Appendix G

Meshed Ready Technical Requirements

This appendix defines the technical parameters that Proposers must follow to be considered "Meshed Ready" and capable of successful future interconnection with other Offshore Wind Generation Facilities in New York in the event that the New York State Public Service Commission directs the implementation of a Meshed Network. Terms that are capitalized but not defined herein have the meanings given to them in the body of ORECRFP22-1.

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Acronyms and Definitions

AC – Alternating current

C&P – Control and production

DC – Direct current

GIS – Gas Insulated Switchgear

HVDC – High voltage direct current

Meshed Implementation – The phase during which a project transitions from being Meshed Ready and connected to the onshore grid with its dedicated radial, to being integrated into a Meshed Network. The Meshed Implementation involves installing equipment described in the Meshed Implementation column of Table G.1

Meshed Network – Offshore transmission configuration in which individual Offshore Wind Generation Facility substations are linked by connecting the AC side of several offshore substations as illustrated in Figure G.1. The interconnection allows more than one power-flow path between the onshore AC grid and an offshore Meshed Network.

Meshed Ready – An Offshore Wind Generation Facility and its associated radial link to the onshore point of interconnection which have been designed in accordance with the requirements set forth in Section G.2.

Meshed Transfer Capacity – The amount of power that each meshed connection shall be able to transmit, which is defined as at least 400 MW of AC power to up to two neighboring offshore substations using a summer rating (total of up to 800MW). The power is to be transmitted via a single 230 kV cable to each neighboring offshore substation.

MGCC – Meshed Grid Coordinated Controller, further described in Section G.3.1.

NERC – North American Electric Reliability Corporation

NYISO – New York Independent System Operator, Inc.

Offshore Grid Operator – The future operator of a Meshed Network that maintains authority over operational controls and scheduling controls. The exact entity or entities assuming operation of a Meshed Network will be determined at a future stage in offshore wind grid development and will necessitate additional Orders issued by the New York State Public Service Commission, delineation of the control area of the Meshed Network, and any access or operational parameters determination by FERC. This entity could be the NYISO for the New York Control Area or another existing or future entity.

OGCC – Offshore Grid Control Center

Onshore Grid Operator – The Operator of the onshore grid, i.e., NYISO.

SCADA – Supervisory Control and Data Acquisition

VSC – Voltage Source Converter

G.1 Introduction

Each Offshore Wind Generation Facility awarded through NYSERDA's first two offshore wind solicitations (ORECRFP18-1 and ORECRFP20-1) has been designed to connect to the onshore AC grid through a radial connection. As further discussed in the Order on Power Grid Study Recommendations (Power Grid Study Order) in Case Nos. 20-E-0197, 18-E-0071, and 15-E-0302, a meshed offshore transmission grid would provide a number of benefits, which NYSERDA and New York State Department of Public Service are now studying in accordance with the Power Grid Study Order.

