March 2012

National Grid Electricity Transmission's approach to determining and procuring an economic and efficient level of Black Start service provision on an ongoing basis

Background

Following the introduction of licence Special Condition AA5J[1], this statement sets out National Grid Electricity Transmission's (National Grid's) approach to determining and procuring an economic and efficient level of Black Start service provision on an ongoing basis as Transmission System Operator (TSO).

This document does not, however, aim to provide technical detail surrounding the Black Start service nor information regarding the structure and content of Black Start contracts themselves. More information on these areas can be found on the Balancing Services area of the National Grid website[2] or by contacting National Grid using the details set out in section 7 of this document.

1. Introduction

1.1 National Grid has an obligation under the Grid Code (CC6.3.5) to ensure that the National Electricity Transmission System (NETS) can be re-energised in the event of a total or partial system shutdown. Such re-energisation is known as Black Start (BS). The likelihood of a total or partial system shutdown occurring is considered remote due to the security standards employed by National Grid to ensure system safety and reliability. However, it is the case that should a total or partial system shut-down occur anywhere on the NETS, contingency arrangements must be in place to enable a timely and orderly restoration of supplies and this capability is therefore maintained 24/7.

1.2 The BS context pre-vesting was much different to that of today, where a large percentage of demand was met by coal fired power stations which had OCGTs for each of their main units for backup purposes. Therefore the number of stations inherently capable of providing Black Start at that time was far greater than exists today. In addition, the resources available to manage BS were greater where Transmission System control was handled by seven control rooms and there were significantly more Distribution System control centres to manage demand segregation. Immediately post-vesting the industry had five Transmission System control centres and twelve Distribution Network Operator (DNO) control centres, so the industry continued to have more resources and capabilities to manage a greater number of BS stations simultaneously, enabling a faster restoration.

1.3 Since that time, the number of control centres have been drastically rationalised, meaning that TSO and DNO resource available to manage Black Start stations and the restoration process has become more of a deciding factor in determining a BS strategy.

1.4 Today the BS requirement is met through the procurement of BS service capability at a number of strategically located power stations across Great Britain and is agreed via bilateral contracts between National Grid and the relevant power station. In accordance with its licence conditions, National Grid aims to procure a BS service economically and efficiently on an ongoing basis.

[1] Licence Special Condition AA5J: Requirement to develop the balancing services activity revenue restriction in relation to external costs for new Black Start service provision

[2] The balancing services area of the website can be found at: http://www.nationalgrid.com/NR/rdonlyres/89760E94-E503-462E-BF47-13FABEB1BDEC/33146/Black_Start_ServiceDescription_Issue_1.pdf

1.5 The procurement of BS power stations is undertaken with the objective of achieving a balance between energising the NETS and distribution systems in the shortest time possible, ultimately restoring full demand, and an economic and efficient level of BS provision. This is realised by ensuring sufficient levels of resilience whilst also taking into account the TSO and DNO resources available to restore the network i.e. to control the various BS power stations and subsequent power islands[3].

1.6 This statement comprises four main sections which set out:

- National Grid's approach to determining a BS strategy including the level of BS contracting and the location of BS stations;
- Given the context of the BS strategy, the site specific requirements sought when considering a station for potential BS service provision;
- The process by which we procure new BS services on an ongoing basis; and
- BS considerations in light of future industry change.

2. Determining a Black Start strategy

2.1 The more power stations contracted for BS the higher number of system restoration options there are and the greater the resilience to BS station failures or unavailability at any given time is provided. However, not all power stations will be capable of meeting the technical requirements for BS and a balance is also required to be struck in terms of service level and the cost associated with such service provision.

2.2 Whilst the Grid Code states that it is an essential requirement for the NETS to incorporate a BS capability, there is no defined standard to prescribe what this capability should be. A review of the BS process by the Electricity Supply Industry (ESI) through the E3C[4] was carried out in 2006 under an initiative entitled Project Phoenix. This project, undertaken by a group of industry participants along with Ofgem representation, raised industry awareness around BS issues although, again, did not determine a standard.

2.3 The output of the work undertaken through Project Phoenix did however include an industry expectation that most of the NETS should be energised within twelve hours of a total system shutdown. The rationale for this timescale being that DNO substation systems, during a BS, will be powered by backup batteries which will keep protection equipment operational and allow switching to continue from the relevant DNO Control Centre. DNO networks therefore need to be energised within approximately 24 hours as this is the expected resilience of the substation batteries. It therefore follows that energisation of the NETS would need to occur well before 24 hours to avoid a major loss of DNO substation operation.

