HM Government

Department of Energy
and Climate Change

South West RDA

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

SEVERN TIDAL POWER

Grid Study Non-Technical Summary

MARCH 2010

INDICATIVE IMPACT OF A SEVERN TIDAL POWER GENERATION SCHEME ON THE NATIONAL ELECTRICITY TRANSMISSION SYSTEM

1. Background

The potential impact of a tidal generation project in the Severn Estuary on the transmission system was last assessed in any detail in the 1980's. As part of the Severn Tidal Power Feasibility Study launched in 2008, an up to date study was required, and National Grid were commissioned by DECC in February 2009 to undertake the engineering studies.

National Grid are the owners and operators of the high voltage transmission system in England and Wales, as well as the operators of the transmission system in Scotland. National Grid is required to develop and maintain the transmission system in accordance with the National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS).

To identify the actual transmission works that would be required to connect any generator, and to obtain a contractual connection date, it is necessary to submit a formal connection application to National Grid. National Grid would then undertake the engineering studies required to identify the transmission reinforcements, given the background of other generation developments that have already contracted with National Grid, and the associated transmission reinforcements and other works already planned. The works required and the associated connection date National Grid can offer an applicant are therefore heavily dependent on the time the connection application is submitted, and the contracted generation background that exists whilst the application is assessed. A connection application submitted on one day could potentially result in a very different connection date than an identical application a month, or in extreme cases a day, later.

A formal connection application would normally be submitted to National Grid when a project developer has a firm understanding of their project's requirements and specification, and the necessary financial resources to take on the liabilities that are part of a signed connection agreement with National Grid. As we are only at the stage of looking into feasibility of a number of Severn Tidal projects, it is not sensible or practical to submit a formal connection application to identify the transmission works at this time, not least because it would not be possible or desirable to accept a contract offer and the associated liabilities.

Therefore, National Grid have been commissioned to undertake studies, similar to those that would be carried out for a connection application, however, the works identified and connection dates are **purely indicative** and are not contractually firm. Note – the contractual connection dates in signed transmission connection agreements are subject to consent delay e.g. if there is a new line required for a generator, and the consenting process is delayed, then the generator's connection date would normally also be delayed.

The capital costs of any transmission connection or reinforcement works undertaken by National Grid would normally be borne by National Grid. The Grid costs would therefore not be included in the capital cost of the tidal generation project. National Grid would make the investments, build and commission the assets, and then recover the allowed remunerations in accordance with the regulatory arrangements, via the locational transmission tariffs. These tariffs are paid by the owners of new generators once they commence operation.

Although the Grid costs are not borne by the generation developer, the developer is liable for these costs if the project is cancelled and the costs and investments become redundant and stranded. To cover this liability, a generation development is required to provide the appropriate financial securities, which will increase over the construction programme.

It should be noted that the cost of the electrical connections between the generators and the National Grid substation e.g. the cable circuits from a barrage or lagoon into a Grid substation, would be borne by the project developer and not National Grid. This equipment would be part of the generation connection and built and owned by the tidal generation project developer. It would not be part of the main interconnected transmission system.

2. Scope of the Grid Study

National Grid were asked to study a representative large Severn tidal generation scheme, and a representative smaller scheme. They were not asked to study every option as this would add to the cost, and as the results could only be used to provide an indication of the likely impact, it was felt that the results from the two representative schemes could be extrapolated to the other schemes with a sufficient level of information.

National Grid were asked to study the Cardiff-Weston barrage and the Shoots barrage . To better facilitate the extrapolation of the findings of this study for Shoots, across to the two land connected lagoons, a generation capacity figure of 1.36GW was selected for Shoots rather than the estimated capacity for the barrage generation of 1.05GW. The impact of the smaller Beachley option can also be assessed by studying 1.36GW. Studying the representative large and small options provided further efficiencies as these proposals have the best available technical data which National Grid require as an input to their studies.

3. Grid Study Conclusions

A non-technical summary of the Grid Studies is set out below for each of the studied options. The full report produced by National Grid is attached as Appendix 2 to this document.

3.1. B3 Cardiff-Weston Barrage

Two connection configurations were considered initially to connect the larger scheme. Option 1 involves splitting the output between England and Wales, and studies showed that dividing the output 50/50 gave the optimum solution. Option 2 involves providing additional transmission capacity between England and Wales by installing a new transmission cable across the barrage.