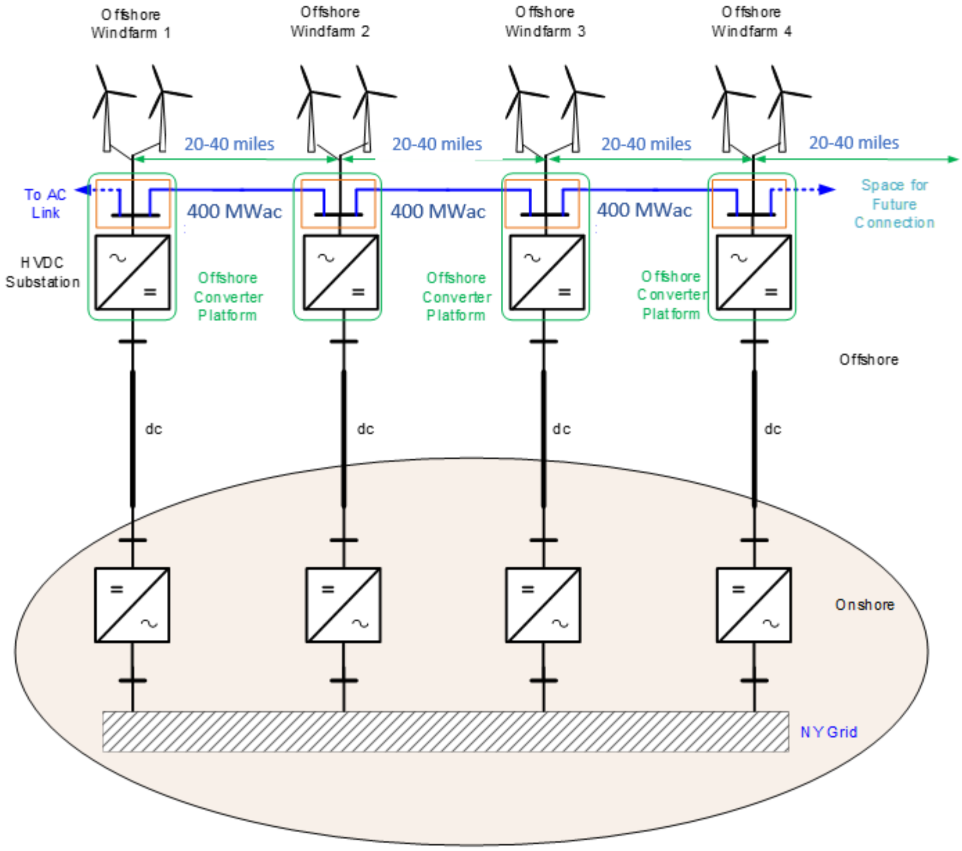
This Appendix carries out the direction given in the Power Grid Study Order and further described in the RFP, for Proposals in ORECRFP22-1 to incorporate measures for the potential integration of the Project(s) into a future Meshed Network system (i.e., to be Meshed Ready).

The criteria to be Meshed Ready in accordance with the RFP are set forth in Section G.2, which will be used to populate Exhibit L of the Agreement. Considerations for reference regarding the future design, control and operation of a Meshed Network are described in Section G.3.

For the avoidance of doubt, neither eligibility under the RFP nor compliance with the Agreement requires implementation of any aspect of a Meshed Network other than the requirements set forth in Section G.2 of this Appendix.

To develop the Meshed Ready requirements, the conceptual model for a Meshed Network as shown in Figure G.1 was used. A Meshed Network as contemplated under this RFP and the Power Grid Study Orders would consist of several Offshore Wind Generation Facilities connected to the onshore grid using point-to-point VSC HVDC transmission links. The 400 MW AC Meshed Network connections shown in Figure G.1. are not part of the Meshed Ready scope.

Figure G.1: Meshed Network Configuration



HVDC Converter and Cable Systems Offshore Windfarms	Traditional Offshore Project
AC Meshed Ready Substation	Meshed Ready project
AC Meshed Connection	Fully Meshed Network

