Other parts of the electrical design scope consist of electrical studies demonstrating the expected steady-state and dynamic performance including power and voltage quality simulations, proving compliance with the grid code requirements at the connection point.

SCADA system

The SGRE SCADA system is a server and communication equipment (hardware and software), typically centrally located in the wind farm. It handles the communication, data collection and control of all WTGs and provides remote user interface for operators outside the wind farm.

The SGRE interface SCADA system:

- Collects the data from the different stations such as WTG, wind farm controller, grid measurement stations and meteorology stations of the OHVS;
- Stores the collected data in a database and retrieves the data for presentation;
- Monitors the wind farm production and the current state of the stations listed above;
- Advanced condition monitoring of non-rotating components using all relevant system signals by the SCADA system; and
- Monitors or controls the operation of the stations on site.

During the detailed design phase the software of the SCADA system will be prepared for the WTGs (e.g. from TenneT switchgears and power metering devices), grid compliance and project specific regulations for the Project enabling bird- and bat control and software for the use of nav aids.

Condition Monitoring System (CMS)

SGRE will provide remote vibration-based condition monitoring on the rotating part of the drivetrain on WTGs, for the purpose of early detection of potential damages (slowly and fast developing). Early detection of failures allows the WTGs' maintenance. This helps to reduce the risk on WTGs coming to a standstill.

The SGRE condition monitoring system offers a reliable and robust vibration diagnostic solution able to monitor rotating elements in the WTG. It consists of high-quality accelerometers, front-end processing hardware, front-end integrated software for in-place real-time processing of vibrational data, and an advanced web-server tool for data management, alarm handling, and service planning. The combination of SCADA and CMS increases transparency of potential failures and hence the increase maintainability and availability of the wind farm.

Certification

As part of the Project certification, the design of the WTG, supporting structure and the fabrication and installation phases will be certified by an accredited Certifying Body (CB) in accordance with the Water Decree. In addition, the IAC will be certified by a type certificate after fabrication.

The SG DD-200 wind turbine will receive a provisional Rotor Nacelle Assembly (RNA) type certificate in June 2021 by TÜV Nord, confirming that the SG DD-200 is listed as an IEC class S turbine using a 66-kV transformer. The final RNA type certificate is expected in June 2022. For the certification plan of the SG DD-200 and the provisional type certificate we refer to Appendix 13 (Certification plan). TÜV Nord has been contracted by SGRE A/S with the Type Certification of their new SG DD-200 turbine.

The certification of the Project specific support structure's design, consisting of the WTG tower and the foundation, will be carried out in two steps: design basis and detailed design. First, during the design basis the design assumptions for the WTG and foundation are reviewed and certified by the CB. Project specific support structure's design the design basis has been established. In this way we can ensure that the design assumptions are aligned and approved before the start of the detailed design phase. Second, certification of the detailed design will be carried out in parallel to the design activities to avoid delays in the certification process.

3.3 Fabrication phase

Once the detailed design of the foundations and towers has been completed and certified, ordering materials and manufacturing of the foundation structures will start. The procurement and fabrication of the IACs will be completed during this phase, hereby ensuring sufficient components are fabricated prior to start of installation, thereby avoiding possible installation delays due to possible delays in the manufacturing process.
The fabrication of the foundations will be subcontracted

by VOOW. The subcontractor will be responsible for the fabrication and storage of the foundations in the marshalling harbour in the Port of Rotterdam.

3.3.1 Manufacturing of main components

The IACs will be manufactured under the supervision of VOOW. The IAC supplier will provide an inspection and test plan prior to the start of production. This test plan secures the offered cables and accessories are tested according to the applicable standards for a 66 kV submarine IAC.

The sourcing and manufacturing process of the WTGs for CrossWind is scheduled such that sufficient numbers of WTGs are completed and transported to the marshalling harbour prior to WTG installation. SGRE reserves a production slot for CrossWind in order to secure a timely production of the WTGs.

The WTG blades are transported from Denmark to the marshalling harbour in Rotterdam. The other WTG components are transported from Germany, France or the UK to the marshalling harbour in Rotterdam. After assembly, the WTGs and towers will be loaded together with the blades onto the WTG installation vessels. Pre-assembly of the WTGs will take place in the marshalling harbour of Rotterdam (Maasvlakte 2). Part of the pre-assembly process is pre-commissioning of the WTGs before load-out. Pre-commissioning reduces the time spent offshore to connect the WTGs to the grid and reduces the risk for delays.

3.3.2 Transport and storage in marshalling harbour

After fabrication at the monopile manufacturing facility, the monopiles are stored in order to build up a buffer before start of installation. Also, the secondary steel items, such as the main platform, boat landing and internal platforms are transported to this marshalling harbour. The parts to be transported by sea will be sea-fastened during transportation. The design of the sea-fastening will be tailor made to the applicable vessel and the environmental characteristics. The monopiles and secondary steel items are stored securely on the quayside at preparatory onshore works.

3.4 Installation phase

This phase starts with an UXO survey and if required clearance of the Project site. Thereafter, the scour protections, foundations (see Figure 10), IACs and WTGs will be installed and commissioned. The installation phase will be certified in accordance with the Project certification requirements of the Site Decision.

