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Gwynt Y Mor
Ex-AnteTechnical Review

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On behalf of Ofgem E-Serve

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EXECUTIVE SUMMARY

The Gwynt y Mor wind farm will be located 13 to 15 km off the north coast of Wales and covers an area of approximately 79km^2, extending from Penrhyn Bay in the west to Prestatyn in the east. When complete the wind farm will have a total installed generation capacity of 576MW and is due to be completed by the end of 2014. The project is being developed by Gwynt y Mor Offshore Wind Farm Limited (GMOWL) which is owned and financed by three shareholders under an Unincorporated Joint Venture ("UJV"), namely RWE Innogy (60%), Stadtwerke Munchen (30%) and Siemens AG (10%). All three shareholders are financing the project on their respective balance sheets. The project will be engineered, procured, constructed, operated and maintained by RWE Npower Renewables Ltd, a wholly owned subsidiary of RWE Innogy ("RWEI").

The transmission assets proposed for transfer to the Offshore Transmission Owner (OFTO) comprise two offshore substations each with two 132/33kV transformers, four 132kV export cable circuits and onshore 132kV and 400kV infrastructure comprising two 400/132kV auto-transformers plus a spare 400/132kV auto transformer, 132kV and 400kV GIS switchgear, reactive power compensation and harmonic filtering equipment. The onshore OFTO infrastructure will connect to National Grid's new Bodelwyddan 400kV substation near St Asaph. The OFTO transmission assets are under construction and are due to be completed and commissioned by the end of 2012/early 2013 ready for commissioning of the first wind turbine in April/May 2013.

This report provides a technical review of the Gwynt y Mor transmission assets which covers overall project design philosophy, technical compliance of the proposed offshore infrastructure with industry codes and standards, procurement process and installation progress to date. Ofgem has carried out a review of the OFTO connection asset costs provided by GMOWL and has advised that there are no outlying costs. This being the case Ofgem has no requirement for a bottom up cost assessment of any of the main component parts of the OFTO assets.

The aim of DNV KEMA's technical review is to establish whether the general design process and approach followed by GMOWL is reasonable and representative of good practice design, review the procurement process applied and establish with GMOWL the installation progress. The review undertaken has considered all relevant technical and procurement information provided by GMOWL to Ofgem and DNV KEMA, up to and including 14 Sept 2012.

Technical Review of the Gwynt y Mor Offshore Transmission System

The technical review undertaken by DNV KEMA has been based on the selected relevant project information provided by the developer to Ofgem and DNV KEMA including the GMOWL

Information Memorandum and various technical documents available in the GMOWL data room. In addition, the developer was also asked to respond to questions developed specifically to seek clarifications and / or explanations and relevant evidence in support of the most important design and planning issues that arose during project development. It should be noted that much of the information required for the review was not present in the developer data room and hence had to be requested.

The high level technical review of the GMOWL Transmission Assets conducted by DNV KEMA has concluded that GMOWL has adopted and implemented a standard engineering design process which has been reasonably well documented and can be considered representative of widespread and good practice design internationally. The engineering design philosophy of the offshore transmission assets that was carried out by the developer and the design specification of the related electrical works that was finalised by the preferred contractor for provision of electrical works, Siemens Transmission and Distribution Ltd (STDL), resulted in a well thought through and fit for purpose design of the offshore transmission infrastructure.

Based on various relevant design and planning information provided to and reviewed by DNV KEMA, the following specific observations can be made in relation to the adopted design process, design philosophy and overall project compliance:

- The project overall design engineering process followed a standard well established and recognised design approach starting with the conceptual design (e.g. consideration of feasibility options and topologies) and following through with the full technical and functional specifications and required system studies. Evidence of review meetings at key stages in the project development has not been established.
- The offshore transmission network layout, export cable transmission voltage and ratings and overall electrical infrastructure design and equipment ratings underwent detailed analysis in terms of their viability and techno-economic optimisation. As a result, the design of the proposed offshore transmission infrastructure appears well justified and fit for purpose.
- All relevant offshore equipment has been specified to international or national standards.
- Where relevant information has been made available the offshore transmission system is compliant with the planning criteria and connection requirements specified in industry framework documents including the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), System Operator and Transmission Owner Code (STC) and Grid Code.

Based on various relevant tender assessment reports and contract information provided to and reviewed by DNV KEMA, the following specific observations can be made in relation to the adopted procurement process:

- GMOWL has adopted a multi-package procurements strategy where the procurement of each major package followed a strategy of investigating the supply market and then holding a pre-qualification phase. Tenders were then either carried out in one or two phases to establish the most favourable commercial terms prior to awarding a contract or appointing a preferred bidder to further develop the scope of work and commercial terms.

- The strategy adopted for the offshore marine export cables was a separate cable supply and cable installation contract in order to gain the best commercial terms overall.
- The GMOWL 400kV bay works at the new NGET Bodelwyddan 400kV substation were in place with NG as a single tender action.
- The offshore substation topside transportation and lift package was to be carried out by RWE's Seabreeze II jackup vessel which in 2010/2011 was still under construction. The vessel was expect to be handed over to GMOWL in November 2011, however, the vessel required substantial remedial works and it was confirmed the vessel would not be ready until summer 2012. To mitigate delays to the topside installation and other related packages GMOWL went to the market for the topside transport and lift package. Maintaining the installation programme meant that only two suitable vessels were available and GMOWL received bids from both parties, SHL and Scaldis [redacted]
- [redacted]
- The only substantial design variation after the award of a contract was on STDL's Electrical System package where an issue with the 29th harmonic voltage distortion is being addressed by changing the 400kV cables from the two 400/132kV auto

transformer to the 400kV switch bays to a larger cross sectional cable to alter the capacitive characteristic of the 400kV network.

1 INTRODUCTION

1.1 Background

The Gwynt y Mor wind farm will be located 13 to 15 km off the north coast of Wales and will have a total installed wind turbine capacity of 576 MW. The project is being developed by Gwynt y Mor Offshore Wind Farm Limited (GMOWL) which is owned and financed by three shareholders, RWE Innogy, Stadtwerke Munchen and Siemens AG.

The wind farm will comprise 160 Siemens Wind Turbine Generators (WTG) each rated at 3.6MW. This turbine type is based on pitch regulated power control and employs an induction generator which is connected to the grid through a voltage-sourced converter (VSC). Each turbine is connected to the 33 kV inter-array cable network via a 0.69/33kV step up transformer[1]. Two offshore substation platforms (OSP) have been built, each containing two 132/33kV, 160MVA transformers, a two section 33kV bus-bar, 33kV switchgear, and auxiliary equipment. Each of the offshore grid transformers is directly connected to a 132 kV export cable. At the onshore substation the four export circuits connect to a 132kV double busbar substation. Two 400kV/132kV auto transformers which have a 13.9kV tertiary winding connect the wind farm to the new NGET Bodelwyddan 400 kV substation near St Asaph where GMOWL own the two 400kV GIS switch bays. The 13.9kV tertiary winding of each super grid transformer connects an SVC PLUS reactive compensation plant which is a combination of two mechanically switched capacitors (MSC), two mechanically switched reactors (MSR) and a static electronic compensator which utilises VSC (Voltage Source Converter) technology and provides dynamic compensation control. A filter is connected to each of the two sections of the 132kV substation designed to reduce 5th harmonic voltage distortion.

For contingency cases e.g. loss of a 400kV circuit the 132 kV onshore busbar interconnector can be used to interconnect the two 132 kV busbar sections. If there is a 132kV busbar section failure then the substation can be reconfigured to utilise the reserve busbar of the double busbar arrangement to restore the wind farm connection to the 400kV connection point.

Four 132kV cables are used to link the two OSPs (one cable per 132/33kV transformer) to the 132kV onshore substation. The two 132kV export circuits from the East wind farm offshore

[1] Details from STDL report "Detailed Load Flow Study SVC PLUS, RWE Doc No. GM01-STDL-0110-EN-001016446-01, Siemens, dated 8 May 2012, Rev 3".

substation connect to one 132kV busbar section with the two 132kV circuits from the West wind farm offshore substation connecting to the other 132kV busbar. The approximate cable circuit lengths are:

- Platform-to-shore connections consisting of four 132kV cables, two cables from the East Substation (each 22.4km in length) and two cables from the West Substation (each 19.0km in length), giving a total cable length of 82.8km (subject to final route engineering). These circuit elements are constructed using 1 x 3core 1000mm^2 XLPE insulated marine cables with aluminium conductors.
- The onshore cables link the subsea cables to the onshore 132kV substation. The onshore connections will consist of 4 underground 132kV circuits, each 11km in length. These circuit elements are constructed using 3 x 1core 500mm^2 XLPE insulated cables with copper conductors.