	Option 1 No Transmission across B3	**Option 2** AC Transmission cables across B3	**Option 2A** DC Transmission cables across B3
New Substations	12	10	10
New Overhead Line (km)	200	78	78
Uprating* existing overhead lines (km)	465	220	220
Cost (£m) in 2009 Prices	£2,349	£2,253	£2,256
Connection Period	2024-26	2021-23	2021-23

*Uprating an overhead line either means replacing the conductors with large higher capacity conductors, or operating the circuit at a higher voltage which again enables higher power flows. An example of voltage uprating would be converting a 275kV overhead line to operate at 400kV.

The key differences between Option 1 and 2 are the lengths of new overhead lines (OHL) and the indicative connection period. Option 1 includes a new OHL running from north Somerset down towards Southampton on the South Coast, which adds cost and significant risk to the project, and a longer construction programme for the transmission works. Option 2 creates a stronger network between South Wales and the South West of England by providing an additional transmission connection across the barrage, avoiding the need for a new OHL to the South Coast. Option 2's costs are slightly lower than Option 1 reflecting the reduced requirement for OHL, offset in part by the large cost for the transmission cables across the barrage. Cables are much more expensive per MW of capacity than an overhead line, therefore a relatively short section of cable can be comparable in cost to a much longer section of overhead line of similar capacity.

Whilst Option 2 significantly reduces the estimated requirement for new OHL compared with Option 1, because of the impact it has on the overall network, it has an adverse affect on stability i.e. how the rotating generation in the locality behaves and interacts when there is an incident. If serious instability occurs generation could be disconnected, or damaged, with the potential for a transmission system failure over a wide area.

With this concern that Option 2 had created a problem with stability, National Grid developed Option 2A, a variant of Option 2, which involves establishing the new transmission cables across the barrage as a Direct Current (DC) connection, rather than the standard Alternating Current (AC) type in Option 2. Option 2A is estimated to cost £3m more than Option 2 (in 2009 prices).

3.1.1. Stability

The stability problems observed in these studies are caused primarily by the relatively low value of the inertia constant for the type of generation that is anticipated would be used. The inertia constant is a measure of the rotating mass of the individual generator and turbine. Should a large tidal generation scheme be taken forward in the Severn Estuary, detailed design studies would be required both by National Grid and by the project developers to identify the optimum generation design and deliver the least cost overall solution. This is one of the key risks that would need to be managed. Indeed, it would be recommended that further detailed design work to establish the maximum potential inertia constant should be initiated to inform any future formal connection application.

3.1.2. Voltage and Fault Level Assessments

In order to maintain the system voltages at the right levels during fault scenarios, in accordance with the NETS SQSS, the Grid report has identified the potential requirement to install 12 capacitor banks at 5 locations for Option 1 (2700MVArs) and 16 capacitor banks at 6 locations (3600MVArs) for Option 2 and 2A. MVArs are units of reactive power: Mega Volt-Amperes Reactive. Capacitors provide coarse voltage control and when switched in, they increase the voltage.

In addition, a possible need for 2 static VAr compensators (SVCs) at Nursling near Southampton was identified for both Option 1 and 2. These devices provide dynamic automatic voltage support and can either help increase or reduce voltage.

The fault level studies carried out by National Grid show the possible fault current, and compares this with the known capability of the equipment at the substations. This shows 9 substations that may have equipment that could require replacement for Option 1. For Option 2 this increases to 15 substations. Option 2 is higher due to the stronger network created with the additional circuits across the barrage, which therefore reduces the system resistance to the fault current.

No costs have been included in the Grid report for possible equipment changes because of higher estimated fault levels as, in many cases, it will be possible to confirm higher capabilities for the equipment and therefore avoid the cost of replacement. This would however require more detailed studies and assessments which would be done if a tidal generation project was taken forward.

Replacing switchgear at a substation, if it is required, is expensive and can be extremely complex and protracted, due to the potential need for construction work at a live site, and/or the interaction with other customers e.g. if the substation has a generator or distribution network operator connected.

There is therefore a significant risk both to the cost of the transmission works, and the overall completion date if new works are required, as such equipment replacement would need to be completed before the new generation could operate.

