Appendix 1

1. Summary of Results from Power System Studies

Table 1: Assessment Summary

Site	Requirement for works on the National Electricity Transmission System where such works are not at a Connection Site	Requirement for works To the National Electricity Transmission System at a Connection Site (Grid Supply Point) for thermal capacity	Requirement for works To the National Electricity Transmission System at a Connection Site (Grid Supply Point) for fault Level	Necessity for Site Specific Requirements (at the site of connection) of the Power Station
ABERTHAW	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below
CARDIFF EAST	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below
MARGAM	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below
PEMBROKE	Yes, see Section 3	Modification Application required to apply diversity. Results in 18 MW headroom	None	Yes See notes below
PYLE	Yes, see Section 3	ANM scheme required to apply diversity.	None	Yes See notes below
RASSAU	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below
SWANSEA NORTH	Yes, see Section 3	Sufficient capacity for Base Case 2. ANM scheme required to apply diversity. Economic consideration: further supergrid capacity recommended	None	Yes See notes below
UPPERBOAT 132 kV	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below
UPPERBOAT 33 kV	Yes, see Section 3	ANM scheme required to apply diversity.	None	Yes See notes below
USKMOUTH	Yes, see Section 3	Greater than 50MW head room at the GSP	None	Yes See notes below

Notes on Site Specific Requirements

Voltage Regulation: there are issues regarding voltage regulation that will prevent connection of further Embedded Generation unless mitigated by the conditions below:

The User should be aware that Embedded Large and Embedded Medium Power Stations are required to satisfy the reactive capability and voltage control requirements of CC.6.3.2, CC.6.3.8 Grid Code.

For new Small Embedded Power Stations, the User shall ensure that each Generating Unit or Power Park Module within each Embedded Small Power Station shall have a reactive capability of between 0.95 Power Factor Lead to 0.95 Power Factor Lag at Rated MW Output at the User System Entry Point. During the operational timeframe, the User shall instruct each Generating Unit or Power Park Module within each Embedded Small Power Station of its required operating Power Factor which shall be within the capability range.

Initially the power factor setting is likely to be 0.95 lead on generation capable of significant output in overnight. The network is at the high voltage limits during the overnight period. For generation that only has the ability to generate during the day, discrepancies between the MVAr demands in the WPD SoW submission and those NG would currently expect to see mean it has been difficult to give certainty to the initial power factor figure. The guidance for 0.98-0.99 lead will therefore be subject to further review

There is no restriction on the User if they wish to employ an alternative method to manage MVAr transfers at the Grid Supply Point, for example through the installation of reactive compensation equipment, intertripping Embedded Generation or the application of other suitable control schemes.

Emergency Instructions to ensure control of the transmission system can be maintained at all times:

In accordance with the requirements of BC2.9.1.4, of the Grid Code, using the principles set out in Grid Code OC6.7.1, the DNO shall maintain a facility such that under emergency conditions on the National Electricity Transmission System, the User shall have the ability to de-energise new Embedded Generation detailed, upon instruction from the GBSO.

2. Assessment of SGT Thermal Capacity

Where there is a large and diverse mix of DG within a GSP National Grid believes that assuming 100% of the DG in the group will dispatch at once does not give an economic and efficient investment decision. This 100% level should instead be the trigger to start controlling curtailment of generation in the group.

National Grid also propose, to avoid perverse incentives between generation curtailment costs and investment decisions, it will be necessary to treat GSPs which are National Grid infrastructure assets differently to those which are connection assets. This situation could change in the future should the industry decide to change how SGT assets are charged to users.

Where the GSP SGT is an infrastructure asset, National Grid will assess the diversity of the embedded generation in the GSP, and allow connection of DG up to the appropriate level. National Grid will take measures to curtail generation to ensure that under planned circumstances where it is not economic to reinforce the SGT assets, the assets will not be overloaded.

Where the GSP SGT is a connection asset National Grid will allow connection of DG such that with 100% dispatch of DG in the group, there will be no overload. From this point National Grid will recommend that an Active Network Management (ANM) system is fitted to control the export from the group to the SGT capabilities. (Alternate systems of manual system control could be considered if the DNO prefers.) Once the ANM scheme is fitted NG will permit the connection of further quantities of DG as the DNO / developers require. National Grid will also, where requested, give an indication of where additional SGT capacity would be appropriate, based on the same criteria as will be used for an infrastructure site. It will remain the decision of the DNO and associated developer(s) as to what point that SGT investment is required in order to reduce the curtailment via the ANM of the associated DG.