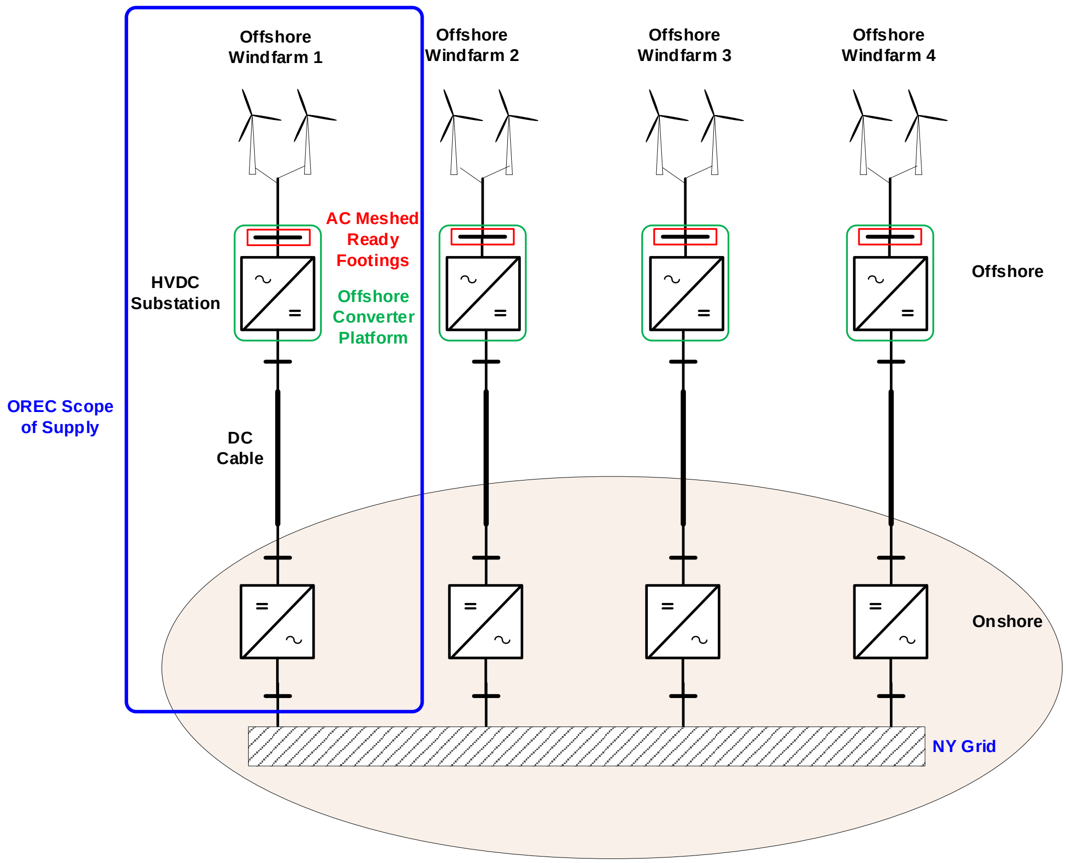
While 400 MW (up to 800 MW total if an offshore substation is connected to 2 others) may not be sufficient to offload 100% of a Project's output to a Meshed Network in the case of an export cable contingency, it will provide congestion relief and resilience as further elaborated on in the Public Service Commission's Order on Power Grid Study Recommendations and the Benefit and Cost of Preserving the Option to Create a Meshed Offshore Grid.

A Meshed Network will not be constructed unless and until its implementation is directed by the Public Service Commission. However, the Meshed Ready requirements will allow minimum compatibility in the future implementation of a Meshed Network, both on a system level and on a geospatial and operational level. If offshore systems are designed Meshed Ready, the implementation of an offshore Meshed Network can occur with reduced costs compared to attempting to integrate offshore systems that do not have the necessary equipment or controls (not Meshed Ready) to integrate with other offshore systems.

This document does not include potential interconnection requirements to facilitate coordinated operation among facilities in a future Meshed Network. Depending on the design, Offshore Wind Generation Facilities could be subject to the NYISO Market Service Tariff and Open Access Transmission Tariff, and any required upgrades will be determined accordingly in the future. Matters relevant to the potential integration of a Project into a Meshed Network is further addressed in Section 5.06 of the Agreement.

The Meshed Ready design scope is outlined in Figure G.2 below.

Figure G.2: Meshed Ready Configuration



G.2 Meshed Ready Requirements

G.2.1 List of Requirements

Table G.1 illustrates the responsibilities to be undertaken and at which phase in project development. Proposers under this ORECRFP22-1 are responsible only for items listed in the Meshed Ready column.

Table G.1: Responsibility Matrix

Item	Meshed Ready	Meshed Implementation	Note
System Studies	X	X	See deliverables section for specific studies to be performed
Single Line Diagrams (SLD) (Including Meshed Equipment)	X	X	See deliverables section for specific SLDs to be provided
Offshore Substation Drawings (Including Meshed Equipment)	X	X	See deliverables section for specific drawings to be provided
Offshore Space	X		Additional space for all equipment to be installed on the Offshore Substation in the implementation of the Meshed Network
Meshed Transformers (Design)	X		Design and Specification of Transformers to be completed in initial design
Meshed Transformers (Installation)	X		Procurement and installation of transformers
Gas Insulated Substation (GIS) Cable Bays (Design)	X		Design and Specification of GIS Bays to be completed in initial design. Design should include if shunt reactors are needed.
GIS Cable Bays (Installation)	X		Procurement and installation of GIS Bays
Cable Hangoffs, J-Tubes (Design)	X		Design and Specification of J-Tubes
Cable Hangoffs, J-Tubes (Installation)	X		Procurement and installation of J-Tubes
Control and Protection Systems (Design)	X	X	Design and Specification of Control Systems to be completed in initial design. Depending on portfolio needs, this may be re-assessed before the final design.
Control and Protection Systems (Installation)		X	Procurement and installation of Control Systems
Auxiliary Power for Future Loads	X		Auxiliary power should be sufficient to accommodate a Meshed Grid
Reactive Compensation (Design)	X		Design and Specification of reactive compensation (see Table G.2)
Reactive Compensation (Installation)	X		Procurement and installation of reactive compensation based on the final Mesh Ready design (see Table G.2).

