed or flexible basis, with three tender rounds per year. There is limited information available regarding the basis on which the tenders are assessed.

- **Operational**
  This was a trial held in the second half of winter 2015/16 through which National Grid was able to procure up to 300 MW of additional reserve capacity. This was in response to a NISM (now called Electricity Margin Notice) being called in early November, and a number of DSR providers noting that they had additional capacity, but no route to market.

- **STOR Runway**
  This is a new development in the reserve market, and is currently in the trial phase. STOR Runway is designed to offer the opportunity for new Demand Side Providers to secure a STOR contract ahead of construction of new STOR plant, and for Providers to secure STOR contracts for plant that they have yet to contract with.

For more information, see here: **www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=8589935929**

- **BM Start-Up**
  This product is procured to make sure that National Grid has on-the-day access to additional generation BMUs that would not otherwise be available in Balancing Mechanism timescales. The product is required to maintain contingent generation reserves in excess of forecast demand and to meet on-the-day demand plus reserve requirements. Procurement is conducted through bilateral commercial services agreements. Two elements exist to the product. The BM Start-Up product is for the provision of 'energy readiness' capabilities that can be converted into energy utilisation if required. The second part of the product is Hot Standby: a contractual agreement to hold a generator in a 'state of readiness' once a start-up request has been made. BM Start-Up Contracts are made bilaterally between the generator and National Grid.

For more information on Reserve Services, see here: **www2.nationalgrid.com/UK/Services/Balancing-services/Reserve-services/Demand-Turn-Up**.

- **Reactive Power**
  Reactive power describes the background energy movement in an Alternating Current (AC) system arising from the production of electric and magnetic fields. Devices which store energy by virtue of a magnetic field produced by a flow of current are said to absorb reactive power; those which store energy by virtue of electric fields are said to generate reactive power.

- The flows of reactive power on the system will affect voltage levels. Unlike system frequency, which is consistent across the network, voltages experienced at points across the system form a 'voltage profile', which is uniquely related to the prevailing real and reactive power supply and demand. National Grid must manage voltage levels on a local level to meet the varying needs of the system. Without the appropriate injections of reactive power at correct locations, the voltage profile of the transmission system will exceed statutory planning and operational limits.

- **Obligatory Reactive Power Service (ORPS)**
  The Obligatory Reactive Power Service (ORPS) is the provision of varying reactive power output. At any given output, generators may be requested to produce or absorb reactive power to help manage system voltages close to its point of connection. All generators caught by the requirements of the Grid Code are required to have the capability to provide reactive power.

- **Enhanced Reactive Power Service (ERPS)**
  Enhanced Reactive Power Service (ERPS) is the provision of voltage support which exceeds the minimum technical requirement of Obligatory Reactive Power Service, or reactive power capability from any other plant or equipment which can generate or absorb reactive power but is not required to provide the Obligatory Reactive Power Service. ERPS is contracted by means of competitive tender, however there is little information available as to how National Grid assesses the merits of different tenders. There is little interest in this service as the total funding for reactive power provision is capped.

For more information on Reactive Power, see here: **www2.nationalgrid.com/uk/services/balancing-services/reactive-power-services**

- **Black Start**
  Black Start is the procedure to recover from a total or partial shutdown of the transmission system. Most power stations need an electrical supply to start up. Under emergency conditions, Black Start stations would receive this supply from small onsite auxiliary generation. Procurement usually takes place via National Grid expressing interest to a new provider during their connection agreement negotiation. National Grid may also express interest in determining the feasibility of retro-fitting the capability. Black Start contracts are arranged bilaterally between the generator and National Grid, and can only be held by a transmission-connected plant. With recent closures of coal generators, the number of Black Start capable plant on the grid is dropping. In future, low-carbon alternatives will have to replace this role within the grid. Different opportunities for the future of Black Start are considered here: **www.smarternetworks.org/NIA_PEA_Docs/MOTTS_FINAL_Black_Start_Alternatives_Approaches_-_151102093125.pdf**

- **Contingency Balancing Reserve**
  Two new balancing services were introduced to address security of supply during times of low system margin. These are Demand Side Balancing Reserve (DSBR) and Supplementary Balancing Reserve (SBR). It should be noted that these services have been withdrawn as the Capacity Market delivery date has been moved forwards to winter 2017.