Where a connection site goes over the limit based on 100% dispatch a modification application will be required to install the NG inputs to the WPD ANM scheme. Where a Infrastructure site goes over the limit based on 100% dispatch, either a modification application, or full implementation of National Grids proposed Appendix G with materiality will be required to ensure any money NG spends on control of generation is economically incurred.

There are a number of GSP's assessed via this SoW where the SGT loading obtained from the WPD BSP loading data provided, does not fully align with a hand calculation, based on the WPD DG list and historic data. Where this makes a difference to the results it has been identified below.

The table below details the thermal overloads observed on SGTs in the South Wales group assessed for both the Base Case 2 Submission and the Statement of Works Submission.

Table 2: SGT overloads

Contingency Name	Overload SGT	Base Case 2 Overload (Model)	Base Case 2 Overload (Manual)	SOW Overload (Model)	SOW Overload (Manual)
PEMB SGT1 or SGT2	PEMB SGT2 or SGT1	103% (7 MVA)	None	Non-convergence	121% (50 MVA)
PYLE SGT2	PYLE SGT1	None	None	201% (182 MVA)	150% (90 MVA)
INTACT SYSTEM	SWAN SGT4B/5/6/7	None	None	130% (54MVA) 121% (50MVA) 123% (55MVA) 108% (19MVA)	Clear large overload
SWAN SGT5	SWAN SGT 4B/6/7	None	None	196% (173 MVA) 170% (168 MVA) 170% (168 MVA)	Clear large overload
UPPB SGT2 or 3 (33 kV site)	UPPB SGT3 or 2	None	None	None	115% (15 MVA)

The Pyle loadings were also studied with the interconnection to Swansea North closed, as this is the normal running arrangement under this outage condition.

Table 3: Pyle SGT outage with 132 kV Interconnection to Swansea North closed

Contingency Name	Overload SGT	SOW Overload
PYLE SGT2	PYLE SGT1	146% (83 MVA)
PYLE SGT1	PYLE SGT2	107% (17 MVA)

Notes on SGT Overloads

1. Pembroke GSP

Pembroke is one of the sites where there are discrepancies between manual calculations and study calculations. This requires resolution: the rest of the advice here is based on hand calculations.

On this basis for the Base Case 2 DG submission, no overloads are identified at Pembroke and therefore all DG can connect.

For the Statement of Works submission, the thermal overload is approximately 121% or 50 MVA. National Grid would expect a Modification Application to be submitted or the Appendix G process to be implemented to include materiality limits. Based on the diversity of DG in this group, National Grid are unlikely to invest in additional supergrid capacity at Pembroke GSP.

2. Pyle GSP

Pyle is one of the sites where there are discrepancies between manual calculations and study calculations. This requires resolution: the rest of the advice here is based on hand calculations.

On this basis for the Base Case 2 DG submission, no overloads are identified at Pyle and therefore all DG can connect.

For the Statement of Works submission, the thermal overload is approximately 150% or 90 MVA. National Grid would expect a Modification Application to be submitted for an ANM scheme once the supergrid loading was over 100%, based on 100% dispatch. Once an ANM scheme is installed, WPD can connect all of the DG is this submission. For guidance purposes, based on National Grid's interpretation of diversity in the group, replacement of SGT1 with a 240 MVA unit may be an economic decision.

3. Swansea North GSP

For the Base Case 2 DG submission, no overloads are identified at Swansea North and therefore all DG can connect.

For the full Statement of Works submission, all SGTs at Swansea are subject to thermal overloads when the network is intact with the normal running arrangement applied. System studies show overloading on SGT4B, 5, 6 and 7 of 130%, 121%, 123% and 108% respectively. Similarly, for N-1 conditions, using the normal running arrangement for planned outages, the overloads increase on SGT 4B, 6 and 7 to 196%, 170% and 170% respectively.

National Grid would expect a Modification Application to be submitted for an ANM scheme once the supergrid loading was over 100%, based on 100% dispatch. It is not possible on the basis of the Statement of Works timescales to offer any guidance on possible reinforcements. Clearly there are significant overload issues which interact with running arrangements and hence fault levels. A Modification Application will be required to take this further.

4. Upperboat 33 kV GSP

Upperboat 33 kV is one of the sites where there are discrepancies between manual calculations and study calculations. This requires resolution: the rest of the advice here is based on hand calculations.

For the Base Case 2 DG submission, no overloads are identified at Upperboat 33 kV and therefore all DG can connect.

For the Statement of Works submission, this thermal overload is approximately 115% or 15 MVA. National Grid would expect a Modification Application to be submitted for an ANM scheme once the supergrid loading was over 100%, based on 100% dispatch. For guidance purposes, based on National Grid's interpretation of diversity in the group, additional SGT capacity at Upperboat 33 kV would not be economical.