Item	Meshed Ready	Meshed Implementation	Note
AC Chopper (if required)		X	If the Meshed Network requires AC choppers they will be installed at this stage
AC Cable (Design)		X	Assume standard 230kV Cable
AC Cable (Installation)		X	Assume Standard 230kV Cable
Meshed Metering Equipment		X	Allocation of space offshore for equipment to be provided in Meshed Ready Phase
AC Switchgear	X		Allocation of space offshore for equipment (including breakers and other protection equipment) to be provided in Meshed Ready phase
Communication Infrastructure		X	Allocation of space offshore for equipment to be provided in Meshed Ready Phase
C&P Interface Panels	X		Interface panels to be installed at same time as wind generation facility

G.2.1.1 Switchgear Requirements

Provisions for reactive power compensation and accessories must be included in the offshore substation based on the design studies described in Tables G.1 and G.2. If the design requires separate breakers for shunt reactors, then additional bays shall be provided in the AC GIS to connect each shunt reactor. It is assumed that reactive power compensation with a capacity of 40% on each side of the AC link will be included. The AC GIS Bay may include circuit breaker, disconnect and ground switches and measuring devices to allow proper control and protection of a shunt reactor. Compensation requirements will be determined based on studies. The cost implication of such requirements should also be described.

Provisions for AC cable terminations shall be included in the offshore substation. Additional bays shall be provided in the AC GIS to connect AC cables. The AC GIS may include circuit breaker, disconnect and ground switches and measuring devices to allow proper control and protection of the AC cable.

An AC chopper may be required to achieve fault ride through capability of the wind farms. AC chopper requirements and sizing must be sufficient for system power grid recovery and stability after fault and disturbance in the offshore and onshore power grid. Accordingly, provisions for AC chopper equipment shall be included in the offshore substation and the AC GIS. The cost implications of such requirements must also be carefully evaluated and described. The AC GIS Bay may include circuit breakers, disconnect and ground switches and measuring devices to allow proper control and protection of the AC chopper.

The AC switchyard control system shall provide all the interlocking, monitoring and control for any shunt reactors, AC chopper and AC cable switchgears.

The AC switchyard protection system shall provide all the necessary protection functions to the shunt reactors, AC chopper and AC cables.

AC GIS equipment shall be adequately rated for the additional maximum current that is expected to be experienced during Meshed Network operation. AC GIS equipment in the offshore substation shall have provisions for future upgrades.

G.2.1.2 230 kV Transformer Requirements

To be Meshed Ready, the offshore substation must have a transformer installed that is capable of converting the Offshore Wind Generation Facility system voltage to a 230 kV level. The transformer shall be rated to satisfy the performance requirements of the Meshed Network. The transformer shall comply with the most current version of the relevant IEEE standards.

G.2.2 Key Assumptions

The following assumptions define the parameters that allow a system to be considered Meshed Ready:

- Meshed Ready Projects are designed to integrate into a system as shown in Figure G.1.
- The radial connections from the offshore substation to the Injection Point will be based on the VSC HVDC technology.
    - The Meshed Network will not include Projects with AC radial interconnection.[1]
    - Each individual Project will have a dedicated radial HVDC link that will transmit power to shore.
- The radial HVDC link is capable of transferring the rated capacity of the wind power generated by the corresponding Offshore Wind Generation Facility regardless of its connection to the Meshed Network.
- The implementation of a Meshed Network will not increase the total capacity of the offshore grid. Designing and building the offshore Meshed Network provides grid benefits by improving reliability, reducing curtailments in case of transmission outages, and re-routing power to the zones with most demand.
- The design of the offshore substation(s) must include space for all equipment needed to integrate with the Meshed Network to be installed, operated and maintained; it should also be able to withstand any additional weight and be designed in a manner such that it can be removed or replaced in the event of a failure of the equipment.
- All Meshed Ready spare parts should be included in the spare parts strategy of the offshore substation.
- Each Meshed Ready offshore substation will include two AC connections, each able to transmit at least 400 MW of power throughout the Meshed Network as defined by Meshed Transfer