3.4.1 Foundation installation

With VOOW as BoP contractor, CrossWind has secured installation vessels such as the Aeolus, MPI Resolution, MPI Adventure, [redacted] and the cable-lay vessel Nexus. The Aeolus, [redacted]and Nexus are all purpose-built vessels and dedicated for offshore wind projects.

For offshore installation works, VOOW uses the same pool of foremen for every project. Key personnel are all on the VOOW payroll, ensuring continuity of execution quality and transfer of lessons learnt between projects. To strengthen the execution quality of the Project, CrossWind has established a Health and Safety policy.

Scour protection installation

The BoP installation works will start with seabed preparations (if necessary) followed by the installation of the filter and armour layer of the scour protection to prevent seabed erosion around the monopiles. The proposed vessel to install the scour protection is [redacted] The scour protection rocks will be loaded at a quarry port and transported on board the [redacted] to the WTG locations. This subsea rock installation vessel is equipped with a DP2 system (Dynamic Positioning class 2) to keep the vessel in the exact position, while installing the stone layers on the seabed. The subsea rock installation for the scour protection will start in [redacted]

Foundation load-out and installation

For each installation round trip, the Aeolus will load three monopiles at the marshalling harbour and will sail to the Project site. After positioning at the desired location, the legs are lowered and preloaded to avoid rapid settlements. Subsequently the vessel is jacked up to operation height ready for pile installation. Before pile-driving starts, an acoustic signal is emitted to enable marine life (especially mammals) to swim away from the installation site. Furthermore, the noise mitigation setup is deployed to reduce noise emissions during pile driving.

[redacted]

Figure 9. Manufacturing main components.

The monopile is then upended, lowered, and pitched vertically. The installation vessel will position the monopiles onto the pre-installed scour protection with an accuracy of $\leq$ 2 m. When the correct orientation is achieved and a slow start is made, the monopile is driven into the soil until the target depth is reached, using the pile gripper to ensure that the pile remains vertical during driving.

Milestone: The installation of the first foundation of Hollandse Kust (noord) is planned on [redacted]

Figure 10. Foundation installation Borssele III & IV.

Risk analysis during construction and operation for environment

Identified environmental risks associated with construction and operation for this Project are:

- Anthropogenic underwater noise from sources-such as pile driving.
- Hydrocarbon/chemical spills from marine vessels and WTG associated equipment.
- Improper ballast water management.
- Collision of birds and bats with WTGs.
- Lighting that can confuse bird and bat migration-through attraction or disorientation.
- Cumulative impacts from operations of several wind farms in a similar habitat; displacement effects to birds, bats, fish populations and marine mammals.
- Loss of archaeology and cultural history.

Mitigation

CrossWind will mitigate the risks by using all regulatory and proven scientific mitigations:

- Underwater noise: we will comply with the regulatory noise limits during construction and operations by applying deterrence and sound damping technologies, and through operational practices-soft start-up of pile drivers to allow marine mammals time to leave the construction area. As an example CrossWind will apply an Acoustic Deterrent Device (ADD) before piling commences to reduce the possible impact on fish, seals and harbour porpoises. The type of ADD that will be applied is the Faunaguard®.
  Unlike other ADDS, type limits the submitted noise as much as possible by using specific frequencies. VOOW has a lot of experience in using the Faunaguard® for deterring harbour porpoises, the most sensitive animals. For instance during the construction of Luchterduinen, Gemini and Borssele III & IV.
- Spills: loss of primary containment will be managed through clear work processes for handling and storing hydrocarbons and chemicals. Secondary containment, where practicable, will be maintained. Spill response plans will be developed, and response capability maintained at the site.
- Seals and bird concentrations: the vessels used for the installation of the Project will monitor and take into account the presence of seals on the plates and designated areas as well as the presence of bird concentrations.
- Ballast water management: all vessels will adhere to MARPOL and country requirements for ballast water discharge.
- Collision risk birds and bats: during conditions favourable for bat migration, the WTGs will be shut down to reduce probability of collisions of bats with the WTGs as per Site Decision.
- Lighting: we will comply with the requirements from the Site Decisions regarding the reduction of the visibility of the wind farm.
- Cumulative impacts: offshore wind farms can mitigate other anthropogenic environment impacts. For example, the CrossWind wind farm could provide the opportunity to mitigate damages caused by fishing by creating dedicated natural habitat or re-introducing local species.
- UXO surveys: to protect archaeology and cultural history UXO (Unexploded Ordnance) surveys will be conducted. The locations of the WTGs and the cable routing is selected such that all known objects of potential archaeological value are avoided. During the UXO studies and combined UXO and archaeology surveys potential archaeological objects may be found. We have included an allowance for rerouting the IACs to ensure at least 100 m distance in case potential archaeological objects are encountered. In other cases, measures will be taken to protect archaeology and cultural history in accordance with the Site Decision.