The new onshore 132kV substation is located at St Asaph next to the new NGET Bodelwyddan 400kV substation where the two 400kV GIS switch bays form part of the OFTO asset transfer. The 400kV and 132kV substations are connected by two 400/132kV auto transformers located at the GMOWL 132kV substation with 400kV cable circuits connecting the auto transformers to the 400kV GIS switch bays. Reactive compensation in the form of Static Var Compensation (SVC) units and mechanically switched capacitors and inductors is provided via a tertiary connection on each auto-transformer. Harmonic filters will also be installed on each of the two 132kV substation busbar sections in order to comply with Engineering Recommendation G5/4-1 harmonic and emission requirements[2].

The OFTO ownership 400kV circuit boundaries[3] are proposed to be the gas barrier between the isolator gas zone and the circuit buffer gas zone, GMOWL presently own the zone between the busbar gas zones and circuit breaker gas zone. The 33kV ownership boundary will be at the busbar clamps of 33kV circuit breakers (Generator owned) on the LV side of offshore grid transformers (TX5, TX6, TX7, TX8).

All of the OFTO offshore assets and wind farm assets will be within UK territorial limits and the asset layout is illustrated in Figure 1.

[2] Engineering Recommendation ER G5/4-1, ``Planning levels for harmonic voltage distortion and the connection of nonlinear equipment to transmission systems and distribution networks in the United Kingdom'.

[3] RWE document STC Part 12,Services Capability Specification Guidance Notes Reference: Part 3 – 4.3. Substation Operational Guide 1 SUBSTATION OPERATIONAL GUIDE Substation: Gwynt y Mor (132kV) prepared by RWE. Draft for comment.

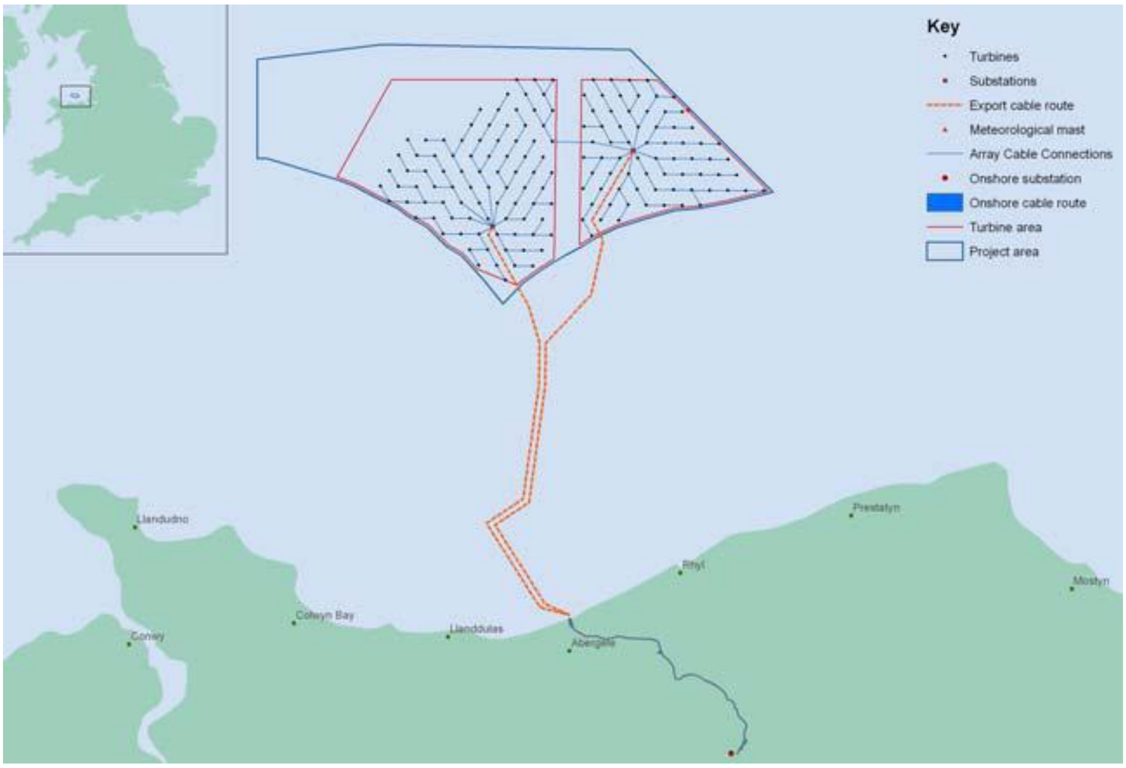

Figure 1: Location of the GMOWL Wind farm *(source: Ofgem)*

1.2 DNV KEMA Terms of reference

1.2.1 Objective

Ofgem commissioned this technical review in support of its own analysis and assessment on whether the costs associated with developing and constructing the GMOWL transmission assets that will transfer to the OFTO are economic and efficient. The review here is intended to inform Ofgem's decision on the indicative transfer value for the GMOWL transmission assets that will be set at the Invitation to Tender (ITT) stage of the tender process for Tender Round 2 ‘Tranche A’ projects.

The review incorporates the following aspects:

1. Design Philosophy

- Offshore transmission network layout and design engineering; including options that were considered for the design, preferred option and rationale, audit trail for decision making and influences i.e. connection points, marine cable landing points, external factors such as planning constraints etc;

- Export Cable design and rating; documentation to back up the design parameters, supporting information regarding the cable route as well as consideration of environmental factors;
- Electrical infrastructure design and equipment rating; supporting information e.g. harmonic studies, redundancy in design, reactive power studies, future operations and maintenance activities; and
- The rationale for the 132/400kV spare transformer.

2. Offshore Transmission Asset Review

- Description of the assets including the onshore substation, offshore substations and export cables, and whether a unique and novel solution was required i.e. driven by external factors;
- Compliance with industry codes e.g. international/national standards and NETS SQSS; and
- Installation progress.

3. Review of GMOWL procurement process

- Identify the main contracts and the timeline and chronological overview of the procurement process;
- GMOWL criteria for assessing tenders, decision making factors that influenced choosing contractors e.g. cost, service etc;
- Tender assessment for the transmission assets;
- Post contract award, were there any substantial design changes; and
- Conclusions on the overall procurement process.

4. Cost Analysis

- Where cost outliers are identified, carry out a bottom up cost review.

Ofgem has indicated that there are no cost outliers associated with the Gwynt y Mor assets to be transferred to the OFTO, hence, no bottom up cost assessments have been carried out.

For the purpose of this review, various relevant project information provided by the developer to Ofgem and DNV KEMA is relied upon and includes:

- Preliminary Information Memorandum[4],

[4] Preliminary Information Memorandum, Gwynt e Mor Offshore Transmission Assets, November 2010, Ofgem Eserve.

- Relevant project information available in the GMOWL data room including various technical, commercial and planning documents. It is noted that many of the technical and tender assessment documents were not available in the data room and were requested directly from GMOWL.
- GMOWL's supporting information provided in response to DNV KEMA's request for information or clarifications of certain project issues. This included the majority of the technical documents reviewed.

1.2.2 Scope and Approach

DNV KEMA’s approach for assessing this transitional project has been designed to confirm:

- Technical and operational compliance including the project engineering design process, design philosophy and ‘fit for purpose’ design.
- The suitability of the procurement process adopted for the main packages associated with the assets to be transferred to the OFTO.

Whilst some of the information with respect to technical and procurement data is available in the GMOWL Information Memorandum[5] and data room, it was necessary to obtain more in-depth knowledge of the engineering design process and design philosophy in particular. This was achieved by asking the developer to respond to an initial list of questions and information requests followed by a meeting with key GMOWL team members on 3 September 2012 at RWE's office in Swindon. From the discussions at this meeting a further list of actions to address further DNV KEMA questions and data requests was produced. During the writing of the draft report a further list of questions and data requests was provided to GMOWL. GMOWL has responded to the requests and actions promptly and, in the majority of cases, has provided the information requested.

During the course of this assessment, no additional modelling, simulation of individual components or physical testing has been undertaken. Areas requiring clarification or further information have been identified and are noted in this report.

[5] Information Memorandum Gwynt y Mor Offshore Transmission Assets, January 2011.

2 TECHNICAL REVIEW OF OFFSHORE TRANSMISSION SYSTEM

This section provides a high level review of the design philosophy and overall design for the GMOWL transmission assets currently under construction. This review has been based on the following selected relevant information provided by GMOWL and Ofgem to DNV KEMA:

- Information Memorandum[6];
- Data room documents including
  - Relevant planning consents and associated supporting documentation; and
  - Maps and the design single line diagram.
- Other relevant supporting information requested by DNV KEMA and provided by GMOWL including:
  - internal design notes produced by GMOWL e.g. justification for a spare onshore transformer, justification for not constructing a 132kV cable link between the two offshore substations;
  - Early design and feasibility studies commissioned prior to the appointment of the electrical systems contractor STDL;
  - Detailed design proposals and system studies undertaken by the electrical systems contractor, STDL; and
  - Detailed design studies carried out by other contractors and consultants.