2.4 National Grid's BS strategy therefore aims to achieve a successful restoration of the NETS within an expected twelve hour period. The BS restoration process is complex and therefore achieving this timescale is reliant on a number of different factors, including technical and communications elements proceeding as planned. A programme of testing BS stations and exercises surrounding procedures and processes with the parties potentially involved in a BS situation is designed to achieve this timescale for restoration.

[3] A power island is formed where gensets at an isolated power station supply local demand. These are configured in accordance with the Local Joint Restoration Plan.

[4] E3C stands for Energy Emergency Executive Committee. E3C sponsored Exercise Phoenix as part of the Black Start review and exercise programmes. This examined the ability of electricity generation, transmission and distribution companies to recover from a Black Start situation

2.5 In meeting this restoration timescale expectation, National Grid's current BS strategy is to divide the NETS into a number of zones. The BS 'zones' do not, as such, have 'fixed' boundaries and therefore can evolve and provide flexibility as the system changes over time. These zones are used as a method of ensuring that the following three BS criteria are considered and met:

1. It ensures DNOs have a balanced share of BS stations, ensuring that resource is optimised in a BS situation;
2. By dispersing BS providers in zones it should follow that non–BS stations should be relatively close to a BS station, allowing a more efficient restoration process
3. BS stations distributed equally across GB should enable a relatively uniform restoration of the total system.

2.6 Within each zone we aim to contract with a number of BS stations. If there were only one station in each zone the risk of failure or planned outage of that BS station is significantly increased which would have a major impact on the timescales for energising the relevant area of the network. Having contracted with a power station for BS, the actual effectiveness of that BS station in a BS situation is extremely difficult to predict. Through the employment of historical testing data and knowledge of station availability we are able to estimate the average chance of any one BS station starting up successfully in a BS situation. Given this information, we therefore contract with a number of stations within a zone which should deliver a greater than 90% chance of at least one BS power station being successful within each zone of the network.

2.7 TSO and DNO resources available to physically manage BS power stations and the associated power islands that need to be developed in a BS situation are limited and will similarly impact the number of stations contracted for the service. Power islands are developed in accordance with a Local Joint Restoration Plan (LJRP) which is agreed alongside a BS contract and sets out the activities and steps that the BS power station, the relevant DNO and National Grid will carry out following a BS situation. A DNO can manage a maximum of two such plans per DNO area given people resources and facilities available at any given time. This capability has been established through industry working groups (referred to in paragraph 2.2 above) however this is reviewed on an ongoing basis with each DNO.

2.8 The location of BS power stations is driven by three primary considerations, the first of which is the technical capability to provide a BS service (described in greater detail in section 3 below) and connectivity or proximity of the station to the main interconnected system. Secondly, the geographic spread of BS stations is taken into account to ensure that transmission and distribution systems can be restored 'evenly' in the event of a BS situation. This is determined to some extent by the spread of all generation on the system as BS stations are required to start up non-BS stations in the event of a system restoration. Thirdly, as mentioned above, the location of BS stations should be such that TSO and DNO resource associated with managing a BS situation is optimised and therefore each DNO has an equal share of BS stations associated with their networks.

2.9 In order to support assumptions surrounding the number of power stations that are contracted for BS and the associated restoration time, a mathematical model has been developed by National Grid along with industry wide input. A working group comprising DNOs and generators was established in 2008 by the Electricity Task Group (ETG), a sub E3C group, to identify the key drivers for Black Start restoration and developed, through probabilistic modelling, a tool that could indicate probable restoration times against a range of input variables.

2.10 Input variables that were modelled during this exercise were:

- Availability and characteristics of Black Start and non-Black Start stations
- Basic network configurations i.e. zones to which generators attach
- Control room procedures
- Telecoms resilience
- Staffing levels
- National demand characteristics
- Contract details
- Substation resilience
- Other major external influences such as weather and potential network damage

2.11 The model runs many simulations to establish patterns and trends. Each Black Start simulation occurs in a discrete random hour of the year and the model captures all relevant conditions and circumstances to prime the model with the appropriate data based on this start point. In addition to this there are many user defined alternatives that allow the modeller to consider a range of scenarios to examine the sensitivity of outcomes against a wide range of credible situations. The model uses @Risk sampling software to convolve the wide range of parameters and calculate a range of output measures. The model was focused on calculating possible restoration times for restoring 60% of the peak load in the day in which the Black Start event occurred.

2.12 The ETG modelling work was presented to the E3C and the resultant model provides an indication of the likely system restoration times associated with different BS station scenarios. Whilst output of this model, alongside practical exercises, assists in providing an indication of the required number of BS stations across GB and therefore the efficient level of BS service provision, it is not used as a decision tool on its own.