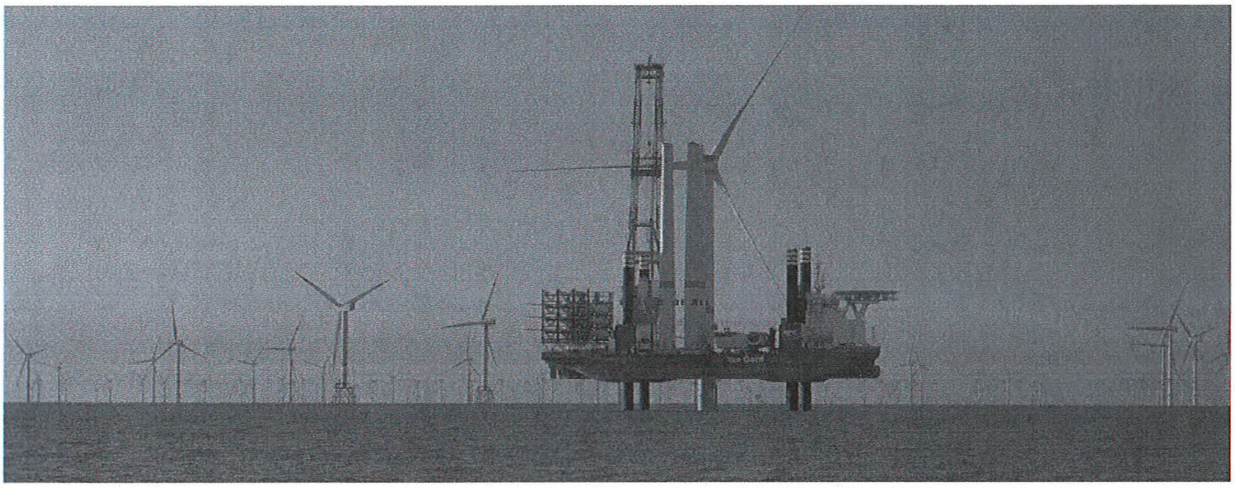

Figure 11. Van Oord's jack-up vessel Aeolus.

During piling, VOOW will apply noise mitigation (double big bubble curtain) in combination with the AdBM noise mitigation system. This combination has been applied recently at the Norther and Borssele III & IV project and has proven to be effective. This provides evidence that with this combination maximum allowable sound levels allowed by the Site Decision are not exceeded.

Secondary steel installation

Once the monopile is installed to target depth, the Aeolus will jack down and sail to the next foundation location. Subsequently, VOOWs owned jack-up vessel MPI Resolution will install the secondary steel items on the installed monopile, such as the boat landing, airtight platform, external service platform and temporary lighting.

In previous projects, installation of the boat landing has proven to be the most weather-critical activity. For CrossWind, VOOW will therefore install the secondary steel onto the monopile with a purpose-designed boat landing installation tool. CrossWind will benefit from the experience gained on the Borssele III & IV project, where the tool has been used successfully. The installation crew can enter the foundation via a gangway deployed onto the monopiles, to secure the secondary steel.

Once the secondary steel installation is complete, the installed foundation will be equipped with a temporary navigation light installed for safety until the WTGs are installed and the permanent navigation aids are activated.

3.4.2 Inter-Array Cable installation and burial

The IAC installation is planned to start on [redacted]
The installation activities start with a pre-lay grapnel run. The pre-lay grapnel run will remove debris (such as old wires, ropes and abandoned fishing gear) that may impede the cable laying and trenching operations (see Figure 12). The grapnel run is executed along the route of each of the IAC. The IAC will have to cross third party sub-sea assets. On these crossings VOOW will install industry standard crossing protections, in close cooperation and agreement with existing cable and pipeline owners. The crossing's protection is proposed to consist of a typical rock berm installed by [redacted]

The main equipment used for the installation of the IACs will be VOOWs dedicated cable installation vessel Nexus. All cable types for the Project will be loaded onto the carousel on board the Nexus. The Nexus will install the IACs along all cable routes on the seabed. The DP2 (Dynamic Positioning Class 2) and on-board survey crew will keep the vessel on the exact cable route whilst laying the cable on the seabed. The cable monitoring and tensioning systems on board of the Nexus will ensure a safe touchdown of the cable on the seabed. Throughout all installation activities, the cable is prevented from exceeding any installation tolerances.

On the foundations and the TenneT platform pull-in wires are installed, to pull-in the IAC from the Nexus into the cable hole in the monopile and the J-tubes at the TenneT platform. The cables are fixed in cable hang-off systems in the foundations and the TenneT platform.

Only the first end pull-ins are typically executed at the TenneT platform (see Figure 12). Nevertheless, it could be that for scheduling reasons, the last end of the cable has to be pulled in at the TenneT platform, given the narrow corridor, requiring a high precision second end pull-in. This can be managed as the Nexus has been designed with a deployment system to allow for precision installation of the pull-in of the last end of a cable at greater depths.
The part of the IAC from the monopile cable entry hole just above the seabed and across the scour protection into the seabed is protected by a cable protection system, consisting of steel and rubber sleeves.