In addition to the impact on the National Grid substations, the studies have flagged up the potential need to replace equipment owned by Distribution Network Operators (DNOs). For both Option 1 and 2, 4 DNO substations have been identified. If it is estimated that the replacement of a 132kV substation costs in the order of £15m-£25m depending on location, size, and complexity, then the costs attributable to Option 1 or 2 could be as high as £100m.

Under the current commercial rules, such costs imposed on a Distribution Network Operator caused by a new generation connection would be recovered directly from the generator. Therefore, unlike the transmission costs which would be borne by National Grid, the DNO costs would be passed through to the generation developer.

3.2. B4 Shoots Inner Barrage

The connection of 1.36GW near Avonmouth would require a significantly reduced amount of transmission connections and wider reinforcements than the much larger B3 Cardiff-Weston option. The studies suggest that the optimum connection location would be to the new Aust substation, that would be required by 2018 for earlier new generation connections, including the 3.3GW of new nuclear generation at Hinkley Point. The Aust substation would be just north of the old Severn road bridge, on the English side of the estuary, near to where the existing cable tunnel under the Severn comes up at a sealing end compound on to overhead lines.

Aust is the preferred connection point even though the existing Seabank substation is closer to the proposed site of the Shoots barrage. This is because a connection into Seabank would require significant works including a new overhead line, which makes a connection into Aust more economic and efficient.

In addition to a new substation at Aust, a short length of new overhead line would be required to increase the number of circuit connections into Aust from 4 to 6.

3.2.1. <u>Voltage and Fault Level Assessments</u>

The Grid voltage studies indicate that the Shoots connection may only need a single new 225MVAr capacitor bank at Melksham and no SVCs.

The fault level studies showed the possibility of 4 National Grid substations potentially exposed to fault currents in excess of their capability. Adopting alternative operational switching arrangements could reduce this number down to a single substation (Cardiff East).

3.2.2. <u>Stability</u>

The stability concerns for the smaller Shoots barrage are much less than the larger B3 Cardiff-Weston barrage. The Grid studies conclude that any stability issues can be addressed relatively easily, although a higher inertia constant remains preferable.

4. <u>Changes to the Generation Background</u>

National Grid were asked to assess the impact of Severn Tidal generation against a generation background that would be established at the start of the engineering studies. They have however noted in their report, that there have been some significant changes to the generation background whilst the studies were underway, with additional generation signing connection agreements at Oldbury and Seabank. The report gives an indication of the possible impact of these changes, but this has not been studied in detail, and is outside the scope of the assessment.

It is an option to ask National Grid to revisit their detailed studies with the new generation in the background, however, this would incur additional cost, and there would be the strong possibility that further changes to the generation background would occur during the new study period.. If the Shoot's barrage or other options were to proceed, by the time a formal connection application was submitted, there could be zero, one or two new nuclear stations contracted to connect to the transmission system at Oldbury.

Similarly, the contracted generation background that National Grid has used, which follows the same process that would be used to assess any formal connection application, could contain generation that may be delayed or potentially may never be built. It could also contain generation that still has a live connection agreement and for which no contractual notice of disconnection has been received, but which ultimately could have closed prior to the connection of the new generation being assessed. In order for National Grid to study any connection, it is necessary to fix the assumed generation background at the start, and in doing so, accept that there is no right answer, and to also accept that the conclusions are only indicative and could change as the generation background evolves. The primary objectives of the Grid Study were to produce an indicative cost and connection date for the tidal generation schemes, and to register risks and issues that would need to be managed if any project is taken forward. The objective was not to definitively determine the actual works that would be required.

At this time, therefore, there are no plans to request any additional work from National Grid.

5. Extrapolation of Results to other Options

The five shortlisted schemes are listed below together with their installed capacity as indicated in the Phase One consultation, with the exception of L3d Bridgwater Bay lagoon, which uses the higher installed capacity identified in Phase 2 of the study.

Scheme	Installed Capacity (GW)
B3 Cardiff-Weston Barrage	8.64GW
B4 Shoots Barrage	1.05GW
B5 Beachley Barrage	0.63GW
L2 Welsh Grounds Lagoon	1.36GW
L3d Bridgwater Bay Lagoon	3.6GW

5.1. B3 Cardiff-Weston Barrage (8.64GW)

This option was studied as part of the Grid assessment and does therefore not need to be the subject of any extrapolation.