3. Wider System Studies: NETS 400kV and 275 kV Circuit overloads

National Grid has assessed the proposed DG connections against the generation connection and wider system criteria. In doing so, National Grid believe it is necessary to consider realistic load factors across the proposed DG capacity. This ensures that investment decisions are economic. Work is ongoing to determine appropriate economic load factors: this will be the subject of a revised proposal under GSR16. This SoW has therefore been assessed using draft capacity factors: STOR 100% (headroom), Solar PV 85%, and other technologies 70%.

Pre-fault criteria

The pre-fault thermal criteria are the minimum thermal requirements to be able to connect generation. Any generation beyond these criteria will not be able to connect on a firm basis. It is suggested that any generation beyond this limit should be subject to a modification application to determine appropriate reinforcements at this stage NG will determine if it is appropriate to allow early connection ahead of any works on a non-firm basis.

Table 4: Transmission System Overloads for N-1

Planned Outage (N-1)	Overloaded Circuit	Base Case 2	SOW
	None Identified*		

* No overloads have been identified against the current network, or the planned network in the Swansea – Baglan – Margam – Pyle – Cowbridge area against the contracted background and its associated VE-route reinforcement. It is possible that there will be a different outcome on this part of the network owing to potential changes in the generation background caused by GB economics and legislation. If this is the case further joint assessment will be required by NG and WPD to determine what the industry most economic and efficient solution to reinforcements in the VE area is.

There is a requirement to secure the wider network to the N-1, N-1 post fault criteria and to have an economic solution to the N-1, N-D post fault criteria (effectively there must be an economic way to secure outages.) Under the Connect and Manage regime, it is possible to offer connection before these works are complete providing the resultant transmission constraints are not deemed unreasonable. A Mod App will be required to cover the works to make the system compliant.

Table 5: Transmission System Overloads for N-D

Unplanned Fault (N-D)	Overloaded Circuit	BC2	SOW
CILF4-RASS4-1-PEMB4-WALH4-1	IMPP4-MELK4-1	N/A	117%
CILF4-RASS4-1-PEMB4-WALH4-1	IMPP4-MELK4-1	N/A	115%
CILF4-IMPP4-1-CILF4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
IMPP4-MELK4-1-CILF4-WHSO4A-1	CARE2-USKM2B-1	N/A	104%
IMPP4-MELK4-1-SEAB4-WHSO4A-1	CARE2-USKM2B-1	N/A	104%
USKM2-WHSO2-2-USKM2-WHSO2-1	USKM2B-WHSO2-1	N/A	101%

Table 6: 400 kV System Overloads for N-1-1

Planned Outage (N-1)	Unplanned Fault (N-1)	Overloaded Circuit	BC2	SOW
RASS4-WALH4-1	WHSO4-WHSO4A-1	IMPP4-MELK4-1	N/A	127%
RASS4-WALH4-1	SEAB4-WHSO4A-1	IMPP4-MELK4-1	N/A	127%
CILF4-WHSO4A-1	RASS4-WALH4-1	IMPP4-MELK4-1	N/A	127%
MELK4-SEAB4-1	RASS4-WALH4-1	IMPP4-MELK4-1	N/A	122%
CILF4-RASS4-1	PEMB4-WALH4-1	IMPP4-MELK4-1	N/A	117%

CILF4-RASS4-1	SEAB4-WHSO4A-1	IMPP4-MELK4-1	N/A	117%
CILF4-RASS4-1	WHSO4-WHSO4A-1	IMPP4-MELK4-1	N/A	117%
CILF4-RASS4-1	CILF4-WHSO4A-1	IMPP4-MELK4-1	N/A	117%
COWL4-WALH4-1	PEMB4-WALH4-1	IMPP4-MELK4-1	N/A	117%
COWL4-WALH4-1	FECK4-WALH4-1	IMPP4-MELK4-1	N/A	115%
CILF4-RASS4-1	MELK4-SEAB4-1	IMPP4-MELK4-1	N/A	113%
FECK4-WALH4-1	RASS4-WALH4-1	IMPP4-MELK4-1	N/A	109%
FECK4-WALH4-1	SEAB4-WHSO4A-1	IMPP4-MELK4-1	N/A	103%
CILF4-WHSO4A-1	FECK4-WALH4-1	IMPP4-MELK4-1	N/A	103%
FECK4-WALH4-1	WHSO4-WHSO4A-1	IMPP4-MELK4-1	N/A	103%
FECK4-WALH4-1	MELK4-SEAB4-1	IMPP4-MELK4-1	N/A	102%