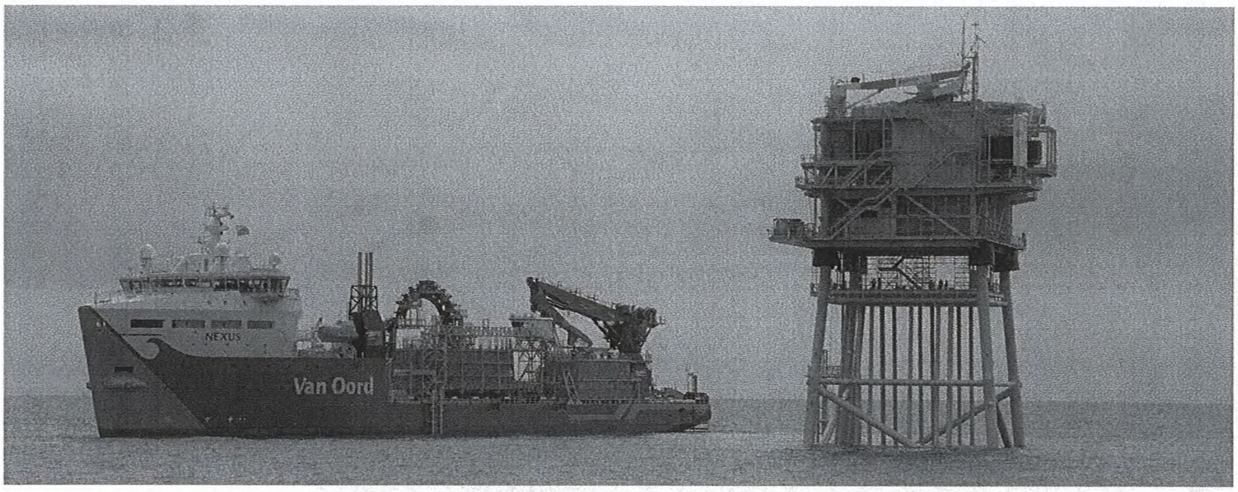

Figure 12. The cable-laying vessel Nexus at Gemini.

Burial of the IACs

After cable-laying, the IACs are buried into the seabed to prevent accidental damage to those cables, thereby avoiding unsafe situations and securing continuity of electricity output. The IACs are buried below the seabed based at a depth depending on the expected seabed level changes over time, but in all cases deeper than 1 m below seabed. The IACs burial is executedby a trenching support vessel and a Q1600 jet trencher, both owned by VOOW (see Figure 14).

3.4.3 Wind Turbine Generator installation

For stability and to ensure safe and efficient working conditions the WTGs will be installed from a jack-up vessel, the MPI Adventure, which is owned by VOOW. Moreover, as soon as VOOW's jack-up vessel Aeolus has completed the monopiles installation, the vessel will be converted for WTGs installation set-up and assist the MPI Adventure with installing WTGs. All WTG components are stored on

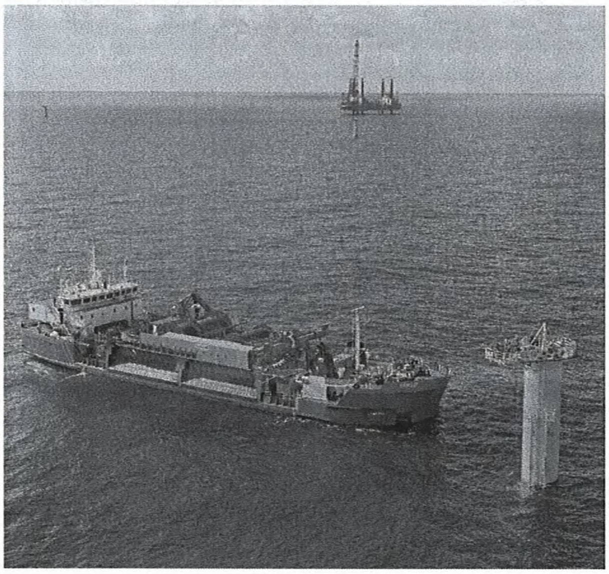

Figure 13. Cable pull-in at Luchterduinen.

the quay side of the marshalling harbour in Rotterdam. Two complete WTG assemblies will be loaded onto each vessel for the transport towards the installation location. The WTG components are securely stored on board by means of sea-fastening.

Milestone: The installation of the first wind turbine of Hollandse Kust (noord) is planned to be completed on [redacted]

At the installation location the jack-up legs will be lowered onto the seabed and pre-loaded to ensure a stable position. Subsequently, the vessel is jacked-up, after which the installation of the WTG components can commence (see Figure 11).

A gangway will be deployed onto the foundation to prepare the foundation for the WTG installation. The first WTG component to be installed is the tower. The lifting gear will be connected to the main crane of the WTG installation vessel and the sea fastening will be released.

The tower is positioned above and lowered onto the foundation. For safety reasons, no people are allowed to be below the tower during the lift. The installation team will enter the tower through the door and secure the tower to the foundation by torqueing the bolts.

Subsequently, the WTG nacelle including the hub is installed. The nacelle will be hoisted onto the WTG tower and bolted to the tower top flange. After the nacelle, the blades will be installed. The blades will be bolted onto the hub one by one. The blades are installed in horizontal position using the main crane including an advanced tag-line system. Once the WTG is installed up to the so-called non-operational safe state, the MPI Adventure will proceed towards the next installation location.