5.2. B4 Shoots Barrage (1.05GW)

This option was studied as part of the Grid assessment and does therefore not need to be the subject of any significant extrapolation, although the lower installed capacity compared with that studied would have a minor impact. It would for example confirm the need for only a single generator connection circuit from the barrage located south of the new Severn road crossing, into the National Grid transmission substation at Aust, just upstream of the old Severn road bridge, on the English side. As explained earlier, the cost of cabling from the barrage to the Grid substation would be borne by the project developer and not National Grid, as it would be part of the generation connection, not the main interconnected transmission system.

5.3. B5 Beachley Barrage (0.63GW)

The proposed site of the Beachley barrage is upstream of Shoots, and is situated very close to the connection point into the transmission system for the Shoots Barrage, at Aust. An installed capacity of 0.63GW would require a single connection circuit into the Aust substation. The wider system reinforcements can be no more than those identified for Shoots. However, in reality they are likely to be a subset of the Shoots works. The transmission works for Beachley can therefore be completed in the same timescales as the works for Shoots.

5.4. L2 Welsh Grounds Lagoon (1.36GW)

At 1.36GW, the effect on the transmission system of the L2 lagoon can be considered as comparable to the assessment for the Shoot's barrage at 1.36GW, however there is a potential difference in the initial connection point of the generation i.e. into England or Wales.

The Grid report notes that as things stand, any connection above 50MW into South Wales would trigger reinforcements to the existing 400kV cable circuit under the Severn, with the likely requirement for a new cable tunnel, costing an estimated £100m. In addition, to connect the new generation from the Welsh Grounds Lagoon, it would be necessary to construct a new National Grid owned transmission substation on the Welsh side, with a cost estimated to be in the order of £20m.

If a formal connection application was submitted to National Grid for a connection of a Welsh Grounds lagoon, it would be necessary to assess what would be the most economical and efficient overall connection arrangement i.e. taking account of both the generator connection costs and the Grid costs. If therefore it is more efficient to offer a connection into a substation at Aust, then National Grid would be obliged to provide a connection to the English side rather than on the Welsh. At this stage however, the design of the lagoon has assumed that the connection would be on the Welsh side. This is an issue that would need to be investigated further if this option is taken forward.

The Grid report estimates the completion date for the transmission reinforcement to be between 2019 and 2021 for the Shoots barrage. With a connection to the Welsh side, the additional works would introduce additional programme risk as well as additional work which could therefore result in a later completion date. At this stage it is felt that this additional work could be constructed within the existing estimated period for completion of the works of 2019-2021. However, the programme would be at higher risk of delay than without the additional works.

This risk could be mitigated if the option of a direct connection from the lagoon generation across the estuary (e.g. via a subsea cable) into a substation on the English side at Aust was selected. This decision would however require further detailed engineering work, if this option was taken forward.

5.5. L3d Bridgwater Bay (3.6GW)

The point of connection into the transmission system is likely to be at one end of the lagoon or another i.e. near Brean Down/Weston-super-Mare, as with the Cardiff-Weston option, or further south at Hinkley Point. Conceivably, the output could be split between each end, depending on cabling and associated costs and the location of the turbines.

The study of 4.32GW connecting into the South West of England showed the requirement for extensive reinforcements between Hinkley Point and the south coast around Southampton. This includes a new overhead line from Bridgwater in north Somerset down to Nursling near Southampton (approximately 125km), and the reconductoring of the existing circuits from Hinkley Point down towards Exeter and then around toward Southampton and Portsmouth. It can be assumed that these works would also be required for L3d with an installed capacity of 3.6GW. As these works are the main driver for the three year difference between the completion dates for the transmission works for B3 Cardiff-Weston Options 1 and 2, it is unlikely that the completion date for the L3d works could be much earlier than the 2024-26 estimated for B3.

The reinforcement works west of London identified for Option 1, are unlikely to be required for this option, as it is triggered by the combined effect of the 4.32GW connecting into Wales and the 4.32GW connecting in the South West of England.

6. National Grid ENSG 2020/2030 Studies

As part of the Government and Ofgem led Energy Network Strategy Group (ENSG), National Grid, in a separate process from the studies for the Severn Tidal feasibility study, has been looking at how the transmission system would need to be developed to accommodate generation scenarios anticipated for 2020 and 2030. In these studies, no specific assumption has been made for tidal generation in the Severn in 2020, however the 2030 forecast does make an assumption of 1.5GW.