2.1 Design philosophy

DNV KEMA notes that the design of the GMOWL transmission assets have undergone a comprehensive and reasonably well documented design engineering process. The early project design and feasibility study documentation was developed at the time of various planning and consent applications, up to 2007/2008. At this time the planned wind farm capacity was 750MW, however, following these studies GMOWL decided to reduce the wind farm capacity to 576MW in order to optimise project economics[7]. While much of the early design information was deemed adequate some early design work was revised as explained in a recent project note[8.] from GMOWL. The designs were firmed up by the appointed onshore and offshore substation contractor STDL who then went on to produce detailed design studies for the transmission connection.

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[6] Information Memorandum Gwynt y Mor Offshore Transmission Assets, January 2011.

[7] RWE document, "Gwynt-y-Mor Choice of Offshore Transmission Technology Summary of Decision Process", rev 01, 20 August 2012.

[8] RWE document "Gwynt-y-Mor Choice of Offshore Transmission Technology Summary of Decision Process", rev 01, 20 August 2012.

The design life is specified as 20 years for the offshore substation and 40 years for the OFTO onshore substation[9].

For the purpose of this review, a high level overview of the overall design engineering process including the offshore transmission network layout(s), cable transmission voltage and ratings and overall electrical infrastructure design and equipment ratings is presented below.

2.1.1 Offshore Transmission Network Layout and Design Engineering

During the conceptual phase of the project development, several feasibility options were put forward and analysed in detail for the 750MW wind farm including 132kV connections with 3 OSPs, 154kV connections with 2 OSPs, 220kV connections with 3 OSPs and two HVDC connections[10,11]. The preferred (optimal) option was selected based on comprehensive technical, economic and procurement related considerations and the 132kV connection option was adopted. NGET were employed to carry out a substation location feasibility study which included identifying cable landing point options and onshore cable routes[12]. The recommendations from this report were largely adopted including the recommended substation location, landing point and onshore cable route. Further detailed studies were carried out to firm up the cable route[13] which was inspected in even greater detail when preparing the planning applications. On moving to a 576 MW wind farm after 2008 the 154kV and 132kV connection options were revisited and the decision to use 132kV connections re-confirmed but with two OSPs[14].

The design basis, information and scope of work for the main electrical contract was developed by GMOWL and first issued for tender in December 2008 based on the original 750MW capacity. The design basis and scope were updated based on bidder queries and to reflect the move to a 576MW wind farm and re-issued for tender in July 2009. [redacted]

[9] Information Memorandum Gwynt y Mor Offshore Transmission Assets, January 2011.

[10] NPower Renewable Report, " Gwynt y Môr Offshore Wind Farm Front End Engineering Design (FEED) Study", WP05 ELECTRICAL AND GRID CONNECTIONS Stage 1 Report, 9 July 2007, Issue 2.

[11] ABB report," Feasibility Study for Offshore HVDC Link to Connect 750 MW Wind Farm", dated 28/6/2004, document No. 1JNL100100-684.

[12] NGET Connection Feasibility Report for Gwynt e Mor, 2005

[13] HAI report, "Gwynt Y Mor Feasibility Study For Onshore Cable Route", dated November 2006.

[14] RWE design note, " GyM's Offshore Transmission System Note on 132kV verses 155kV a.c. Issue 1, 16th June 09

From this point STDL continued on to produce the detailed designs for the electrical network. The final issue of the design basis and scope of work was agreed with STDL and issued on 15 June 2010[15].

2.1.2 **Export Cable Design and Rating**

There is evidence in the data room that contracts were placed for geophysical and geotechnical surveys to enable the optimum cable route to be selected between landfall and the wind farm including:

- Agreement for Array Cable and Offshore Export Cable Geotechnical and Geophysical Site Investigation with OSIRIS HYDROGRAPHIC & GEOPHYSICAL PROJECTS LIMITED.

As part of these studies, due recognition has been made of seabed conditions and cable crossings with an existing pipeline and the Rhyl Flats offshore wind farm export cable.

The design rating for the four export circuits is identified as 655Amps. Continuous cable rating design is impacted by many factors for a given cable including burial depth, ambient temperature, soil resistivity, proximity to other cables and how hot they run, running through ducts or J tubes etc. The route area identified as having the greatest impact on the continuous cable rating impacts the marine cables as they pass under the coastal rail line at the landing point heading to the transition joints with the onshore cable circuits. The original plans appear to have been to directional drill and insert ducts at a depth of 5m below the railway line. However, GMOWL has indicated that due to stability concerns regarding the rail line the burial depth was increased to 10m. Detailed calculations by the marine cable supplier NKT has estimated the best continuous cable rating of the installed cable under the rail line is 611Amps using a suitable backfill material[16]. NKT has also calculated that 100% full load design rating (655A) can be sustained for 11000hours, starting at the temperature reached at 75% load after 11000hours and then reaching the 90^{o}C cable temperature limit. GMOWL has confirmed that after considering the anticipated wind profile, and resultant load profile for selected wind turbines GMOWL was in no doubt that the selected export cable cross-sections were adequate for the anticipated load profile of the wind farm. [17].

[15] RWE document, GWYNT-Y-MOR OFFSHORE WIND FARM Electrical System Contract Employer's Requirements Part B - Technical Requirements GYM-GMOL-CMP-SP-01752-2-APP, issue 3, 15 June 2010.

[16] NKT "Gwynt y Mor, As Built Ampacity Calculations" doc no. 1245638, dated 8/3/2012, rev 1

[17] Email from RWE to DNV KEMA date 11 Sept 2012.

A comprehensive set of in-house load flow[18] and short circuit calculation studies[19] was also undertaken in order to determine the required cable parameters. The aim of these studies was to clarify various technical and/or compliance issues associated with the transmission connection design to include load sharing, load balancing, voltage profile, fault level and reactive power provision etc.

The onshore reactive generation is to be a mixture of continuously controllable SVC (+/- 50MVAr)) with mechanically switched capacitive (MSC) and reactor (MSR) elements. With the network in normal configuration, the SVC scheme is capable of meeting reactive power requirements, in accordance with the Interface Point (IP) capacity; equivalent to 0.95 power factor leading and lagging at IP capacity.

These in-house load flow and fault level studies served as the basis for the main cable design requirements that have subsequently been finalised by the cable contractors (NKT for marine cables and Prysmian for onshore cables).

2.1.3 Electrical Infrastructure Design and Equipment Rating

The electrical infrastructure contractor Siemens Transmission and Distribution Ltd (STDL) has completed and reported extensive system studies conducted in order to finalise the electrical design for the onshore and offshore system. These detailed studies aimed to confirm initial basic design requirements, firm up equipment ratings and demonstrate compliance with relevant codes and standards. They include the following reports that have been reviewed by DNV KEMA:

- Early harmonic studies (3 revisions from November 2010 to July 2011);
- Load flow study (4 revisions from Feb 2010 to May 2012);
- Short-circuit calculations (4 revisions from Feb 2010 to Feb 2012);
- Propagation of background harmonics(October 2011);

Also the following reports forming part of the STDL contracted scope of work which DNV KEMA has not received but that GMOWL has confirmed have been completed[20].

- Wind turbine harmonic generation study;

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[18] Detailed Load Flow Study SVC PLUS, RWE Doc No. GM01-STDL-0110-EN-001016446-01, Siemens, dated 8 May 2012, Rev 3.

[19] Siemens report "Short Circuit Study, Gwynt y Mor Offshore Wind Farm", RWE EcoDoc Reference: GM01-STDL-0110-EN-001016449-01, rev 3, dated 3 February 2012.

[20] Email from RWE to DNV KEMA dated 19 Sept 2012.

- Switching transients and insulation coordination;
- Earthing study;
- Voltage fluctuation study;
- Transient and dynamic stability study;
- Electromagnetic interference;
- System Power Losses Study; and
- Grid Code and STC Compliance Study

The base design case has made provision for onshore filters in order to meet Engineering Recommendation G5/4 harmonic limit requirements. To comply with the 5th harmonic voltage distortion limit specified by NGET, 5th harmonic filters have been designed and connected to each of the two 132kV substation busbar sections. There is also an issue with the 29th harmonic voltage distortion identified which STDL are addressing by altering the capacitive characteristic of the short 400kV cables from the two 400/132kV transformers to the 400kV switch bays at the new NGET 400kV substation. GMOWL has advised that this design variation has still to be finalised.