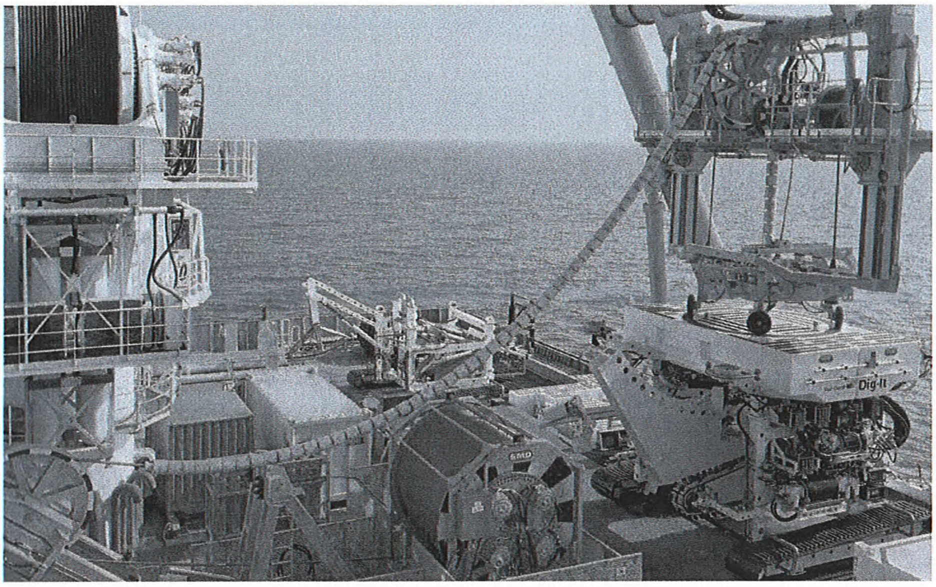

Figure 14. Q1600 trencher Dig It.

3.4.4 Mechanical completion, commissioning and trial runs of the WTGs

After installation and burial, the IACs are tested by a very low frequency test, which means the IACs are powered by low voltage for 24 hours to detect any flaws in the cables. Upon passing the tests, the termination of the IACs cables can be completed and the IACs will be connected to the WTG switchgear. With mechanical completion tests on completion of the WTGs can start.

The tests on completion for the WTGs consist of mechanical completion, commissioning and trial runs of the WTGs. The WTG is in a so-called "non-operational safe state" after the WTG installation vessel leaves the installation location, meaning it is safely installed, but not yet completely mechanically and electrically completed for operation. Installation teams will return to the WTG for the mechanical completion and commissioning. This mechanical completion means that all bolted connections are fully torqued and tensioned, loose items are fixed and all wire connections are established.

At this moment in time the cold commissioning of the WTG components starts with the use of generators. The individual subsystems that do not require energisation of the full WTG are tested on correct working order.

Energisation will start after the cold commissioning is completed. During the hot commissioning (i.e. grid connection from TenneT Hollandse Kust (noord) OHVS is available), the cable installation and correct functioning of the assembled WTGs are checked, and the switchgear is energised. After hot commissioning, the WTGs will be functional and the trial runs can start. During the trial runs the WTGs are operational and able to supply electricity.

During the trial runs, the WTGs are operated (see Figure 15), for at least 72 hours. Afterwards several acceptance tests are being completed. Trial operation should include at least a certain amount of operational time at full power and a certain availability threshold should be achieved to pass the trial. Passing the trial runs means that the WTGs are fully operational and accepted and ready for take over by CrossWind.

A final walkdown is done by CrossWind and SGRE to establish the punchlist of items to be handled or rectified after take over. [redacted]

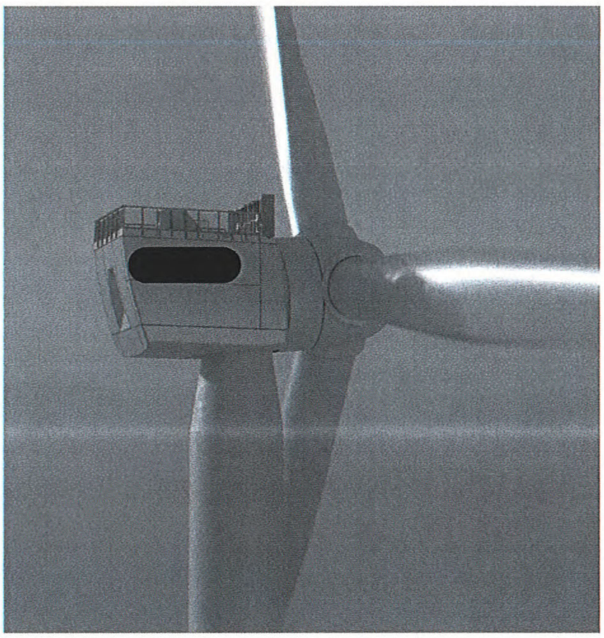

Figure 15. WTG ready for operation.

The SCADA systems are installed during the OHVS installation period in the TenneT onshore and offshore Wind Park Owner (WPO) rooms. The SCADA commissioning procedure commences after the relevant part of the SCADA server building has been fully installed and commissioning of at least one WTG has been completed.
At least four weeks before the wind farm is operational, CrossWind will provide a statement to the Minister of Economic Affairs and Climate Policy confirming that the construction of the wind turbines and other BoP components forming part of the wind farm are sufficiently strong to withstand the expected forces resulting from wind forces, waves, sea currents and use of the turbine itself.