[1] AC interconnection is not contemplated because interactions between the offshore Meshed Network and the onshore AC grid may introduce additional challenges and design requirements for all Offshore Wind Generation Facilities in the Meshed Network such as higher fault currents, wider transient over voltage, and different control requirements.

Capacity. Proposers are to assume a connection distance of at least 20 nautical miles for their meshed connection.

- The Meshed Network is to transmit the energy at a voltage level of 230 kV.
- The internal layouts of Offshore Wind Generation Facilities are in radial or radial-ring configuration, so that active power flows only from wind turbines to the offshore Meshed Network.
- Meshed Ready designs should comply with all NERC Reliability Standards including NERC PRC-024-02 as a guideline for offshore design. NERC Standards are applicable to defined Bulk Electric System (BES) assets, which include any group of generation greater then 75 MW.
    - A Meshed Network would be part of the Bulk Electric System (BES) and should be registered with NERC (NPCC) as a GO/GOP. Proposers are encouraged to reference NERC's CMEP Practice Guide Application of the BES Definition to BESS and Hybrid Resources.

G.2.3 Documentation Deliverables

Table G.2 summarizes the key documentation that Proposers must deliver with the formal COP submission for the Project. The Proposal Submission must lay out a clear plan to address each of the documentation deliverables during the Project's development process.

Table G.2: Deliverables

Deliverable	Notes
Control Room layout drawings	Including Meshed Network panels
Hardware Overview Diagram	List of all Meshed Network components
Offshore substation Layout Drawing	Layout of Meshed Network equipment. Include locations for future equipment.
Offshore substation SLD	Showing the connection of all Meshed Network equipment
Control & Protection Design	Conceptual design report
Meshed transformer design & specification	Conceptual design report
Reactive compensation design and specification	Conceptual design report
GIS bay design specification & drawings	Conceptual design report, interface points for cable and switchgear
Measuring scheme	Showing the interface points for Revenue metering and other measuring devices
J-Tube design	Design and implementation of J-tubes and other cable pull-in infrastructure
Cable pull-in	Show preliminary strategy to pull in 230 kV Cables, demonstrating sufficient space on the cable deck.

Deliverable	Notes
Structural design	The structural design of the offshore substation should include the weight of the additional Meshed Network Components
Additional Topics to Address The following topics must be addressed by the Proposer in the Proposal Submission in as much detail as is relevant for the Project and appropriate for its stage of development.	
Grounding	Concept design report
AC/DC insulation coordination	Ensure proper clearances offshore
Reactive power support	Determine the reactive power requirements for the Meshed Network
AC harmonics	Determine whether additional filters are required
AC and DC resonance	Determine whether additional filters or controls are required
Short-circuit analysis	Consider the Meshed Network
Auxiliary power design	Consider the auxiliary power required for the Meshed Network

G.3 Meshed Network Concept

The following sub-sections describe aspects of the Meshed Network design that may be relevant to consider for a Project's Meshed Ready design elements. For the avoidance of doubt, this Appendix does not require implementation of any aspect of the Meshed Network other than what is set forth in Section G.2.

G.3.1 Control Requirements

G.3.1.1 Control Concept

A centralized control system, referred to herein as the "Meshed Grid Coordinated Controller" or "MGCC" would be necessary to operate the Meshed Network. The MGCC would control power delivery through the Meshed Network to optimize power distribution to shore during normal operating conditions and during offshore grid outages. The MGCC control system would be designed to permit control and monitoring of the Meshed Network, HVDC links and Offshore Wind Generator Facilities in a coordinated manner.