- These are widely seen as examples of what not to do in terms of procuring services – specifically:

- (a) The artificial split between SBR and DSBR prevented competition between technologies to provide equivalent services, and

- (b) The rushed tender resulted in a non-market mechanism distorting the market and costing significant amounts of money.

- **Demand Side Balancing Reserve (DSBR)**
  DSBR is targeted at non-domestic consumers able to reduce/shift demand or run 'behind-the-meter' standby generation, and owners of small embedded generation or storage accruing to a supplier's consumption account. It can be provided by non-domestic consumers directly or by third parties, including suppliers, aggregators or other intermediaries. In the event there is insufficient plant available to meet demand, consumers signed up to the scheme may be asked to reduce demand on the transmission system in return for a payment. It is not intended for those consumers who already reduce/shift demand or run embedded generation during peak times on winter weekday evenings in response to pricing signals (e.g. Triad avoiders).

  Those with committed STOR contracts for these winters cannot participate. The declared capability of a DSBR Unit must be >1MW, which may include an aggregation of smaller sites. DSBR is awarded by tender, however with little transparency regarding how tenders are assessed. National Grid has announced that it will not be contracting any DSBR for winter 16/17, because a 'minimal volume would be available across this period'. It is unclear what information was used to come to this decision, or the likely impacts this could have on (often nascent) firms that operate on the Demand Side.

Supplemental Balancing Reserve (SBR)
SBR is targeted at power stations that would otherwise not be available to the market or the SO. This may include plant that has closed or is intending to close or mothball, or will be exiting the market. This plant would be held in reserve outside the market, ready to respond in the unlikely event that it is needed. All providers must be able to deliver their SBR capability within Balancing Mechanism (BM) timescales (< 89 minutes notice), or be able to be made available in BM timescales via a BM Start-Up / Hot Standby instruction such that the full contracted SBR capability can be delivered. Under an SBR contract, plant would be required to be available on weekdays between 6am and 8pm from the beginning of November to the end of February.

Plant contracted under SBR will be prohibited from participating in the markets for energy and other balancing services for the entire duration of the contract (not just the winter availability period within the term of the contract). SBR providers would not be required to hold Transmission Entry Capacity (TEC) in order to deliver SBR capability to the transmission system but would be granted, to the extent necessary, sufficient transmission access rights under the SBR contract whenever the SBR plant is dispatched. SBR contracts are awarded by competitive tender, primarily on a price basis – however it is not clear what other considerations are taken into account.

For more information on Contingency Balancing Reserve, see here: **www2.nationalgrid.com/UK/Services/Balancing-services/System-security/Contingency-balancing-reserve/**

- **Demand Turn-Up**
  Demand Turn-Up is a new service designed to encourage large energy users and embedded generators to either increase demand (through shifting) or reduce generation when there is excess energy on the system – typically overnight and during weekend afternoons. Demand Turn-Up has been developed to allow demand side providers to increase demand (either through shifting consumption or reducing embedded generation) as an economic solution to managing excess renewable generation when demand for electricity is low – typically overnight and during the middle of the day on weekends and bank holidays. Demand Turn-Up is contracted on a bilateral basis.

  For more information, see here: **www2.nationalgrid.com/UK/Services/Balancing-services/Reserve-services/Demand-Turn-Up/**

- **Commercial and Obligatory Inter-Trip**
  The intertrip is a service where generators agree to curtail/deload/disconnect from the grid in response to certain events (usually a fault on specific transmission lines). The need for this service is determined by National Grid at the connection stage (which normally feeds into the Bilateral Connection Agreement as "Mandatory Inter-Trip"), or informed to the generators to form a commercial contract (Commercial Intertrip). The generators receive an annual intertrip capability payment (fixed price per BMU), an arming fee and in the event of activation of intertrip will receive an intertrip activation+restricted export level payment.