Milestone: The planned start date for supply of electricity for this Project i[redacted]

Risk analysis during construction and operation for Health, Safety and Security

CrossWind has identified the risks for the construction and operation phase based on the experience and risk registers of the Partners. These will be further consolidated into a Project risk register in order to systematically ensure that all identified risks can be properly mitigated. Summarising the main identified risks for the construction and operations phase:

- Insufficient preparation and inadequate work procedures.
- Inadequate response to emergencies.
- Security of the Project, both on site security and cybersecurity.
- A set of detailed operational risks including:
  - Personnel transfer from vessels and helicopters to the WTGs.
  - Working on a remote offshore location.
  - Working with high and low voltage equipment.
  - Other high risk activities, such as working in confined spaces, hot works and working at heights.
  - Lifting and hoisting activities.

Mitigation

A brief summary of the mitigating measures to the risks described above are:

- Well-developed permit to work management systems to ensure proper review, approval and availability of work procedures, including management of change process.
- Marine coordination to ensure management of simultaneous operations and emergency coordination, as required under the Veiligheid & Gezondheid (V&G) responsibility of CrossWind.
- Emergency response and management, tested through drills and exercises.
- Strict access control and anti-intrusion measures on site as well as to windfarm industrial control systems.
- Extensive sets of measures regarding cybersecurity, covering prevention measures, detection and monitoring and damage limiting measures.
- To deal with the operational risks, works will be assessed using methods such as job safety analysis and Hazard Identification and Risk Assessment (HIRA) to ensure proper preparation. An important goal will be to minimize the execution of high risk activities.

Furthermore, CrossWind wil monitor that all activities comply with national legislation implementing the monitoring and evaluation programme established by the Minister of Economic Affairs and Climate Policy. CrossWind has the experience and sees the importance of an early involvement in the monitoring and evaluation programme, such that an optimal design can be realised for installing the equipment. For the wind farms Prinses Amaliawindpark and Luchterduinen the monitoring and evaluation programme are already successfully implemented.

Appendix 9 (Description demonstration innovation), 10 (Identification and an analysis of the risks) and 11 (Measures to ensure cost efficiency) provide more details on risks and mitigations in the construction and operation phase.

4 Operation plan

The operational phase will start after commissioning and take-over (from contractor to CrossWind) of the last installed WTG. According to the current construction schedule this will be [redacted] before the deadline to bring 95% of the wind farm operational within the 39 months after the permit becomes irrevocable. The WTGs will be operational for [redacted] years, ending the lifetime of the WTGs in [redacted]

The Project has awarded the AMSA to [redacted] (department based in a local office in IJmuiden). [redacted] will manage and coordinate the overall Project O&M (see Figure 16). [redacted] will dedicate specialist managers to look after the WTG and BoP O&M and is supported by legal, regulatory and technical support from the Partners. [redacted] has more than 12 years of operational experience with the operation and maintenance of the Prinses Amaliawindpark (since 2008), the Luchterduinen wind farm (since 2015), Borssele III & IV (since 2020). All O&M synergies with these wind farms, operated from [redacted] O&M offices in IJmuiden and Oostende, are taken into account for this Project.

The maintenance for the wind farm will be executed by experienced companies [redacted] The first [redacted] years of maintenance of the WTGs is carried out under the responsibility of SGRE under the SMA. Key aspects of this SMA are the [redacted] The transfer of knowledge between SGRE and CrossWind will take place during the SMA maintenance period and consists of knowledge exchange, detailed maintenance

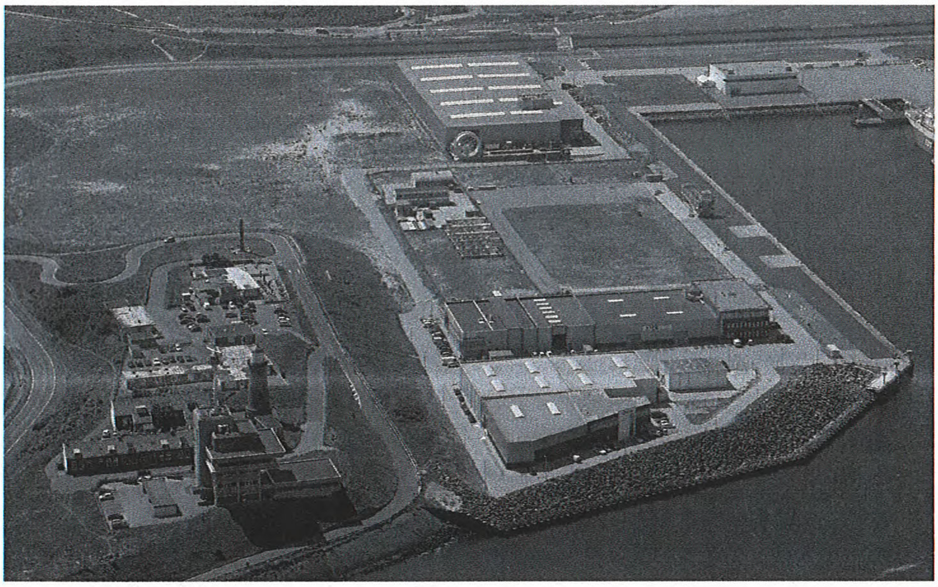

Figure 16. [redacted] office in IJmuiden.