Reactive Power Control

The strategy adopted for reactive power control is to control the wind farm and offshore components of the offshore transmission network to a constant reactive power desired value. This desired value, measured at the 132kV side of the respective 400/132kV super grid transformer (SGT), has been selected to optimise the sizing of the onshore static VAr Compensation (SVC) scheme. As such, the reactive power compensation scheme can be considered in two operational parts:

1. Onshore Constant Reactive Power Scheme
2. Interface Point Voltage Control Scheme

Dealing with each in turn:

Onshore Constant Reactive Power Scheme

During normal operation (aka normal running arrangement), the 132kV measurement point is controlled, via the Wind Turbine Generators (WTG) of the wind farm, to a constant reactive power desired value of 27MVAr. This scheme consists of a Siemens Wind Power High Performance Park Pilot (HPPP), acting as a 'Master' controller onshore and two 'Slave' HPPPs per Power Park Module (PPM) offshore (One PPM = One 33kV bus section). Ordinarily, in normal arrangements, the HPPP associated with SGT1 will communicate with the Slave HPPP on the East platform and the HPPP associated with SGT2, with the HPPP on the West platform.

The capability to configure the HPPP rests with the wind farm operator and operational liaison will be necessary with the transmission network operator to change configurations and/or desired values, in accordance with the running arrangements. The overall HPPP control structure is shown in the Figure 2 below.

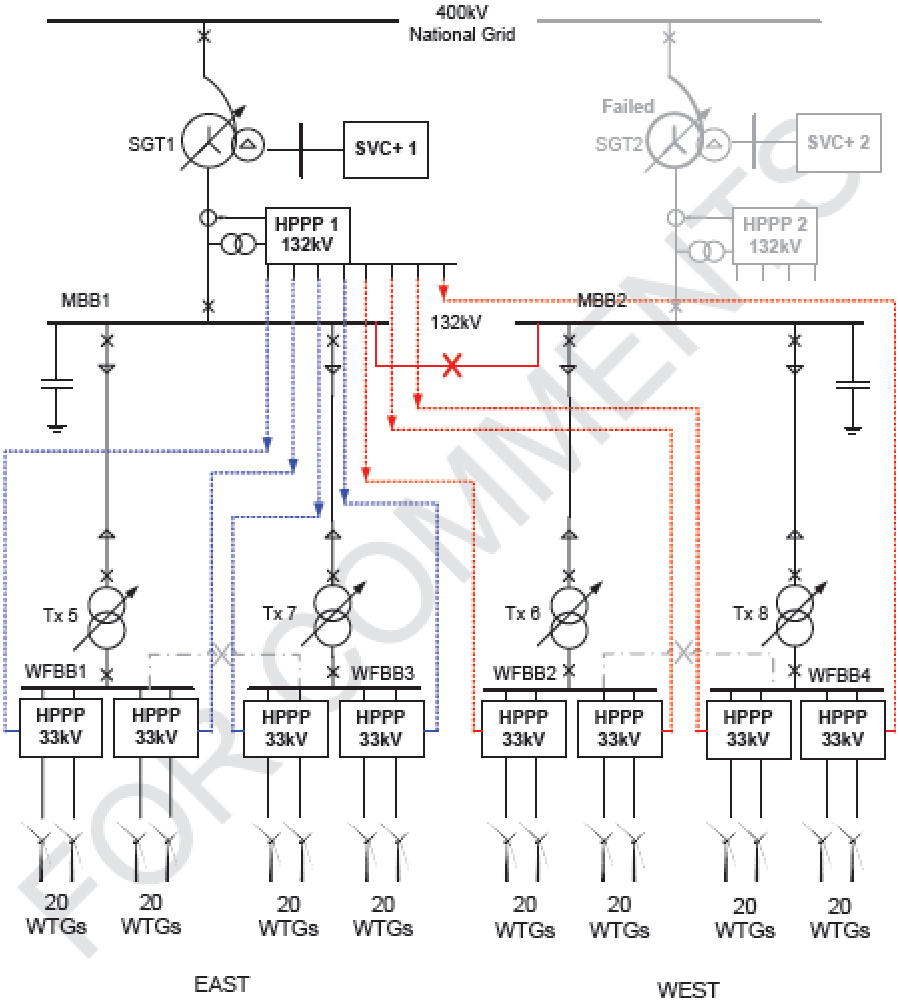

Figure 2 High Performance Park Pilot (HPPP) Arrangement Schematic

It should be noted that ability to deliver the desired value of constant reactive power is associated with WTG being in service and generating. Under conditions of ‘No Wind’, for instance, this is not possible and control reverts to the delivery of unity power factor at the respective slave HPPPs associated with a PPM.

400kV Interface Point Voltage Control Scheme

The IP control scheme has been designed such that equipment will contribute to the control of voltage, at the Interface Point, as desired by the STC.

The SVC plant consists of a combination of switched static capacitors (2 off) and reactors (2 off), together with a Siemens SVC+ (STATCOM) of +/-50 MVAr. The scheme has been designed to provide a continuous and automatic contribution of reactive power in proportion to the voltage deviation. Proportional slope (droop) and target voltage can be set, via instruction to the OFTO, in accordance with STC requirements. With the network in normal configuration, the SVC scheme is capable of meeting reactive power requirements, in accordance with the IP capacity; equivalent to 0.95 power factor leading and lagging at IP capacity.

The SVC scheme will provide proportional voltage control action continuously, regardless of active power generation levels. Leading capability will be restricted below 20% active power output due to necessity of compensating for cables. It is anticipated that lagging export capability will be maintained.

STDL carried out extensive load flow studies to identify operational boundaries of the reactive compensation scheme under extreme conditions and the following operational points were noted from the resulting report[21]:

1. Noted that with no wind and the harmonic filters and array cables connected and an SGT out of service then the number of 132kV export cables connected has to be limited to two to meet the grid code VAr requirements using the single remaining SVC. Connecting a third export cable via the emergency back feed circuit would mean the STC requirements would not be fully met. This is an operational issue for NG as the operator to manage.

   GMOWL has advised that for all running arrangements compliance with the STC can be maintained, however in the extreme scenario described operational action is an additional consideration. Under no wind conditions, the Wind Farm (WF) controls the offshore grid entry points (GEPs) to unity power factor, that is the WF becomes a neutral reactive power load; leaving the SVC installation to compensate the offshore transmission network and fulfill the STC requirement for unity power factor at the IP. If there is then a fault with the offshore transmission network (such as loss of the SGT) this needs to be managed operationally. GMOWL did not consider it to be economic or efficient to size the SVC for every contingency or to over design the WF to account for such contingencies.

2. Noted that under certain conditions there is a requirement for the generator to maintain a certain amount of turbines to provide sufficient voltage control to prevent an overload of the land fall cable section. This is based on a 655A design rating for the land fall cable.

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21 Detailed Load Flow Study SVC PLUS, RWE Doc No. GM01-STDL-0110-EN-001016446-01, Siemens, dated 8 May 2012, Rev 3.

It is noted from the NKT land fall cable ampacity calculations that this section of the marine cables has an estimated continuous rating of 611A and not 655A, however it could cope with 655A for 11000hrs at a starting temperature based on a 75% loading condition.

While this issue of cable ampacity is correct GMOWL wished to comment that the WTGs operate in reactive power control not voltage control. They vary their terminal voltage as the means of delivering or absorbing reactive power, but the High Performance Park Pilot (HPPP) controller is operating in reactive power control mode. Automatic tap change controls are applied to control the voltages at both the 33kV busbars offshore and the 132kV busbar onshore. A certain number of turbines are required to be in service to maintain the desired reactive power set-point. However it should be noted that both the STC and the Grid Code allows for depleted reactive capability with reduced plant in service. Thus if less than the necessary number of WTGs are in service the reactive power at the 132kV level increases and the absorbing capability at the IP is proportionately reduced. Under no wind conditions the offshore GEP is designed to control to unity power factor (no wind control of the WTG) and the SVC installation is sized to control the IP also to unity power factor (although it still operates in voltage control and will thus still have lagging (export capability)).

3. There are other operational issues, power asymmetry above 90% between 33kV bus sections that the wind farm operator needs to manage under certain extreme conditions. Also, STDL recommended to ensure that the voltage of the two 33 kV busbars which are related to the same onshore transformer do not differ by more than 1%.

4. For the calculation of the reactive power capability the SVC operating area was used. If the complete range of the reactive power capability is used for low 400 kV voltages, the current seen in the HV winding of the onshore transformer will be higher than the thermal limit. GMOWL has advised that the SVC has an output limitation function which will correct to keep the loading on the transformer within limits. This is particularly relevant for conditions of low 400kV voltage.

5. The reactive power concept of the wind farm includes that the WTGs will provide reactive power in order to optimise the rating of the SVC. The steady state voltage of the WTGs at the LV side of the WTG transformer has to stay within +/-5%. Therefore the range for the voltage of the 33 kV busbar is defined to be +/-1% in order to allow the WTGs to operate well within their limits. Calculations have been carried out to point to the consequences for the rating of the SVC if the 33 kV voltage is extended to +/-6%. The currents in the compensation plant under this scenario would increase to nearly 10kA which will exceed the rating of the SVC and also the rating of the tertiary winding of the onshore transformer (from the meeting with GMOWL on 3 Sept 2012 it was indicated

that the SVC limits itself to 95MVAr to avoid this). GMOWL has also advised that +/- 5% of the WTG terminal voltage is recommended by Siemens Wind Power as the design range; hence this was used in the load flow study. In operation the WTG terminal voltage can vary by +/- 8%. WTG terminal voltage is a controlled variable, based upon reactive power delivery at the 132kV point. The 33kV voltage is required to be controlled (by the 132/33kV transformer automatic tap changer control (ATCC)) to 1pu (+/- 1%) and within 1% asymmetry in order to efficiently deliver turbine reactive capability.