As can be seen above, the transmission reinforcement works identified for the Shoots 1.36GW connection is relatively low, and this is consistent with the 2030 assessment.

It is not possible to compare the reinforcement costs indicated by this study for the Severn, with the costs estimated in the ENSG work. This is because the large amounts of new renewable wind generation are dispersed geographically, and would therefore not all be inputting to the same part of the transmission system, and will not all be operating at full output simultaneously. A large tidal scheme such as the B3 Cardiff-Weston barrage will operate often at peak output, and the network will need to be designed to cope. It would be expected that a detailed study looking at the concentrated peak output from a large tidal scheme will show a larger Grid reinforcement cost than compared to an equivalent amount of dispersed wind generation. It should also be noted that offshore wind has significant offshore transmission costs which would be less of a factor in the assessment of the Severn tidal options, For the avoidance of doubt the estimated costs of the electrical connections from the barrage or lagoon on to land and the onshore substation are included in the overall project costs.

7. Implications of cabling across barrage

Option 2 includes transmission cables running across the barrage, and whilst there would be alternatives to using the barrage as a cable route, such as overhead lines, or a separate cable tunnel, indicative costings have been produced to estimate the incremental cost of modifying the B3 Cardiff-Weston barrage to include a dedicated and secure cable tunnel for the transmission cables. This includes the cost of the cable route across the locks.

In 2008 prices, the incremental civils cost to provide a cable tunnel route across the B3 Cardiff-Weston for the 400kV cable circuits described in the Grid Report, is estimated to be £81m.

8. Conclusions

The table below summarises the indicative conclusions for each of the five shortlisted options. Bandings have been used for the costs to reflect the indicative nature of the cost estimates and in some cases their extrapolated basis.

The specific risks to the transmission works are also included in the table below, with all the options exposed to the two key risks of uncertainty regarding the inertia constant of the generation, and changes to the generation background. Further detail on the transmission reinforcement related risks and issues that would need to be managed if a Severn Tidal generation project is taken forward are summarised in the next section.

Tidal Option	Installed capacity (GW)	Network costs	Likely window for connection	Option specific major risks to transmission costs and programme
B3 Cardiff-Weston Barrage (Option 2A)	8.64GW	£2-2.5bn	2021-2023	• High fault levels trigger additional works
B4 Shoots Barrage	1.05GW	£0-500m	2019-2021	
B5 Beachley Barrage	0.63GW	£0-500m	2019-2021	
L2 Welsh Grounds Lagoon	1.36GW	£0-500m	2019-2021	• Additional works required for connection into Wales and upgrading Severn cables
L3d Bridgwater Bay Lagoon	3.6GW	£500m-£1bn	2023-2025	• The closure of Hinkley B generation or changes to the planned new nuclear stations at Hinkley would have a major impact on the level of transmission works required .

9. Risks and Issues for consideration in any future studies

Reference	Description	Impact	Action
GRI1	It may be more economic to connect the Welsh Grounds lagoon directly into Aust substation. National Grid must pursue lowest cost solution overall.	Higher capital cost for generator to fund cable across estuary.	Ensure overall cost is factored into option appraisal.
GRI2	Substations identified with high possible fault levels cannot be uprated at zero cost and must be replaced instead	Higher Grid costs and extended construction programme for the Grid works – therefore delay to connection	For any project being taken forward, submit formal connection application at earliest opportunity to obtain connection date that is firm against fault level risk
GRI3	Major redesign of transmission works and generation is required due to transient stability issues caused by low inertia constant.	Higher costs and programme delay	For any project being taken forward, commission detailed technical and engineering studies to identify maximum and optimum inertia constants for Severn tidal generation
GRI4	Generation background uncertainty	Actual connection date for a real project could be much later than indicated in this study due to other changes to National Grid's contracted generation background	If a tidal generation project is taken forward, a formal connection application should be submitted at the earliest opportunity so that a contractually robust connection date can be confirmed.

APPENDIX 1

TECHNICAL BACKGROUND

For any new generation project requiring a connection to the transmissions system in England and Wales, National Grid must determine what connection and wider reinforcement works are required to ensure the transmission system remains compliant with the NETS SQSS.