For more information, see here: **www2.nationalgrid.com/uk/services/balancing-services/system-security/intertrips/**

Summary of ancillary service

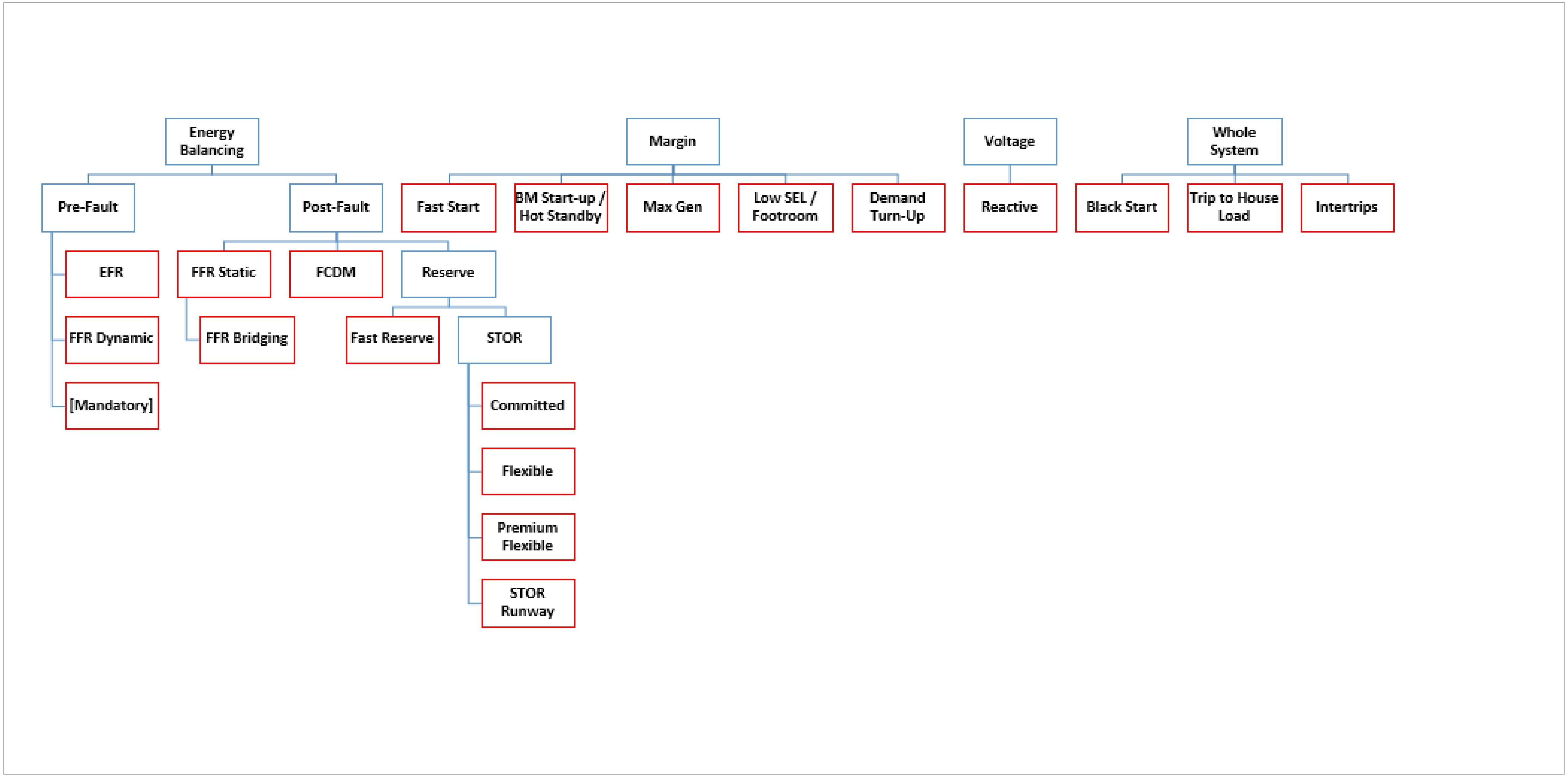
The table below sets out the range of ancillary services available through the GB SO as well as providing details of operation, procurement and payment structures.