SCADA

Offshore transmission assets are planned to be operated from a stand-alone SCADA system that is independent of the Generator SCADA system. Each of the two offshore substations and the onshore substation are designed to have separate OFTO and Generator SCADA equipment rooms. The proposed Generator and OFTO SCADA systems are responsible for the supervision of all switchgear within the onshore and offshore substations, associated control and protection and various common facilities (e.g. fire and safety systems, diesel generators, battery back up systems etc).

Redundancy in electrical design

The offshore transmission system is designed according to the planning criteria defined in the NETS SQSS[22]. The standard requires that for the loss of a single AC transformer circuit on an offshore substation platform, the loss of power infeed shall not exceed 50% of the grid entry point capacity. This has led to the project design requirement for 2 x 50% rated transformers on each offshore substation, each connected to a 132kV export cable circuit to shore.

Each transformer picks up 50% of the output from each platform where each transformer has a design rating of 25% of the total output from the wind farm. The same can be said for the four subsea cables. For the loss of one of the 400kV onshore circuits or one of the two offshore substation platforms in its entirety, a minimum of 50% of the total output from the wind farm would need to be maintained in order to meet the requirements of NETS SQSS[23]. The project has been designed such that this condition is appropriately met (noting some operational requirements under extreme conditions when one SGT is out of service along with the associated SVC, discussed earlier).

The onshore 132kV busbar is, as per the requirements of the NETS SQSS, of double busbar type and therefore enables full export to be maintained on occurrence of a 132kV onshore busbar fault, i.e. following post fault re-configuration of the 132kV busbar connections. The

[22] National Electricity Transmission System Security and Quality of Supply Standard

[23] National Electricity Transmission System Security and Quality of Supply Standard

132kV busbar arrangements also allow up to all four offshore export circuits to be connected to a single SGT should the need arise.

As four independent 132kV cables connect approximately 25% of the installed capacity each, the ratings selected result in the need for a power constraint of up to a maximum of 25% should there be a failure of one offshore transformer or 132kV cable. At the offshore substation the two 33kV busbar sections, one per offshore transformer can be linked together should one transformer or export cable be unavailable. This arrangement allows the generation from the wind farm to be maximised up to the limit of the remaining 132kV export circuit and up to approximately 75% of the 576MW Transmission Entry Capacity (TEC). The 132kV substation arrangements combined with the 33kV link arrangements between 33kV busbar sections at each offshore substation avoids the need for 132kV busbars and switchgear at the offshore substations.

Performance and Availability

The developer has calculated availability of the OFTO assets to be between 98.4% to 99.7% depending on if the weather is good or bad and whether spare parts are available or not.[24] However, it is noted that these figures are for unplanned failures and do not account for planned unavailability due to plant isolations for planned maintenance.

To reduce unavailability due to unplanned events, GMOWL has procured spares for the transmission system, including spare onshore and offshore transformers and spare 132kV onshore and offshore export cable[25]. While the spare onshore transformer will be transferred to the OFTO, GMOWL plan to keep the offshore transformer. Also, it is indicated that there will be spare 132kV onshore and marine cable, however, no cable has been identified for transfer to the OFTO.

The spare 400/132kV transformer is located at the onshore substation to facilitate rapid replacement if required.

2.1.4 **Spare Onshore Transformer Justification**

A business case for the spare 400/132kV transformer based on the calculated risk and cost of lost energy from the wind farm has been made by GMOWL and shows a positive benefit to

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[24] Siemens report, " System Unavailability Analysis" document reference GM01-STDL-0110-EN-001016464-01, 30/3/2012, rev 02.

[25] Information Memorandum Gwynt y Mor Offshore Transmission Assets, January 2011.

purchasing the spare transformer[26]. It is noted that if the business case was made by an OFTO based on penalties for lost availability this may not show a business case for transformer purchase. GMOWL has indicated (verbally at meeting on 3 Sept 2012) that considering lost energy sales to the wind farm in assessing the business case was agreed by Ofgem.

It is noted that GMOWL deem the procurement of a spare transformer is not building above the NET SQSS requirements. GMOWL believe that all credible failure rates (FR) and mean times to repair (MTTR) support the purchase of a spare transformer, i.e. all combinations of FR=>1% and MTTRs=>3285hrs result in incremental lost energy valued of [redacted] (the cost of the spare transformer). GMOWL has also indicated that the onshore transformers are a non standard design and it is unlikely a spare would be available, hence a new transformer would require to be ordered taking 12 months (plus) to arrive at site.

2.2 Offshore Transmission Assets Overview

The simplified single line diagram for the GMOWL project is shown in Figure 3.

[26] GyM Spare Transformer CBA Note - 26th July 2012.pdf. (provided by Fiona Alexander of Ofgem in email dated 17 Aug 2012)

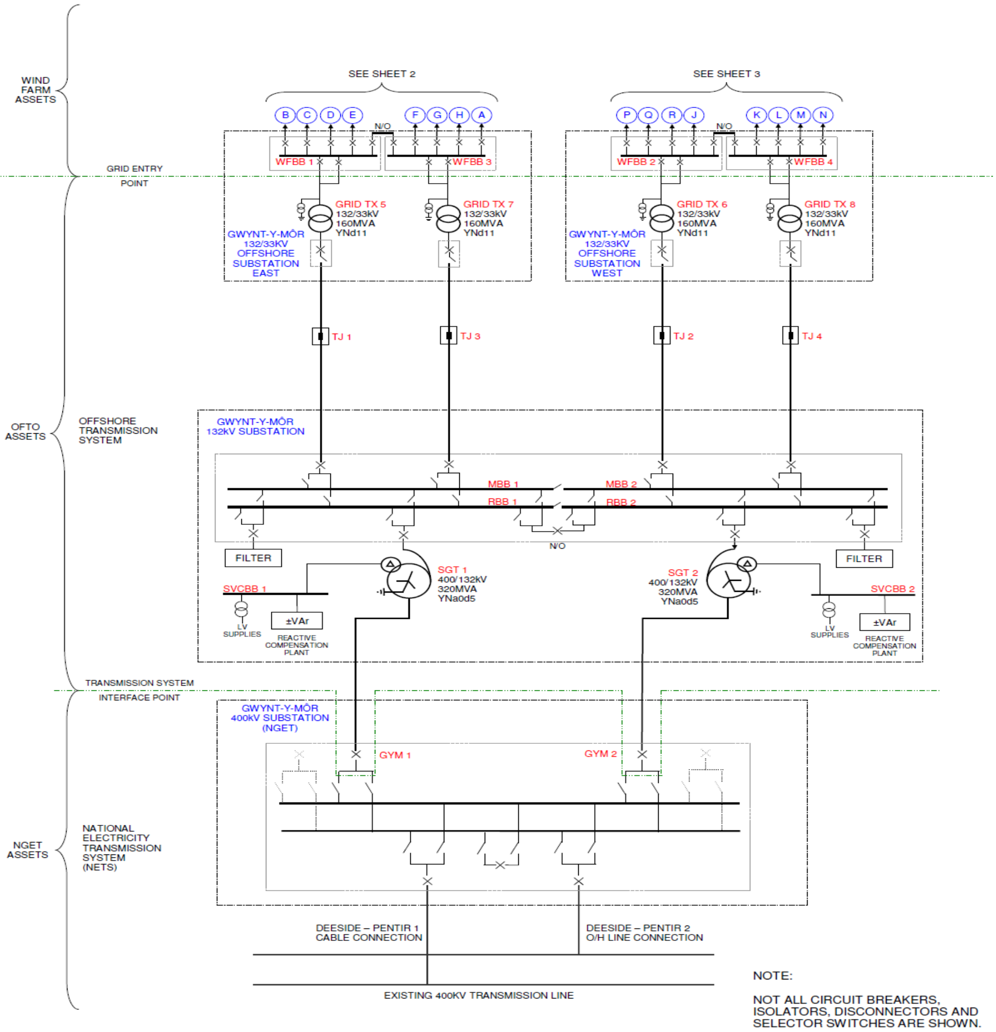

Figure 3: GMOWL simplified single line diagram *(source: Information Memorandum)*

A list of the main onshore and offshore transmission assets, proposed ownership and life expectancy is provided in Appendix C1. All electrical equipment has been specified to standards issued by the International Electrotechnical Commission (IEC) and International Organisation for Standardisation (ISO) as fit for the purpose intended and project compliant in that the equipment will meet the specified contractual 25 year[27] design life of the OFTO system.