Operation of the Meshed Network would comply with all applicable NERC reliability standards, Northeast Power Coordinating Council criteria and New York State Reliability Council reliability rules.

The purpose of the centralized Meshed Grid Coordinated Controller would be to:

- Act as a master control system for the Meshed Network to properly coordinate active power flow within the Meshed Network at the discretion of the Offshore Grid Operator.
- Monitor the power flow of the Meshed Network and ensure that the power flow within its limits and cables are not overloaded.

- Properly coordinate the power flow within the Meshed Network when the Onshore Grid Operator requests a power transfer change for any of the radial HVDC connections to the onshore grid.
- Facilitate supervision and coordination of the startup and shutdown of an HVDC system.
- Interface the Onshore Grid Operator's systems with the Offshore Grid Operator, and the Offshore Wind Generation Facility controllers.
- Ensure high reliability and availability of the entire Meshed Network.

G.3.1.2 Control Functions and Communication

Each Offshore Wind Generation Facility would communicate with the Offshore Grid Operator through the MGCC. Each Offshore Wind Generation Facility controller and HVDC controller will accept and follow signals for active power control, reactive power control, and automatic switching sequences. Automatic switching sequences include:

- Connect and energize any AC cable circuit to the Meshed Network
- Deenergize and isolate any AC any cable circuit from the Meshed Network
- Connect/disconnect reactive power sources

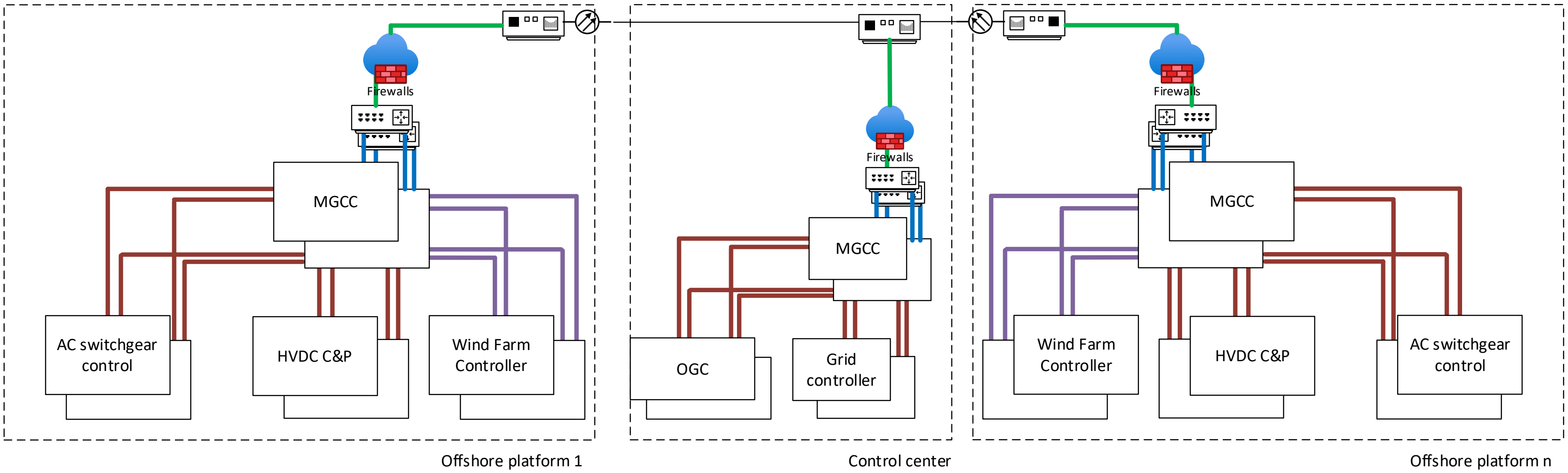
G.3.2 Interface Requirements

G.3.2.1 Control and Protection Signal Interfaces

Figure G.3 shows the conceptual overview of MGCC with interfacing systems. Interfacing systems are listed below:

- Offshore grid control center (OGCC)
- HVDC system control and protection systems
- Offshore Wind Generation Facility controllers
- AC switchgear protection and control

Figure G.3: Conceptual Overview of MGCC Interface



A detailed signal list would be provided by the Offshore Grid Operator for each interfacing system that includes signal type and communication protocol to reduce interoperability risk when integrating future links with multiple vendors. A conceptual signal list is provided in Table G.3.