2.13 In terms of future development of this model, further refinements such as improvements to the input data or the addition of network models are possible. This would require support and input from across the industry and other sectors and therefore we would expect any such developments to be initiated through E3C/ETG. Any simple changes to the model, such as generator parameters (block loading, ramp rates, load factors etc) can easily be modified as and when any new generators become connected.

2.14 Having determined the BS strategy on the basis of the elements set out above, Section 3 below examines the site specific considerations of BS stations.

3. Black Start service requirements

3.1 There are a number of specific technical power station characteristics that can provide greater BS capabilities and therefore provide more value, these are:

- Location – proximity to other stations and other BS stations
- Connectivity – voltage level and number of circuits
- Number and size of main units
- High block loading and charging capabilities
- Expected availability of station
- Expected reliability of station
- Start up time from cold
- Age of station
- Number and size of auxiliary starting units
- Independent fuel supplies
- Station configuration

3.2 These aspects have to be considered in the context of the existing portfolio of BS station capabilities and are compared with the capabilities of any potential alternative BS stations.

3.3 The main objective of a BS power station is to start other non-BS power stations and the closer a BS power station is to other non-BS stations, the more timely, safely and securely this objective can be achieved. Once additional non BS power stations are synchronised, the resultant power islands should have greater stability, capabilities and provide more system restoration options.

3.4 A single BS power station can only restore a limited amount of the GB demand and network on its own, so other power stations are required to expand the network restoration process and re-connect more demand. The proportion of network that can be energised by a single BS power station will depend on the capabilities of that station and the characteristics of the network around that station e.g. charging capability of the station and length of local overhead lines.

3.5 A power station would have limited BS value if it were connected to the same substation connection point or within close proximity of another BS power station. This would potentially limit restoration options should there be any local network damage. Also a substation that has greater wider system connectivity is a preferred connection site for a BS power station as this gives a greater number of restoration options. Both transmission and distribution connected power stations may be considered as potential BS providers although the value of an embedded station would depend on its proximity to the Main Interconnected Transmission System and its size.

3.6 A station with greater MW capacity (and MVAr) and multiple units should deliver greater restoration capabilities and higher levels of resilience as the station will be able to provide more restoration options by re-energising more non-BS stations. A higher block loading capability has the effect of simplifying the DNO switching requirements and therefore facilitates quicker restoration of demand.

3.7 A BS power station is also expected to have high availability over the life of its contract in order to provide greater value. This is particularly important for thermal power stations as the warmth of the generating unit can severely affect its time to connect, its block loading capability and therefore its ability to provide an effective BS service.

3.8 The age of a station is a consideration because a newer station provides increased contracting value as the cost of the contract is spread over longer periods.

3.9 A BS station would ideally have independent fuel supplies (e.g. distillate fuel), to enable the station to run for a minimum duration, ideally in the range 3 to 7 days following a Black Start instruction. This duration ensures that the station is able to run and provide the service in a BS situation, taking into account the possibility of trips and unforeseen situation that may delay the restoration process.

3.10 National Grid believes it is important to procure new BS stations that can best fulfil the requirements identified above. It should be noted that these requirements are normally dictated by the main plant type and location rather than the BS auxiliary equipment that needs to be installed in order to be able to provide a BS service

3.11 Although there are a large number of existing generators and new connections planned to the GB system, given the aforementioned requirements, few stations are actually suitable for BS. The BS specific equipment required at most stations is very similar and therefore the selection process focuses on the capabilities, location and the type of generating units that the power station has already connected (or plans to connect).

4. Black Start station procurement process

4.1 Given the context of the BS strategy and the site specific technical requirements of BS stations, National Grid will look to procure an economic and efficient level of BS service on the basis of the process set out in Figure 1 below. This process is described in further detail in the following paragraphs.