2.2.1 **Offshore Substations**

Each OSP contains two 132/33kV 160MVA transformers each connected to a 33kV bus-bar with a link between the busbar sections which is run normally open. The 33kV feeders connecting the wind turbines are split equally between the two bus sections. The

27 Information Memorandum Gwynt y Mor Offshore Transmission Assets, January 2011.

OFTO/GMOWL boundary is located at the lower voltage terminals of the 132/33kV transformers.

The 160 Siemens 3.6MW turbines will be divided equally between OSP East and OSP West respectively. Each OSP has 8 outgoing wind turbine collection feeders, four per 33kV bus-bar section.

2.2.2 **Onshore Substation**

The OFTO onshore 132kV substation is adjacent to the new NGET 400kV Bodelwyddan substation which includes two 400kV GIS bays to connect the Gwynt y Mor wind farm.

The OFTO onshore substation includes two 400/132kV auto-transformers which are rated at 320MVA. A tertiary winding (13.9kV, 130MVA) is used on each transformer to connect approximately +110/-120MVAr of reactive compensation to meet both steady-state and dynamic Grid Code requirements. This level of compensation is made up from a SVC unit (of a multi-level VSC design marketed as SVC+ by STDL) and two additional mechanically switched reactors (MSR) rated at 55MVAr and two mechanically switched capacitors (MSC) rated at 30MVAr. The control strategy is such that the SVC can continuously operate over a ±50MVAr range and when required the MSR/MSC can be switched in to provide the full range (note that the reactive capability of the wind turbines is also utilised through the HPPP wind farm control system). The proposed ratings and control strategy of the SVC and MSR/MSC has been finalised by STDL to ensure that the Grid Code requirements can be met. Harmonic filters have also been installed (40MVAr Siemens C-Type) in order to ensure compliance with ER G5/4-1 requirements[28].

2.2.3 **Export Cables**

The 132kV export circuits are made up of onshore and offshore sections. For the former, each land feeder uses three 1000mm^2, aluminium, XPLE, single-core cables each with an approximate length of 11.1km. The submarine circuit uses 500mm^2, copper, XLPE, three-core cables, the cables to the East OSP being 22.4km in length and those to the West OSP being 19km. It is noted that the GMOWL marine cables will traverse the Rhyl Flats wind farm export cable and also a gas pipe.

[28] Engineering Recommendation ER G5/4-1, ``Planning levels for harmonic voltage distortion and the connection of nonlinear equipment to transmission systems and distribution networks in the United Kingdom'.

2.3 Compliance with industry codes and standards

The GMOWL project is designed as an integrated system, compliant with the current Grid Code requirements at the onshore connection point. DNV KEMA's assessment of the project compliance with the industry codes is provided in Appendix C2-C4. Where information has been provided, the project was found to be compliant.

All equipment has been designed with reference to international (EN, IEC, ISO), National Grid (NGTS) and national standards. Where EN, IEC or ISO standards have been adopted by British Standards then the BS EN version takes precedence.

2.4 Conclusions

A high level technical review of GMOWL transmission assets conducted by DNV KEMA has concluded that GMOWL has adopted and implemented a standard engineering design process which has been reasonably well documented and can be considered representative of a widespread and good practice design internationally. The engineering design philosophy adopted and the electrical design work initially carried out by the developer and finalised by the preferred contractor (STDL) resulted in a well thought through and fit for purpose design of the offshore transmission infrastructure.

Based on various relevant design and planning information provided to and reviewed by DNV KEMA, the following specific observations can be made in relation to the adopted design process, design philosophy, onshore substation design and overall project compliance:

- The project overall design engineering process followed a standard well established and recognised design approach starting with the conceptual design (e.g. consideration of feasibility options and topologies) and following through with the full technical and functional specifications and required system studies. Evidence of review meetings at key stages in the project development was not found.
- The offshore transmission network layout, export cable transmission voltage and ratings and overall electrical infrastructure design and equipment ratings underwent detailed analysis in terms of their viability and technical and economic optimisation. As a result, the design of the proposed offshore transmission infrastructure appears well justified and fit for purpose.
- All relevant offshore equipment has been specified to international or national standards.
- Where relevant information has been made available the offshore transmission system is compliant with the planning criteria and connection requirements specified in industry framework documents including the National Electricity Transmission System Security

and Quality of Supply Standard (NETS SQSS), System Operator and Transmission Owner Code (STC) and Grid Code.

3 PROCUREMENT

GMOWL has adopted a multi package contracting strategy for the Gwynt y Mor offshore wind farm. In relation to the OFTO transmission connection the following main packages have been tendered and awarded:

- Electrical Systems Package (ESP), awarded to STDL
- Onshore cable supply and installation, awarded to Prysmian
- Offshore cable supply, awarded to NKT
- Offshore cable installation, awarded to Global Marine.
- OSP Jackets design and fabrication, awarded to Burnt Island Fabrication (BIFAB)
- OSP Jacket installation, awarded to Seaway Heavy Lift (SHL)
- OSP topside transport and lift, awarded to SHL
- Two 400kV bays unlicensed works contract was placed with NGET.

3.1 Tender for the Electrical Systems Package

3.2 Onshore Cable Supply and Installation Package

3.3 Offshore Cable Supply Package

3.4 Offshore Cable Installation Package

3.5 OSP Jacket Design and Fabrication Package

3.6 OSP Jacket Installation

3.7 OSP Topside Transport and Lift Package

3.8 Two 400kV bays unlicensed works contract was placed with NGET.

3.9 Installation Progress at beginning of September 2012

Progress on the installation contracts was provided by GMOWL and is summarised in the following.

Offshore Substation Platform Foundations Design and Fabrication Package

The BIFAB design and supply contract is complete and has now been closed out, with final account discussions nearing completion.

Electrical System Package

Onshore Substation

STDL continue to progress the onshore works in line with their latest programme, which has all works completed by 14 December 2012. Work is nearing completion on the 132kV GIS switch room building, cold commissioning of the equipment and internal wiring of the building.

Offshore Substations

The East OSP was successfully installed over the night of the 14 August 2012. The West OSP was installed on 26 Aug 2012.

Onshore 132kV Export Cables Supply and Install Package.

All onshore cables have been installed by Prysmian. HV testing is planned to start 7 Sept 2012 on the onshore export cables. Reinstatement along the cable route is ongoing and all landowners have agreed how their land will be reinstated.

Offshore 132kV Export Cable Supply Package and Installation Package.

To date, approx. 9 km of the first export offshore cable has been laid by Global Marine. Cables 1 and 2 supplied by NKT are on the Global Marine Cable Enterprise vessel and the installation vessel has transited to the wind farm site. Cables 3 and 4 supplied by NKT are now loaded onto the Global Marine UR141 barge, which has transited to Liverpool. NKT are to provide additional support for jointing and ongoing maintenance.

Grid Connection

The National Grid 400kV Bodelwyddan Sub Station has now been adopted into NGET's Safety Rules. RWE NRL Safety Rules were implemented at St Asaph substation from 1200 hrs on the 10 August 2010. The 400kV circuits 1 and 2 up to the power quality monitoring VTs have been included within the Safety Rules Clearance Certificate (SRCC). First energisation of the circuits took place on 12 August 2012. NGET has been undertaking power quality monitoring (PQM).

Onshore Commissioning

The St Asaph substation Control Person Operations (CPO) role will be fulfilled by NGET up to sub station handover in December 2012, due to substation SCADA control system issues. NGET has agreed to this strategy, as it is a NGET project issue. The substation commissioning works are progressing to programme.

Offshore Commissioning

Offshore commissioning through diesel generators will commence shortly after the OSP topsides are installed.