Service Type	Service	Response Time	Response Duration	Minimum Capacity	Procurement Process	Payments	Additional Notes
Mandatory Frequency Response	Primary Frequency Response	<10 secs	20 secs	Transmission Network dependant: NG ≥ 100MW SP ≥ 30MW SHET ≥ 10MW	Tendered	Availability & Utilisation	
	Secondary Frequency Response	<30 secs	30 minutes		Tendered	Availability & Utilisation	
Commercial Frequency Response	High Frequency Response	<10 secs	Indefinite		Tendered	Availability & Utilisation	
	Primary Firm Frequency Response	<10 secs	20 seconds	≥10MW	Tendered	Multiple Availability & Utilisation	
	Secondary Firm Frequency Response	<30 seconds	30 minutes	≥10MW	Tendered	Multiple Availability & Utilisation	
	High Firm Frequency Response	< 10 seconds	indefinite	≥10MW	Tendered	Multiple Availability & Utilisation	
	FFR- Bridging	10 or 30 secs (depending on type of FFR offered)	30 secs – 30 minutes (Depending on type of FFR offered)	1-10MW	Bilateral Agreement	Multiple Availability & Utilisation	
	Frequency Control Demand Management	2-10 secs	30 minutes	>3MW	Bilateral Agreement	Availability	
	Enhanced Frequency Response	<1 second	15 minutes	1MW	Tendered	Availability	
Reserve	Fast Reserve	Start in 2 mins, full output by 4 mins	15 mins	50MW	Tendered	Multiple Availability & Utilisation	

	BM-STOR	Typically 20 mins, can be up to 240 mins.	2 hours	>3MW	Tendered	Availability & Utilisation	Must be a BM-Unit, or part of a BM-Unit.
	Non-BM STOR	Typically 20 mins, can be up to 240 mins.	2 hours	>3MW	Tendered	Availability & Utilisation	Dispatched outside the balancing mechanism.
	STOR-Runway	Typically, <15 mins, can be up to 240 mins	2 hours	3MW	Tendered	Availability & Utilisation	
	BM- Start-up	89 mins	As agreed		Bilateral Agreement	Readiness	
	SBR	≤48 hours	As required	20MW	Tendered	Readiness	
	DSBR	2 hours	60-240 Minutes	>1MW	Tendered	Set-Up & Utilisation	
Reactive Power	Obligatory Reactive Power			~≥50MW	Generally, requirement of transmission connection agreement	Utilisation	
	Enhanced Reactive Power			>Obligatory Reactive Power Requirements	Tendered	Multiple Availability & Utilisation	
Black Start					Bilateral Agreement	Availability	
Demand Turn-Up				≥1MW	Bilateral Agreement	Availability & Utilisation	
Intertrip				Determined by National Grid	Bilateral Agreement	Capability Payment & Arming Fee & Activation Payment	Determined By National Grid and only available to Transmission Connected generators

Diagram of ancillary services

The below diagram shows the groupings of ancillary services available in GB from the SO.



Case studies

A number of case studies are set out briefly here, not as an exhaustive explanation of the ancillary services regime in each country, but to give insights into alternative ways of contracting for ancillary services. When designing a new ancillary services market, it is prudent to take best practice from other energy systems around the world, a number of which have greater experience in supporting high levels of variable renewable generation or inflexible nuclear power.

New Zealand

New Zealand's system operator and transmission owner is a state-owned enterprise called Transpower. The system includes a HVDC line from the central South Island (SI) to Wellington in the North Island (NI), built mainly to transfer hydro power from SI to NI and thermal power from NI to SI. There are 29 distribution network companies, with 2,500+ tariffs.

New Zealand's peak is significantly smaller than the UK's at 7 GW. 80% of the electricity is from hydro-powered generation. Inflows and careful lake management are therefore crucial to New Zealand's electricity supply. The biggest generator is Manapouri at 800 MW. Other than hydro-powered generation, New Zealand has three large CCGT units and two 250 MW coal generators as well as a gas peaker. Due to low total demand relative to the size of the large generators, the NZ power grid has low system inertia, which means the loss of one large generator can cause a significant drop in frequency.

New Zealand has a far more challenging frequency management task than the UK (although the lack of inflexible generation is helpful for the management of the system) and manages it through:

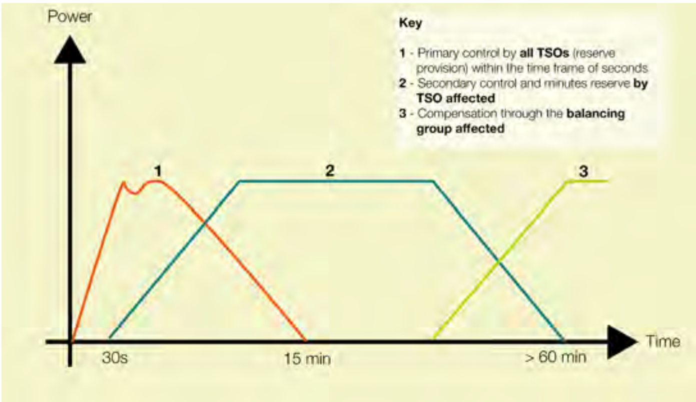
- 2 products: Fast (1s) & Sustained (30s)
- Procured in a simple, transparent, half-hourly market
- Co-optimised with energy dispatch
- Costs recovered from causers of risk, such that generators seek to hedge

Germany

It should be noted that those systems on the Continent enjoy very high levels of inertia, response and reserve compared to GB and therefore cannot be fully comparable. Nevertheless, we consider below some of the approaches adopted.

Germany offers an example of an alternative ancillary services regime. There are four transmission operators in Germany, which all share a combined market platform[12] for the procurement of ancillary services. The market is broadly designed into three products – primary, secondary and tertiary control, which vary by required response time after an event that causes a net frequency imbalance. Primary and secondary control are used to provide both frequency response and balancing. Generation, DSR, and storage are able to bid into any/all of the three products.

- **Primary Control** – activated within 30 seconds, and operating for up to 15 minutes
- **Secondary Control** – for participants able to respond within five minutes.
- **Tertiary Control** – activated within 15 minutes, for a period of up to an hour.



The products are procured in much shorter term markets than they are in GB, with primary and secondary procured in weekly tenders, and tertiary procured in a daily tender. Pre-qualification is required, but the criteria are the same for all products. Aggregators are able to combine the bids of participants that would otherwise be too small to operate.

Table to show Data: NZ System Operator TASC 033 (2013/14 snapshots); National Grid SOF 2015 Chapter 4 + own minimum demand estimates.

	North Island 2013 peak	North Island 2014 trough	UK 2016/17 trough	UK 2025/26 trough
Demand	4,564 MW	1,762 MW	22,000 MW	22,000 MW
Biggest risk	396 MW	170 MW	1,000 MW	1,600 MW
Risk/demand	8.6%	9.6%	4.5%	7.2%
Inertia	21,700 MWs	11,900 MWs	225,000 MWs	130,000 MWs
Risk/inertia	0.018/s	0.014/s	0.004/s	0.012/s

Procurement occurs against two different time periods: the main period (Haupttarif) from Monday to Friday from 8am to 8pm with a total of 60 hours per week, and the sub-period (Nebentarif) that covers the rest of the time, totalling 108 hours per week. The structure of payments varies between different products, with payments based on capacity (€/MW) and/or energy (€/MWh). The former compensates for keeping power available and the latter compensates for actual balancing energy delivery.

Not all services are procured in an equally transparent and liquid way, for example black start. However, there are a number of projects in Germany looking at innovative approaches to lowering barriers to entry in the ancillary services market and developing local ancillary products for use by DSOs.

Denmark

Requirements to be met by suppliers of ancillary services vary slightly depending on whether the services are to be supplied in Eastern Denmark, i.e. east of the Great Belt[13] (called DK2) or in Western Denmark, i.e. west of the Great Belt (called DK1).

DK1:

- Primary reserves (Frequency Response)
- Secondary reserves, LFC (Load Frequency Control)
- Manual reserves
- Short-circuit power, reactive reserves and voltage control.

DK2:

- Frequency-controlled disturbance reserve
- Frequency-controlled normal operation reserve
- Manual reserves
- Short-circuit power, reactive reserves and voltage control.

For primary reserve, procurement takes place day-ahead, and is divided into six blocks of four hours over the day. The bids must state an hour-by-hour volume and a price for the following day of operation. The bidder must offer to make available the same number of MW within each block.

The secondary reserve serves two purposes. One is to release the primary reserve which has been activated, i.e. restore the frequency to 50.00 Hz. The other purpose is to restore any imbalances on the interconnections to follow an agreed plan. Secondary reserve is procured on a monthly basis, and the volume procured is made in reference to recommendations by ENTSO-E and the uncertainty of wind forecasting. The reserve is procured as a combined, symmetrical reserve for upward and downward regulation.