Table 7: 275 kV System Overloads for N-1-1

Planned Outage (N-1)	Unplanned Fault (N-1)	Overloaded Circuit	BC2	SOW
IROA2-WHSO2A-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	152%
ABTH2- UPPB2-2	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	120%
CILF2A-UPPB2-2	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	118%
ABTH2- UPPB2-2	CARE2-COWT2A-1	ABTH2-TREM2A-1	N/A	117%
ABTH2- UPPB2-2	COWT2A-PYLE2-1	ABTH2-TREM2A-1	N/A	117%
ABTH2- UPPB2-2	ABTH2-COWT2A-1	ABTH2-TREM2A-1	N/A	117%
CARE2-COWT2A-1	CILF2A-UPPB2-2	ABTH2-TREM2A-1	N/A	114%
CILF2A-UPPB2-2	COWT2A-PYLE2-1	ABTH2-TREM2A-1	N/A	114%
ABTH2-COWT2A-1	CILF2A-UPPB2-2	ABTH2-TREM2A-1	N/A	114%
ABTH2- UPPB2-2	ABTH2-TREM2A-1	CARE2-USKM2B-1	N/A	114%
ABTH2-TREM2A-1	CILF2A-UPPB2-2	CARE2-USKM2B-1	N/A	112%
ABTH2- UPPB2-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	111%
BAGB2-SWAN2-	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	110%
IROA2-WHSO2B-2	USKM2-WHSO2-1	USKM2A-WHSO2-1	N/A	110%
ABTH2- UPPB2-2	USKM2A-WHSO2-1	CARE2-USKM2B-1	N/A	108%
ABTH2- UPPB2-2	USKM2A-USKM2-1	CARE2-USKM2B-1	N/A	108%
ABTH2- UPPB2-2	TREM2A-USKM2A-1	CARE2-USKM2B-1	N/A	108%
CILF2B-UPPB2-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	108%
ABTH2- UPPB2-2	CARE2-USKM2B-1	ABTH2-TREM2A-1	N/A	108%
ABTH2- UPPB2-2	USKM2B-USKM2C-1	ABTH2-TREM2A-1	N/A	108%
ABTH2- UPPB2-2	USKM2B-WHSO2-1	ABTH2-TREM2A-1	N/A	108%
BAGB2-SWAN2-1	CARE2-COWT2A-1	ABTH2-TREM2A-1	N/A	108%
BAGB2-SWAN2-1	COWT2A-PYLE2-1	ABTH2-TREM2A-1	N/A	108%
ABTH2-COWT2A-1	BAGB2-SWAN2-1	ABTH2-TREM2A-1	N/A	108%
ABTH2-TREM2A-1	CILF4-IMPP4-1	CARE2-USKM2B-1	N/A	107%
CILF2A-UPPB2-2	USKM2A-USKM2-1	CARE2-USKM2B-1	N/A	107%
CILF2A-UPPB2-2	TREM2A-USKM2A-1	CARE2-USKM2B-1	N/A	107%
CILF2A-UPPB2-2	USKM2A-WHSO2-1	CARE2-USKM2B-1	N/A	107%
ABTH2-TREM2A-1	IMPP4-MELK4-1	CARE2-USKM2B-1	N/A	107%
CARE2-USKM2B-1	CILF2A-UPPB2-2	ABTH2-TREM2A-1	N/A	106%
CILF2A-UPPB2-2	USKM2B-USKM2C-1	ABTH2-TREM2A-1	N/A	106%
CILF2A-UPPB2-2	USKM2B-WHSO2-1	ABTH2-TREM2A-1	N/A	106%
CILF4-IMPP4-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	106%
IMPP4-MELK4-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	106%
IROA2-WHSO2A-1	USKM2-WHSO2-2	USKM2B-USKM2C-1	N/A	105%
CILF4-IMPP4-1	WHSO4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
CILF4-IMPP4-1	CILF4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
CILF4-IMPP4-1	SEAB4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
ABTH2- UPPB2-1	ABTH2-TREM2A-1	CARE2-USKM2B-1	N/A	105%
RASS4-WALH4-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	105%
CILF4-WHSO4A-1	IMPP4-MELK4-1	CARE2-USKM2B-1	N/A	105%
IMPP4-MELK4-1	SEAB4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
IMPP4-MELK4-1	WHSO4-WHSO4A-1	CARE2-USKM2B-1	N/A	105%
ABTH2- UPPB2-2	CARE2-COWT2A-1	TREM2A-USKM2A-1	N/A	104%