Table G.3: Conceptual Interface Signal List for MGCC

Signal name	Interface point	Input/output	Signal type
Schedule Power	AC grid controller	Input	Control
Available Power	AC grid controller	Output	Control
Transmitted Power	HVDC system controllers	Input	Control
Offshore PCC Frequency	HVDC system controllers	Input	Indication
Converter Status	HVDC system controllers	Input	Indication
Available Power	Offshore Wind Generation Facility controller	Input	Control
Wind farm status	Offshore Wind Generation Facility controller	Input	Indication
Wind farm trip/power reduction	Offshore Wind Generation Facility controller	Output	Indication
Additional status and control signals interface with SCADA systems	OGCC, AC grid controller, HVDC controllers	Input/output	Indication/ Control

The MGCC would be able to communicate with each redundant panel installed in the control room of each offshore substation and onshore control center.

During a telecommunication outage, each panel would be able to operate without any interruption to the power flow.

Communication bandwidth and latency requirements would be identified to meet performance requirements.

Protection systems for the offshore mesh grid system would be designed and coordinated to reliably detect all possible fault conditions and would be included in AC switchyard protection panels. At least two independent protection systems would be implemented. Both protection systems would operate in the first time protection zone and under different protection principles.

G.3.2.2 AC Cable Requirements

The 230 kV AC cables would be rated to deliver the Meshed Transfer Capacity to match with the peak loading requirements at a summer rating between the offshore substations. Cable cross sections would be selected based on studies under the consideration of the thermal rating, short circuit rating and voltage profile. In addition, the optimal cable cross section would be defined by a cost benefit analysis based on the cable capital costs, installation costs, operation and maintenance and the cost of losses over the Project lifetime.

The AC cable would have a fiber optic cable to provide the appropriate data transfer between substations.

G.3.2.3 Interface Management Recommendations

Main technical interfaces and organizational interfaces would be managed in each Project. The interface items and roles would be defined before the implementation of a Meshed Network.

The main technical interfaces could include:

- 230 kV cable between the offshore substations
- 230 kV switchgear at the offshore substation
- Revenue metering points
- Main power equipment and accessories: shunt reactors, and AC chopper
- Telecommunication and fibre optic infrastructure (offshore and onshore)
- MGCC equipment located on offshore substation and control center including:
  - MGCC system
  - HVDC control and production (C&P) interface to the MGCC
  - AC switchyard P&C interface to the MGCC
  - Wind farm control interface to the MGCC
  - AC grid control interface to the MGCC
  - Offshore grid control interface to the MGCC

Involved parties would be allocated with a functional role for the relevant interface for each phase (design, fabrication, installation, testing and commissioning). Functional roles (RASCI) can be as follows:

- R: The party who is responsible for the interface and is responsible for the execution. The responsible must report to the accountable.
- A: The party who is accountable and qualified for the correct and thorough completion of the interface and must give an approval before an action item or solution can be effective.
- S: The party who supports the responsible party to achieve the result of the work execution.
- C: The party who is consulting the other involved parties regarding the implementation or must be pre consulted.
- I: The party who needs to be informed about the decisions, on the progress, achievements etc.

G.3.3 System Studies and Testing

When connecting a new Project to a Meshed Network, system studies and system tests would be performed to verify the performance of the Meshed Network. Study models adequately representing the behavior of the HVDC system and the Offshore Wind Generation Facilities for steady-state, dynamic and electromagnetic transient (EMT) performance would be provided by HVDC and Offshore Wind Generation Facility developers.

Factory acceptance test (FAT) of the MGCC is expected to be done using replica control systems obtained for the Offshore Wind Generation Facility and HVDC controls. HVDC Offshore Wind Generation Facility developers would provide replica control systems for use in hardware-in-the-Loop (HIL) type tests in the meshed implementation phase.