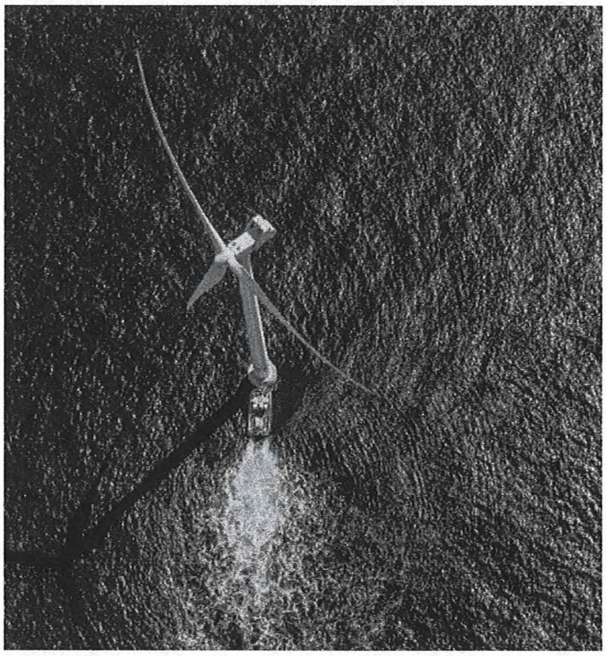

Figure 17. WTG maintenance.

manuals and method statements for exchange of components. CrossWind has the possibility to embed technicians in the service teams of SGRE to ensure an experienced workforce after the term of the SMA.

To enable efficient collaboration between SGRE and [redacted] SGRE will conduct its maintenance activities from IJmuiden as well. A service organisation of approximately 30-35 persons will be based in the local service office and will operate and maintain the wind farm on a daily basis. The maintenance of the turbines will be performed using crew transfer vessels sailing out to the wind farm from IJmuiden. SGRE will have long-term charters for their crew transfer vessels, subject to the time of the year and the scheduled activities.

Consumables and small spare parts will be stored in a local warehouse. For repairs and construction of specific parts and components, local subcontractors and workshops will be used.

The BoP inspection and maintenance shall be carried out by experienced contractors, under clearly defined contractual arrangements which will be established at least nine months prior to the start of the operations. The scope will consist of the foundation, corrosion protection system, IACs, grid connection at the TenneT platform, and WPO rooms provided by TenneT. For the IACs a monitoring campaign is scheduled during the O&M phase to prevent exposed IACs and the associated risk of cable damage. To be able to respond quickly to cable failures a spare cable and connectors are stored by [redacted] The O&M strategy will be a so-called "risk-based approach" which means inspection and maintenance is not at regular intervals but rather based on a detailed risk and failure assessment of the separate components within the wind farm. A risk-based inspection and maintenance is recommended for offshore wind farms by DNV GL.

During the operational phase CrossWind will liaise with owners of neighbouring assets to coordinate vessel movements and maintenance activities. In the event cable or pipeline owners perform repair or maintenance on the cables in the maintenance zones intersecting the Project site, the turbines located within 1,000 m of the maintenance activities will be set to idling mode.

CrossWind will through its parent company Shell have access to and utilise an extensive, and probably the largest, network of people with hands-on experience in offshore oil and gas operations in The Netherlands. CrossWind can rely on this expertise during operations e.g. when aligning concurrent operations with neighbouring gas production platforms or hydrocarbon pipeline operators and when dealing with Dutch authorities such as Staatstoezicht op de Mijnen and Rijkswaterstaat. Close alignment with neighbours and authorities will be of increasing importance as activity levels in the North Sea are likely to increase.

CrossWind will strive to transfer best practices from the Dutch oil and gas sector to the offshore wind industry. The wind/gas shared regulator Staatstoezicht op de Mijnen has expressed the good safety standards in the oil and gas sector through its Inspector General[4] and recently published a report in November 2019 expressing the wish for the offshore wind sector to set goals comparable to the oil and gas sector using operational best practices[5]. CrossWind will have access to a network of professionals with field experience in Dutch offshore gas operational best practices, such as Safety Management and Incident Reporting, Learning from incidents, Emergency Response, Authority and Legal Compliancy, Management of Change and Technical Expertise.

[4] 'Veiligheid als uitgangspunt nemen vanaf de tekentafel, kan ook. Het wiel hoeft niet opnieuw te worden uitgevonden. Op zee is bij het winnen van gas en olie in vele jaren ruime ervaring opgedaan met veilig werken. Daarmee is een goede standaard gesteld. SodM wil dat ondernemingen in de windenergie die standaard hanteren als instapniveau'. Quote from Theodor Kockelkoren, Inspecteur-generaal der Mijnen. Staatstoezicht op de Mijnen, December 4th 2019, Published Newsarticle on SODM website.
[5] 'Gebruik het veiligheidsmanagementsysteem zo dat preventie in ontwerp, onderhoud, operatie en nazorg voorop staat en de gewenste veiligheidscultuur bevorderd wordt. Stel doelen die vergelijkbaar zijn met de olie- en gassector en gebruik ervaringen en lessen uit de operationele praktijk in nieuwe ontwerpen/methodes. Werk themagewijs om de veiligheid te verbeteren.' Staatstoezicht op de Mijnen, Staat van de sector Windenergie op zee, November 2019, pp. 35.