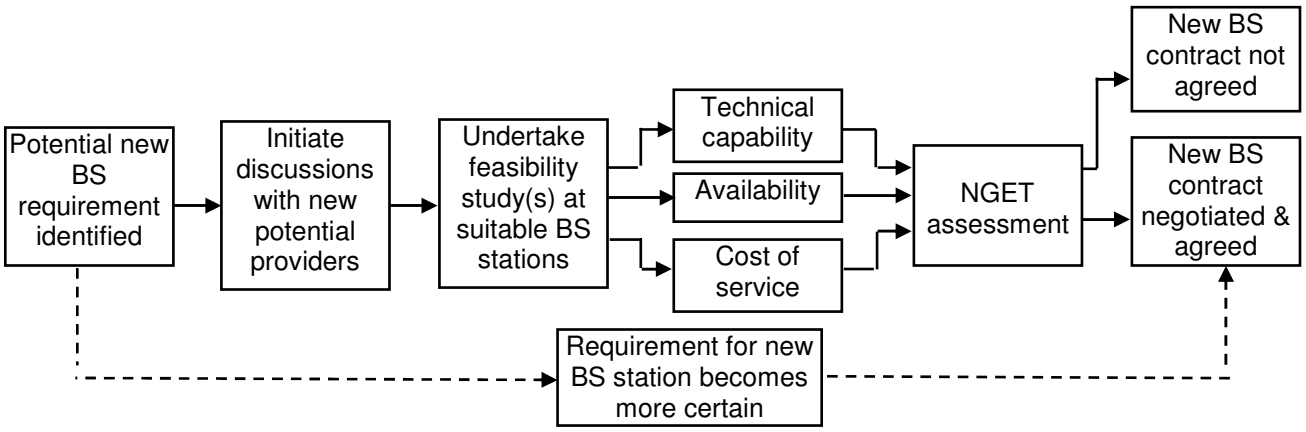

Figure 1 New Black Start station procurement process

4.2 The requirement to procure a BS service from a new BS station is usually triggered by the closure of an existing BS station. There is often great uncertainty surrounding closure dates or mothballing of the existing BS power station fleet which in turn makes timely procurement of a new BS power station challenging. A current CUSC modification proposal, CMP 192[5], is looking at, amongst other areas, what the appropriate timescale should be for a generator to notify a TO of Transmission Entry Capacity (TEC) reductions. The outcome of this modification should provide greater certainty on future station closure timescales and therefore also provide greater certainty for the requirement of a new BS service.

4.3 Where possible, a decision could also be made to extend current existing BS contracts beyond original expiry dates either whilst a new service is being investigated at a new station or to effectively 'bridge' a contracting gap in service availability. On the basis that the costs of providing an asset capable of BS provision are likely to have been recovered over the course of the previous contract this should, in theory, present the most economic option and there are many instances where National Grid has taken the decision to extend an existing contract rather than contract with new stations that would require significant capital investment. National Grid's ability to do this however is dependent upon the anticipated remaining lifetime of the station, the willingness of the contracting party, and the commercial terms under which they would seek to extend a BS contract.

4.4 Where existing contract extension is not an option, initial exploratory discussions with potential new providers are carried out well before it is considered necessary to contract for a new service. This early dialogue ensures that a thorough understanding of National Grid's requirements, station capabilities and service solutions are ascertained between

[5] The original CUSC Modification Proposal can be found on the National Grid website at: http://www.nationalgrid.com/NR/rdonlyres/D2D6F81D-7C3E-4049-8429-817E6A5DA657/45775/CMP192EnduringUserCommitmentv1.pdf

the parties and ultimately means that a new service can be delivered more quickly when the requirement for a new station becomes more evident.

4.5 As the requirement for a new BS station becomes more certain, potential providers deemed suitable for providing BS from a contracting strategy perspective are asked to undertake a detailed feasibility study. The feasibility assessment is typically scoped in two stages where Stage 1 clarifies the technical capabilities and Stage 2 is a full design of all equipment and connections required, including estimated costs for main plant and project items. This enables an assessment of total project costs, financing options and likely returns on the project, and how these relate to the ongoing contract cost of the service to National Grid.

4.6 Where more than one potential provider is identified to undertake feasibility studies to meet a service requirement within a zone, National Grid will look to negotiate with those potential providers in order minimise feasibility study fees by ensuring that:

- the scope of the study is well defined and agreed up-front to avoid unnecessary work or duplication of effort at extra cost
- Stage 2 of the study is not undertaken at cost if Stage 1 determines that the station is not technically suitable for BS
- the study is required solely for Black Start and not also for other potential projects
- the projected cost of the study is in line with previous studies undertaken at similar station types

4.7 Whilst a feasibility study is typically carried out at stations that are initially deemed to be suitable for BS, the outcome of the study might not necessarily prove this to be the case. Other factors may also prevent further BS discussion with a specific provider having completed a feasibility study which could include uncertainty surrounding build times or funding of new station projects or issues around development of new technologies.

4.8 Where the feasibility study work confirms that the station can meet the BS station specific requirements as set out in section 3 above, and the relevant costs of service provision are deemed appropriate, National Grid will make an assessment as to whether to proceed to contract with the new station in question. This assessment may include the comparison of technical capability or cost of another BS provider, the projected delivery timescales of the project and/or a reassessment of the need for a new provider. A period of contract negotiation may then follow.