Frequency-controlled normal operation reserve, and Frequency-controlled disturbance reserve (DK2) are both automatic regulation provided by production or consumption units which, by means of control equipment, respond to grid frequency deviations. The TSOs within the Nordic synchronous area are jointly responsible for the supply of frequency-controlled normal operation reserves, and frequency-controlled disturbance reserve, and Energinet.dk buys both in collaboration with Svenska Kraftnät through daily auctions.

Manual reserve in both DK1 and DK2 refers to the manual upward and downward regulation reserve which is activated by Energinet.dk's Control Centre. The reserve relieves the Load Frequency Control (LFC) and the frequency-controlled normal operation reserve in the event of minor imbalances and ensures balance in the event of outages or restrictions affecting production plants and international connections. These reserves are put up for sale at daily auctions.

Short-circuit power, reactive reserves and voltage control are services ensuring stable and safe power system operation in both DK1 and DK2. Currently, short-circuit power and reactive reserves can only be supplied by the central power stations as they are connected to the main high-voltage grid. Bids are submitted on a monthly or weekly basis, or on request.

Overall, ancillary services in Denmark are simpler than in GB, and purchased over much shorter timescales. Denmark is a country with both significant volumes of wind generation on the system and high levels of interconnection. The ancillaries market is an essential tool to managing the variation in wind output, and demands of other markets across interconnectors.

For more information see here: **www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/8871-11%20v3%20Ancillary%20services%20to%20be%20delivered%20in%20Denmark%20-%20Tender%20conditions.%20Valid%20from%203%20October%202012.pdf**

Resources

Notes

1 **www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework**

2 A whole systems approach which is referred to in the SOF refers to 5 key areas: Visibility and coordination of generation, active network management, voltage control from distributed energy resources, low frequency demand disconnection and black start.

3 For example, it was traditionally safe to assume that frequency response services would be provided by thermal generators who could ramp up or down and hence design services to require symmetrical bids. It is much more cost-effective for some newer technologies to provide unidi rectional bids: loads can more easily reduce demand than increase it and renewable generators are much more cost-effective at reducing generation than increasing it i.e. a preference for high rather than low frequency response. Hence a simpler product design which does not require symmetrical performance will allow lower cost combinations of resources to be found.

4 **www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=8589934824**

5 Project TERRE is part of the implementation of the European legal Guideline on Electricity Balancing. There are eight European Transmission System Operators (TSOs) currently participating in Project TERRE, including National Grid, and those from France, Spain, Portugal, Switzerland, Italy as full members and from Ireland and Greece as observers. TERRE will be a system by which these TSOs can do joint balancing of generation and demand using a common set of bids and offers.

6 See case studies on page 20-21.

7 **www.energy-uk.org.uk/publication.html?task=file.download&id=5903**

8 RIIO-ED2 will be the second electricity distribution price control to reflect the new RIIO (Revenue = Incentives + Innovation + Outputs) model for network regulation.

9 BM Unit Specific Transactions

10 The requirement for FFR Bridging has now been met for the short-medium term and is currently under review by National Grid. It is not clear yet as to whether there will be further opportunities, but once this is known National Grid shall communicate accordingly.

11 **www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=37710**

12 **www.regelleistung.net/ext/**

13 The Great Belt is a strait between the major islands of Zealand and Funen (Fyn) in Denmark

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Useful links

System Operability Framework:
www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

Policy Exchange Report, Power 2.0, Building a smarter, greener, cheaper electricity system:
www.policyexchange.org.uk/wp-content/uploads/2016/11/POWER-2.0.pdf

Economic grid support services by wind and solar PV:
www.reservices-project.eu/wp-content/uploads/REserviceS-project-recommendations-EN.pdf

Market Design for an Electricity System with higher share of RE Energy Sources:
www.indiaenvironmentportal.org.in/files/file/Market-Design-for-an-Electricity-System-with-higher-share-for-RE-Energy-Sources.pdf

An Economic Analysis of the German Secondary Balancing Power Market:
www.strommarkttreffen.org/2016-1-22-Ocker-German-Secondary-Balancing-Power-Market.pdf.pdf

Market Access for Smaller Size Intelligent Electricity Generation report, Fraunhofer Institute for Solar Energy Systems:
www.ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/massig_final_report.pdf

Procurement of control power and energy in Germany:
www.amprion.net/en/control-energy

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