ABTH2- UPPB2-2	COWT2A-PYLE2-1	TREM2A-USKM2A-1	N/A	104%
ABTH2- UPPB2-2	ABTH2-COWT2A-1	TREM2A-USKM2A-1	N/A	104%
PEMB4-WALH4-1	USKM2-WHSO2-2	USKM2B-WHSO2-1	N/A	104%
IMPP4-MELK4-1	RASS4-WALH4-1	CARE2-USKM2B-1	N/A	104%
ABTH2-TREM2A-1	BAGB2-SWAN2-1	CARE2-USKM2B-1	N/A	103%

Notes on Transmission Circuit Overloads

The pre-fault criteria

This has been met for both stages of this Statement of Works, therefore this criteria will not delay the connection of any embedded generation. (See note on VE-route area.)

The post-fault criteria

Under Connect and Manage it is possible to connect generation ahead of the works for the post fault criteria providing works to achieve full compliance are achieved as soon as reasonably practical and any resultant constraint costs are not excessive.

1. Base Case 2 Generation

All Base Case 2 generation can be connected as there are no overloads identified against this background.

2. Statement of Works Generation

It will be possible to connect all of this generation by the required date as the overloads can be managed effectively on a Connect and Manage basis ahead of works. However, to ensure costs are managed in the most economical way, as soon as reasonably practical National Grid will require a Modification Application (it must be within 90-days of this SoW response).

4. Fault Level Analysis

The table below shows the approximate headroom based on the worst-case National Grid owned circuit breaker at WPD controlled site, or any circuit breaker on a National Grid controlled site.

Table 8: Fault Level Summary for all GSPs

Site	Fault Level	Fault Type	Headroom	Notes
ABERTHAW	CB 280/410	Three Phase RMS	Greeter than 3kA	
CARDIFF EAST	CB 280/380	Three Phase Peak	1.4 kA	
MARGAM	CB 2T0	Three Phase RMS	1.63 kA	
PEMBROKE	CBs 130/120/180/280	Single Phase RMS	2.00 kA	
PYLE	CBs 180/280	Single Phase RMS	8.96 kA	
RASSAU	CBs 180/280	Three Phase RMS	2.66 kA	
SWANSEA NORTH	CB 480B	Three Phase RMS	2.21 kA	
UPPERBOAT 132 kV	N/A	N/A	Headroom is not limited by NG assets.	No NG circuit breakers at 132 kV site so the headroom is not limited by NG assets here
UPPERBOAT 33 kV	CB SG2/SG3	Three Phase RMS	8.04 kA	
USKMOUTH 275 kV	CB L45	Single Phase RMS	To be confirmed	
USKMOUTH 132 kV	CB 150	Single Phase RMS	Greater than 3kA	

Notes on fault level

Fault levels were modelled using the data provided by WPD for infeed at BSP level and the 132/66 kV equivalent for generation directly connected at these voltage levels.

The fault levels at all GSPs, with the exception of Uskmouth, were found to be within the rating of the relevant circuit breakers.

Uskmouth GSP

The original studies at this site showed fault levels at Uskmouth 275kV are already at nominal rating pre-connection of any generation in this statement of works. This indicated there is no headroom to connect any further DG in the Uskmouth GSP without management of generation infeed.

However, discussions with our Switchgear Technical Lead have confirmed that the circuit breakers being considered are capable of a higher rating than is currently used to assess them. Therefore it has been determined that the rating of these breakers can be sufficiently increased to ensure there is no limitation on the connection of embedded generation at Uskmouth. Therefore a Mod App is not required for this site to assess the fault level issues originally identified at Uskmouth. The fault level headroom will be updated when the new rating of these circuit breakers is confirmed.

All other GSP's

All generation in the Base Case 2 submission and Statement of Works submission can connect.

The fault level headroom at the relevant GSPs are shown in the table above, based on the limiting 132 kV circuit breaker either owned by National Grid on a WPD controlled site or any breaker on a National Grid controlled site.

5. Dynamic voltage Stability

The dynamic voltage stability limit has not been reached by the generation in this statement of works in the intact condition, although the additional DG at Pembroke will be behind an active stability limit during outage conditions.

The Pembroke site is known to be limited under outages conditions by dynamic stability issues. If some or all of the currently MITS connected generation projects connecting in the Baglan Bay or Pembroke connect these stability issues will increase and include the Swansea network. The current contracted position of this generation is indicated on the TEC register. Changes to this position in response to legislation and economics are likely. Depending on this outcome, it is therefore possible that a detailed stability assessment of this part of the network will be required. National Grid may need to request further data for this.