APPENDIX A – TECHNICAL ASSESSMENT

Appendix A1. Electrical equipment and system design

Equipment	Owner	Type & ratings	Rating	Voltage	Life Expectancy (contracted or estimated)	Applicable Standards - see contracts for details	Quantity for both platforms	Design Comment
Shunt capacitors	OFTO		30MVAr	13.9kV	25 years	BSEN60871	4	reacitve compensation
Shunt reactors	OFTO		55MVAr	13.9kV	25 years	BSEN	4	reacitve compensation
SVC	OFTO		+/- 50MVAr	13.9kV	25 years	BSEN	2	reacitve compensation
Harmonic Filters	OFTO	Siemns C Type	40MVAr	132kV	25 years	BSEN	2	
Protection and control equipment (CVTs, surge arresters, post CTs)	OFTO		not known	not known	25 years	BSEN		
Miscellaneous (LV cable, lightning protection and earthing,).	OFTO		not known	not known	25 years	BSEN		Protection relays are likely to need replacement or upgrades after 15 to 20 years.
Auxilliary supply transformers	OFTO		500kVA	13.9/0.4kV	25 years	BSEN60076	2	
ac and dc supplies	OFTO		not known	400/230V ac.	25 years	BSEN	2	Batteries Life 10years
Manweb backup supply transformer.	OFTO		up to 250kVA	11/0.4kV	25 years	BSEN	1	
Back-up supply cable(s) from SP MANWEB LV board	OFTO		not known	400/230V ac.	25 years	BSEN	1	
Ancillary DC & UPS supplies including batteries and distribution switchgear	OFTO		not known	not known	25 years	BSEN		Batteries Life 10years
Central monitoring control scheme (CMCS)	OFTO		not known	not known	25 years	BSEN	2	
Communication network	OFTO	fibre optic	48 core at 132kV; 24	132kV and 33kV	25 years	BSEN		
Onshore NGET 400kV Substation OFTO Elements								
400kV breaker bays	OFTO	ABB ELK-3	4000A	420kV	40 years	NGTS	2	
400kV cables from CBs to TFRs	OFTO	not known	not known	400kV	40 years	BSEN		Size being selected to address 29th Harmonic voltage distortion issue.
400kV cable sealing ends	OFTO	not known	not known	400kV	40 years	NGTS		
400kV CTs and VTs for harmonic monitoring to 100th harmonic	OFTO	not known	not known	400kV	40 years	NGTS		

Appendix A2. National Electricity Transmission System Security and Quality of Supply Standard Compliance Assessment

NETS SQSS Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
1.14 to 1.25	Offshore Criteria & Methodologies	Ownership and boundaries of offshore transmission system components.	The OFTO ownership 400kV circuit boundaries are proposed to be the gas barrier between the isolator gas zone and the circuit buffer gas zone, GMOWL presently own the zone between the busbar gas zones and circuit breaker gas zone. The 33kV ownership boundary will be at the busbar clamps of 33kV circuit breakers (Generator owned) on the LV side of offshore grid transformers (TX5, TX6, TX7, TX8). Data from RWE document STC Part 12,Services Capability Specification Guidance Notes Reference: Part 3 – 4.3. Substation Operational Guide 1 SUBSTATION OPERATIONAL GUIDE Substation: Gwynt y Mor (132kV) prepared by RWE. Draft for comment.	Compliant	None
7.2.1	Maximum capacity of offshore PPM	Maximum of 1500MW	CEC 590MW, TEC 574MW. (BCA dated 9 August 2010)	Compliant	None
7.2.3	Distance GEP to IP	Maximum 100km	Longest offshore cable 22.4km All onshore cables 11.1km. Longest circuit Total 2 x 33.5kM. Information Memorandum.	Compliant	None
7.2.4	Length of any overhead line section	Maximum 50km	not applicable	Compliant	None
7.2.5	Offshore network configuration	Radial only	The transmission connections and LV cable arrays will be operated as radial circuits.	Compliant	None
7.8.1.1	Planned or fault outage of a single AC offshore transformer circuit	Where GEP capacity is 90MW+, planned or fault outage of a single AC offshore transformer circuit the loss of power infeed shall not exceed the smallest of either 50% of the offshore GEP or the full normal infeed loss risk (at present 1000MW for frequency deviations of greater than 0.5Hz for longer term)	Failure of a 132kV circuit will result in a 25% capacity reduction. Failure of a 400kV circuit or 400/132kV SGT will result in a 50% capacity reduction. With a main and reserve 132kV busbar, in the event of a busbar fault, the 132kV substation can be reconfigured to provide 100% capacity. Network single line diagram and Information Memorandum.	Compliant	None
7.8.1.3	Fault outage of single AC offshore	The loss of power infeed shall not	This scenario would result in a maximum 50%	Compliant	None
7.8.2.1	Planned or fault outage of a single DC converter	Loss of power infeed shall not exceed the normal infeed loss risk	not applicable	n/a	None

NETS SQSS Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
7.8.2.2	Fault outage of single DC converter on offshore platform during a planned outage of another DC converter	The loss of power infeed shall not exceed the infrequent infeed loss risk	not applicable	n/a	None
7.8.3.1 - 7.8.3.5	Loss of any single section of busbar or bus coupler circuit breaker	Not to exceed normal or infrequent infeed loss risk	The loss of any single section of busbar or bus coupler circuit breaker (132kV or 33kV) will not result in exceeding the infeed loss risk (normal or infrequent).	Compliant	None
7.9.1 to 7.9.2	Loss of AC or DC cable transmission circuit (between offshore platforms or between offshore platform and IP).	Not to exceed normal or infrequent infeed loss risk	The loss of the AC offshore cable transmission circuit (between offshore platforms or between offshore platform and IP) will not result in exceeding the infeed loss risk (normal or infrequent).	Compliant	None
7.10 to 7.12	Onshore Overhead Line Sections	Justification for a minimum number of overhead lines 132kV and above and infeed loss risk	not applicable	n/a	None
7.13	Onshore connection facilities (AC, DC, Busbar & Switchgear)	AC circuit requirements where GEP capacity is 120MW+ ; infeed loss risk for loss of onshore connections	not applicable	n/a	None
7.14	Background conditions with respect to active and reactive power output of the offshore power station	Active power output at the offshore GEP is equal to registered capacity. Reactive power output should be set to deliver unit power factor at the GEP and meet STC, Section K requirements at IP	Reactive power control will be delivered by the offshore windfarm and onshore reactor. Compliant at GEP as confirmed by STDL load flow studies, except for some extreme conditions.	compliant	None
7.15 - 7.19	Pre and post fault criteria with and without local system outage	Various	Steady state confirmed in STDL loadflow study, dynamic checks in STDL report "Transient and Dynamic Stability Study", ref GM01-STDL-0110-ES-001170925-01, rev 02, dated 25/4/2012..	compliant	None
7.20 & Appedix A Part 2	Switching Arrangements	Offshore and onshore substation (GEP & IP) configuration	Single line diagram.	complies	None
8.5 to 8.10	Demand Connection Criteria applicable to an Offshore Transmission System	Offshore power station demand connection capacity requirements; includes planned and unplanned contingency conditions and supply capacity following a secured event.	There is offshore power station auxiliary demand only which is derived from local substation supply provision and backed up by diesel generation.	Compliant	None
8.11	Switching Arrangements	Switching arrangements for demand groups	Switching arrangements do provide operational flexibility.	Compliant	None

NETS SQSS Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
8.12 - 8.15	Variations to Connection Designs	Demand connection design variation	Not aware of additional cost variations.		None
9	Operation of an Offshore Transmission System	Normal operational criteria and post-fault restoration of system security.	STDL Loadflow report. Also, GMOWL document, STC Part 12, Services Capability Specification Guidance Notes Reference: Part 3 – 4.3. Substation Operational Guide 1 SUBSTATION OPERATIONAL GUIDE Substation: Gwynt y Mor (132kV) prepared by RWE. Draft for comment.	complies	None
10	Voltage Limits in Planning and Operating an Offshore Transmission System	Planning and operational timescale voltage limits.	STDL Loadflow report	complies	None

Appendix A3. System Operator – Transmission Owner Code Compliance Assessment

STC Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
C Part 1: 3	Services Capability Specification	Provision of transmission services to NGET.	BCA agreement 9 Aug 2010. Noted that GMOWL did not ask to provide any auxiliary services inthere connection application or amendments and this is reflected in the BCA.	No agremment to provide services.	None
C Part 2	Transmission Outage Planning	Coordinated development of outage proposals and plans with NGET.	No information presented in this regard.	cannot comment	GMOWL to provide information.
C Part 3: 3	Requirement to Enter into an Interface Agreement	Connection Sites and new connection sites require a Transmission Interface Agreement or Embedded Transmission Interface Agreement as appropriate.	BCA agreement 9 Aug 2010 details many interface arrangements but no interface agreement made available.. Noted that GMOWL did not ask to provide any auxiliary services inthere connection application or amendments and this is reflected in the BCA.	cannot comment	GMOWL to provide information.
C Part 3: 5	Black Start	A TO shall comply with OC9.4 and OC9.5 of the Grid Code.	BCA indicated that black start is not required.	No requirement	none
C Part 3: 7	Provision of Training	As required to discharge obligations.	No information provided.	Apointed OFTO will be required to satisfy training needs.	None
D Part1: 2.1	Transmission Investment Plans	A TO shall develop and maintain a single investment plan for current year and subsequent 6 years.	No evidence provided of future transmission investment planning	This would be for the OFTO when appointed	None
D Part 1: 2.2.6.1	Transmission System Technical Criteria and Planning Assumptions	Compliance with: Connection Conditions 6.1, 6.2, 6.3 and 6.4. Planning Code 6.2.	See comments under Grid Code Compliance sheet.	See comments under Grid Code Compliance sheet.	See comments under Grid Code Compliance sheet.
D Part 1: 2.2.6.3	Transmission System Technical Criteria and Planning Assumptions	Compliance with Section K of STC.	STDL Load flow study report.	Studies indicate compliance	None
D 2.3	Co-ordination of Transmission Investment Planning	To consider the implication of planned changes NGET investment plans	No evidence that relevant future NGET investments plans have been considered/under consideration	This would be for the OFTO when appointed	None
D Part 1: 2.6	Connection Site Specification	Description of connection assets and clear boundary. Description of technical design and operational criteria.	GMOWL document, STC Part 12, Services Capability Specification Guidance Notes Reference: Part 3 – 4.3. Substation Operational Guide 1 SUBSTATION OPERATIONAL GUIDE Substation: Gwynt y Mor (132kV) prepared by RWE. Draft for comment.	Satisfactory	None