G.3.4 Future Meshed Network Development

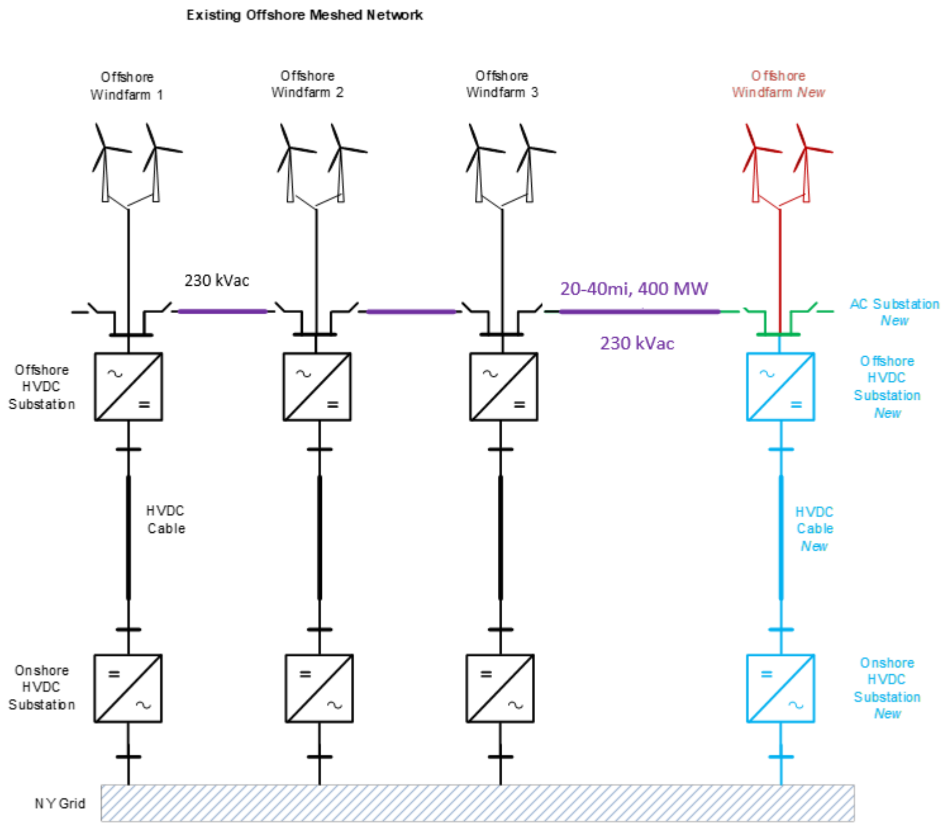
A coordinated process with the HVDC cable developers, Offshore Wind Generation Facility developers and AC switchyard and offshore substation developers would be required to implement the offshore Meshed Network.

The radial connection would serve as the starting point. The approach would be to first identify the Project that would be integrated to the offshore Meshed Network. Based on the assumptions outlined in Section G.2.1.1, the distance between the offshore substation of the new Project and the offshore substation of the meshed connection point assumes the offshore substations are located within adjacent Offshore Wind Generation Facilities and are within a 20 to 40 mile range of each other.

In the second stage, the new Project would be added to the offshore Meshed Network as shown in Figure G.4. The meshed connection would be able to transmit a minimum of 400 MW of active power between two neighboring Meshed Ready offshore substations using 230 kV AC cable technology. A single 230 kV AC cable circuit would be utilized to meet the 400 MW active power transfer capability for each connection between two neighboring offshore substations. The associated AC cable to the meshed grid connection point and/or AC switching station would consider the number of cables being connected for the new Project as well as another connection to a future project. This approach reflects that the exact design of the future connection will not introduce any restrictions to connect to the Meshed Network.

Suitable design measures would be considered for the new Project to minimize the modifications to the existing system when connecting the new Project to the Meshed Network. The design would ensure that connecting the new Project to the Meshed Network will not cause any risk of damage either to the HVDC system or to the Offshore Wind Generation Facility of the new Project while the Meshed Network operates satisfactorily under all conditions.

Figure G.4: Meshed Network Development



Existing System

Scope of New HVDC Converter and Cable Systems Developer(s) Scope of New Offshore Windfarm Developer	Traditional Offshore Project	Meshed Ready project	Fully Meshed Network
Scope of New AC Meshed Ready Substation Developer			
Scope of AC Meshed Connection Developer			