4.9 A set of standard BS contract terms is available on the National Grid website[6] although each BS power station may require specific variations to these standard terms. In theory there can be variations to any part of the contract that may be required to reflect individual station characteristics or project detail. The length of contract for a BS service can be varied although it is expected that for a new build solution, particularly when a large capital investment is required by the provider, that the minimum contract would be 10 years in duration with termination options drafted into the contracted based on expected availability levels. The minimum contract length is determined through negotiation with the generators and is typically based upon a generators anticipated length of service and their need to recover capital and rates of return.

5. Ongoing Black Start Considerations

5.1 The NETS faces significant change in the future, including a changing generation mix in order to facilitate environmental targets. These targets will be met by an increase in wind

[6] Standard contract terms and further information regarding the Black Start service can be found at: http://www.nationalgrid.com/uk/Electricity/Balancing/services/systemsecurity/blackstart2/

generation and other low carbon technologies such as Nuclear and interconnectors. The closure of existing BS stations will require some of these stations to be replaced, potentially with stations powered by these new technologies, provided they meet the technical requirements specified above.

5.2 Whilst it is generally not possible to accurately predict specific station closures in 5-20 years time, certain legislation changes can provide a degree of certainty about closures dates. The LCPD legislation for example has made it relatively certain that particular stations will close by 2016, although it is not clear as to whether specific stations will cease to operate before this date. This presents a challenge to National Grid to set timescales in which to extend existing BS contracts where possible to do so or to seek out new providers to maintain BS capability and availability.

5.3 'Gone Green', 'Slow Progression' and 'Accelerated Growth' are scenarios produced by National Grid with industry input and provide a view on future supply and demand profiles[7]. National Grid uses such scenarios to assess possible future solutions for procuring BS. National Grid continually engages with new potential BS providers to understand their BS capabilities and requirements. Each type of provider is assessed against the principles set out in Section 3 above and can be incorporated as required into the mathematical model described in paragraph 2.9 to understand the resultant impact to system restoration times.

5.4 Whilst the extent of change over the next 10 years is uncertain, it is not expected that the level of BS provision should change from that of today. There are anticipated closures of existing BS stations within this period and we expect to replace some of these with new BS stations, however our current view is that it is likely that the majority of these new stations will be CCGTs.

5.5 National Grid does, however, assess the suitability of different technologies from a BS perspective on an ongoing basis and any generator technology can be considered as a BS service provider. For instance, the ability of interconnectors to provide BS will depend upon whether it is current or voltage source technology and therefore whilst there is limited scope for existing interconnectors to provide BS, this may be possible in future.

5.6 Wind and the new nuclear generators may also be able to provide BS services in the future. It is possible that some wind farms will be able to provide BS although it is not expected that wind farms will feature significantly within the BS fleet as BS service capability has to be maintained when wind load factors are low. Some of the new nuclear power stations have indicated an interest to National Grid in providing BS. These are likely to have very good BS capabilities (e.g. high block loading, charging capability and MW capacity) although it is likely that their starting requirements will be significantly higher than the current BS providers.

6. Summary

6.1 BS is an extremely important strategic service that can be procured from only a few generators that are connected to the GB transmission system or relevant distribution network. National Grid believes it is important that BS services should be procured from power stations that are likely to provide the most effective technical BS service, although this must be balanced against the cost of service provision.

[7] Future UK Energy Scenarios can be found on the National Grid website at: http://www.nationalgrid.com/NR/rdonlyres/86C815F5-0EAD-46B5-A580-A0A516562B3E/50819/10312_1_NG_Futureenergyscenarios_WEB1.pdf

6.2 Procuring an optimal BS service is an assessment of a combination of many factors, most of which relate to the inherent capabilities of the main power stations' existing configuration and location. Initial discussions with potential BS providers can provide a fairly good indication of these inherent capabilities. A thorough assessment of each power stations BS proposal is made against their detailed assessment of the project design and specification of equipment on a case by case basis.

6.3 Whilst there can be uncertainty surrounding the exact timing for the requirement for a new BS service, a long development phase of potential BS projects means a detailed assessment of BS requirements can be developed into a detailed BS proposal when there is greater certainty of the requirement.

7. Contact

Should you wish to discuss any element of this statement further, then please contact either your Balancing Services Contracts Account Manager or Nicola Forrest of our Contracts and Settlements team on 01926 654043 or Nicola.Forrest@uk.ngrid.com.