The NETS SQSS set out what credible events the transmission system should be capable of withstanding. These events are a set of credible faults or planned outages of key transmission system components, for which the transmission system must be able to cope. There are a number of different effects each fault or outage could have, and each of these must be studied to ascertain the potential impact and identify the necessary network reinforcement.

The key effects that must be considered for a new generation connection are:

- Thermal – during an event and with the particular part of the transmission system out of service (either due to a planned or forced outage) the power flows should not exceed the rating of the circuits (overhead lines or cables) or other equipment, which is defined by the thermal capacity of each component;
- Voltage – The voltage following an event should not exceed certain upper and lower limits and also should not change by more than a given percentage. This requirement is designed to maintain acceptable voltage quality to domestic and commercial electricity users and to ensure loss of supply does not occur due to unsustainable voltages;
- Stability – the imbalance between electrical and mechanical energy that occurs within generation during credible fault conditions. Stability of generators should be maintained to avoid damage to individual generators, and also to prevent the spread of instability causing a major transmission system failure over a wide area;
- Fault Levels – To prevent damage or catastrophic failure, the very high fault level currents that flow for a split second before a fault is removed by automatic operation of circuit breakers, should not exceed the rating of the equipment.

Stability

Conventional transmission connected generators produce alternating current which means that the output from the generation is cycling up and down very fast, and this is seen in the power supplies in our homes which cycle up and down roughly 50 times a second. During normal operation, the sources of generation need to be synchronised to the transmission system. However, during an incident such as a fault there is the potential for generators to become decoupled from the synchronised transmission system, and in extreme situations, machines can accelerate excessively causing damage if they are not able to disconnect themselves quickly enough. With a strong, heavily interconnected transmission system, and large, heavy generating units, the generation is able to ride out an incident without sustained instability occurring. For B3, because of the large number of relatively small machines, this is not the case, especially under Option 2, and therefore Option 2A has been developed involving the use of a Direct Current transmission connection, which enables this dynamic situation to be controlled.

A DC connection requires converter stations at each end of the cables to convert between the standard network AC and DC. The converter stations are likely to be indoor facilities with a larger footprint than the indoor substations already required. The technology required to convert between AC and DC (referred to as Voltage Source HVDC) is currently only in service at lower levels below 1GW so technological developments would be required to provide the equipment with the necessary larger capability.

The DC Option 2A is identical to Option 2, with the exception of the replacement of the standard AC cables across the barrage, with the smaller DC cables, but with the additional converter stations mentioned above. A smaller cable is required to transmit the same amount of power using DC than AC. With the reduction in cable costs offset by the cost of the converter stations, the estimated cost of Option 2A is £3m more than Option 2 (in 2009 prices).

Even with the use of a DC connection across the barrage, the stability of generation remains marginal, and the underlying cause of which is primarily the low inertia constant of the barrage generation. The inertia constant is a measure of the rotating mass of the generator and turbine and is relatively low for the type of units anticipated to be used. The Grid report looks at other solutions to improve stability such as faster fault clearance times, and the use of reactive compensation, however although these techniques do reduce the severity of the problem, based on the results of these studies, installing machines with an inertia constant of at very least 1.5MWs/MVA is an absolute minimum requirement. In the studies a value of 0.82MWs/MVA has been used.

The inertia constant of generation is something that can be designed into the equipment, but only up to a point, as there will be technical limits as to how large this can be. There is evidence that similar machines with an inertia constant this high are feasible, however detailed design and modelling of the generators and turbines would be required to confirm that machines capable of operating in the Severn, can be built with a suitable inertia constant. Generally, the inertia constant for this type of hydro generation is relatively low compared with other generators, due to the implications on the design of the slow rotational speed of the machines.

Fault Levels

National Grid undertook fault level studies to assess the likelihood of transmission equipment requiring replacement due to the higher fault levels caused by the connection of the new tidal generation. When there is a fault, extremely high currents flow to the fault, before the automatic systems identify the fault and open the necessary circuit breakers to isolate the fault from the rest of the transmission system. Before this automatic protection can operate, for a split second, equipment can be exposed to the high fault currents and must be capable of withstanding these currents, and in the case of circuit breakers, operating safely to stop the current flowing.

APPENDIX 2

Attach Grid Report v1.4

Department of Energy and Climate Change. www.decc.gov.uk