STC Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
D Part 1: 2.7	Transmission Interface Site Specification	as above	as above	Satisfactory	None
D Part 1: 2.8	Embedded Transmission Site Specification	as above	as above	Satisfactory	None
D Part 1: 3	Default Planning Boundary	Guidance on planning boundaries. Check appropriateness of developer proposed boundaries.	as above	Satisfactory	None
D Part 2: 2	NGET Construction Application	Requirement is to have a TO Construction Agreement	Latest constuction agreement provided is dated 10 Jan 2010.	compliant	None
D Part 2: 3	Construction Planning Assumptions	Issued to TO to assist in preparation of Construction Offer.	Appendix P in construction agreement, however, these assumptions are out of date. NGET assumed to have relevent assumptions but no documented	partially compliant	GMOWL to confirm up to date assumptions were passed to NGET.
D Part 2: 4	TO Construction Offer	Each TO that receives a NGET Construction Application must notify NGET if it intends to submit a TO Construction Offer.	n/a	n/a	n/a
D Part 2: 5	Acceptance of TO Construction Offer	Offer will remain open for at least 6 months.	n/a	n/a	n/a
D Part 2: 10	Communications Plant	NGET and TO to agree provision of communications equipment.	Information on control, protection and telephony communications provided. BCA, construction agreement, GMOWL electrical system package scope.	Complete.	None
D Part 2: 11 to 13	Site Rules	Provision of Safety Rules for all site types to be submitted prior to Completion Date of Construction Agreement.	NGET Operational Notification Compliance Checklist.	Complete.	None.
G 2.2	Transmission Owner Safety Requirements	TO shall comply with the relevant appendix of Operating Code 8 and Appendix 1 of the Connection Conditions of the Grid Code.	NGET Operational Notification Compliance Checklist. Indicates RWE safety rules have been sent to NGET and that NGET and RWE has agreed local safety procedures during commissioning and after commissioning is complete.	substantly complete.	None.

STC Reference		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
STC Reference	Reactive Capability and Voltage Control	Reactive power capability at the Interface Point may be provided by a combination of plant owned by the OFTO and plant owned by the generator(s).	Reactive power control will be delivered by the offshore windfarm and onshore reactor.	Design appears valid.	None.
K2.2 to 2.5 and Appendix B	Reactive Capability and Voltage Control	Active and reactive power transfer criteria at Interface Point. Also limit on control facilities.	STDL Loadflow report indicates the VAR scheme is compliant except for some extreme conditions.	Appears largely compliant	None.
K3	Fault Ride Through Capability	Wind farm must meet the fault ride through characteristics defined (refer to figure K2)	STDL report "Transient and Dynamic Stability Study", ref GM01-STDL-0110-ES-001170925-01, rev 02, dated 25/4/2012.	Compliant	None
K4	Additional Damping Control Facilities for DC Converters	Convertors must not cause sub-synchronous resonance and provide power system damping facilities.	not required in BCA	N/A	No compliance issue
K5	Frequency capabilities and signals.	Provide a local frequency measurement and comply with the active power output requirements across the defined frequency range (refer to figure K3)	This is in STDL scope of work but no evidence of compliance.	not assessed	GMOWL to provide details of compliance.
K6	Neutral Earthing Requirements	At 132kV and above the HV winding shall be star connected with suitable star point earth connection. Earthing and LV winding arrangement to comply with Grid Code CC 6.2.1.1 (b).	132/33kV transformer is star -connected with star point earthed; earth fault factor and voltage rise capabilities not known. Earth design study report is in STDL scope of work.	Insufficient information to assess full compliance.	GMOWL to provide details of compliance.
K7	Power quality requirements	Ensure that the wind farm meets the criteriaa set out in STC part D 2.2.6 in terms of interface points and perform waveform quality measurement when designing or making to offshore systems.	STDL carried out harmonic studies and subsequently designed harmonic filters.	complys	None

Appendix A4. Grid Code Compliance Assessment

Grid Code Reference (as stated in STC)		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
CC	**Connection Conditions.**				
CC6.1	NETS Performance Characteristics.	Requirements in relation to voltage variation, frequency variation, waveform quality, harmonic content and phase unbalance.	NGET Operational Notification Compliance Checklist. STDL report "Transient and Dynamic Stability Study", ref GM01-STDL-0110-ES-001170925-01, rev 02, dated 25/4/2012. 400kV substation has been energised including the 400KV connections to Gwynt y Mor.	Not clear if accepted as fully compliant based on information provided.	GMOWL will continue to work to energisation of OSPs by end of 2012.
CC6.2	Plant and Apparatus Relating to Connection Site.	Provision of earth fault factor and voltage rise, requirements for protection equipment and arrangements, settings, metering signals.	NGET Operational Notification Compliance Checklist. 400kV substation has been energised including the 400KV connections to Gwynt y Mor.	Appears to be substantially complete, still item open regarding pole slip protection if their is any.	GMOWL to close out item on NGET Operational Notification check list.
CC6.3	General Generating Unit Requirements.	Technical and design criteria and performance requirements for Generating Units, DC Converters & Power Park Modules (directly connected or embedded). Does not apply to small generators. Main points in STC Section K.	NGET Operational Notification Compliance Checklist. STDL report "Transient and Dynamic Stability Study", ref GM01-STDL-0110-ES-001170925-01, rev 02, dated 25/4/2012. 400kV substation has been energised including the 400KV connections to Gwynt y Mor.	Not clear if accepted as fully compliant based on information provided.	GMOWL will continue to work to energisation of OSPs by end of 2012 and first commissioing of WTGs starting April 2013.
CC6.4	General Network Operator and Non-Embedded Customer Requirements.	Technical and design criteria in relation to neutral earthing, frequency sensitive relays and operational metering.	132/33kV transformer is star -connected on 132kV side with star point earthed; proposed operational metering appears satisfactory; no info on frequency sensitive relays.	Appears substantially compliant	Check provision of underfrequency relays.
Appendix 1	Format, Principles and Basic Procedure to be Used in the Preparation of Site responsibility Schedules.	NGET to prepare schedules for new connection sites.	NGET Operational Notification Compliance Checklist. 400kV substation has been energised including the 400KV connections to Gwynt y Mor.	Compliant	None
PC	**Planning Code.**				
PC6.3	Planning standards in relation to Offshore Transmission System.	Appendix E lists technical and design criteria. Compliance with NETS SQSS, P28, P29, G5/4 and technical standards.	E.1 Compliance with technical standards	see Equipment & System Design sheet,	see Equipment & System Design sheet.
			E.2 Compliance with NETS SQSS	see NETS SQSS compliance sheet.	see NETS SQSS compliance sheet.
			E.2 Compliance P28 limit on voltage fluctionations.	no information	information to be provided by GMOWL.

Grid Code Reference (as stated in STC)		Requirement	Info Provided	Assessment Comment & Result	Compliance Action
PC6.3	Planning standards in relation to Offshore Transmission System.	Appendix E lists technical and design criteria. Compliance with NETS SQSS, P28, P29, G5/4 and technical standards.	E.2 G5/4 Harmonic Distortion Limits. STDL Filter design report.	Compliant	None
			E.2 P29 Voltage unbalance limits.	no information	information to be provided by GMOWL.
OC	**Operating Code.**				
OC8A	Safety Coordination on the E & W Transmission System.	Specifies the standard procedures to be used by Relevent E&W Transmission Licensee for the coordination, establishment and maintenance of necessary safety precautions.	None provided	Assume this is being complied with as STDL are liaising with NGET regarding the installation and commisioning interfaces between the GMOWL S/S and NGET S/S works.	information to be provided by GMOWL.
OC9	Contingency Planning.	Suport to Black Start and resynchronise with the network.	Bilateral Connection Agremment, 9 August 2010.	Black start facilities not required.	None
OC9.4	Black Starts	The implementation of recovery procedures following a total shutdown or partial shutdown.	Bilateral Connection Agremment, 9 August 2010.	Black start facilities not required.	None
OC9.5	Re-Synchronisation of Desynchronised Islands.	Requirements, strategies and planning for re-synchronisation following a total or partial shutdown.	Gwynt y Mor not allowed to operate islanded.	n/a	None