By relying on this network, CrossWind will be best equipped in its contribution to transfer oil and gas best practices to the Dutch wind sector and strive for an ever-increasing safety culture in the Dutch Offshore Wind industry.

CrossWind will take measures to comply with the Site Decision:

- Limit collision victims amongst birds during mass bird migration

  During times of mass bird migration, the turbines will be shut down to reduce the probability of birds colliding with the turbines. The decision to shut down the wind farm will be aided by a system that detects the actual bird migration placed in the wind farm that can detect approaching flocks of migrating birds. Eneco is involved in a research project at Luchterduinen investigating bird migrations with the aim to validate the bird migration model. During conditions favourable for bat migration, the WTGs will be shut down to reduce probability of collisions of bats with the WTGs as per Site Decision.
- Reduce nuisance from lighting and reduce the visibility of the wind farm

  We will comply with the requirements from the Site Decision regarding the reduction of the visibility of the wind farm. Furthermore, we see much potential in Aircraft Detection Lighting Systems (ADLS) and are closely monitoring developments of such systems which are already allowed by the corresponding aviation authorities in Canada, Finland, Germany, Norway, Sweden, and the United States.
- Increase visibility for ships

  CrossWind will cooperate with the placement of nautical equipment that can observe the ship movements in and around the wind farm at the location(s) determined by the government. CrossWind will provide access for the management and maintenance of this equipment.
- Safe accessibility of oil and gas platform Q4C

  CrossWind will ensure that the oil and gas platform Q4C is accessible by helicopter for the purposes of employee transport and search and rescue operations. CrossWind will set out the above in a procedure and submit this plan to the Minister of Economic Affairs and Climate Policy no later than eight weeks prior to start of construction.

5 Decommissioning

After the operational lifetime of the WTGs has ended, decommissioning of the wind farm will start. The decommissioning will be finished at the latest on 10 September 2050, assuming the permit becomes irrevocable on 10 September 2020.

Milestone: The decommissioning period of the wind farm will start at the latest on 10 September 2049 and will be completed before 10 September 2050.

A detailed decommissioning plan for removal of the WTGs and foundations will be developed based on experience of Shell in decommissioning other offshore projects. The plan will be submitted to the authorities at least four weeks before start of the works. The following items of the wind farm will be removed:

- WTGs (towers and rotor-nacelle assemblies);
- Monopiles (down to a sub-seabed level as specified in the permit), including scour;
- IACs;
- Baseload power hub (separately placed on a monopile);
- SCADA system and other offshore wind farm owners' properties at the TenneT platform and TenneT onshore control building; and
- All other items and objects that ended up in the vicinity of the WTGs and IACs related to the installation, maintenance, use or decommissioning of the offshore wind farm.

The above reflects decommissioning for the entire wind farm with the exception of the floating solar PV system as part of CrossWind's innovations. Appendix 09 (Description demonstration innovation) provides more detail on the decommissioning of our innovations.

The Partners are involved through the GROW project in projects investigating novel methods for decommissioning. Through their involvement in the GROW consortium, the Partners are participating in projects investigating novel pile extraction methods. Examples are Hydraulic Pile Extraction Scale Tests (HyPEST), aiming to demonstrate that monopiles can be decommissioned through applying hydraulic pressure inside the monopiles and Gentle Driving of Piles (GDP), in which piles have been installed and extracted through combined torsional and vertical vibrations.

As per tender regulations, a decommissioning reserve will be kept by CrossWind for the full scope of the decommissioning of the wind farm. An experienced marine contractor will be contracted for the offshore decommissioning of the wind farm. Method statements, risk assessments, instructions and a recycling plan will be developed in the preparation of the decommissioning. Rijkswaterstaat and the Dutch Coast Guard will be consulted in preparation of such plans. The execution will follow the procedures from the method statements and plans.

During the decommissioning the wind farm areas will be monitored and guarded by guard vessels for offshore safety. After securing the site, the decommissioning starts with the de-energisation of the WTGs and IACs. The WTG parts will be removed in the reverse order as they have been installed. The same lifting techniques can be used, carried out from a jack-up vessel or similar. The monopiles will be removed in line with permit requirements. The monopiles can be removed from a jack-up or floating vessel.

IACs will be pulled-out by a cable barge or vessel and transported away from the site. Special attention will be paid to the IACs at the TenneT platform and cable crossings to avoid damage to any other existing cables and pipelines.

All components are transported towards a storage yard in a Dutch port in the vicinity of the offshore wind farm. CrossWind has based its budgets for disposal of components on the assumption that WTGs and foundations will not be re-used and that only scrap steel, copper and aluminum have rest value. Looking at the typical breakdown of materials used in a windfarm, the most important portions are:

- Steel: used in foundations, towers and component frames, amounting to roughly [redacted] tons for Hollandse Kust (noord) of which about [redacted] tons will be recoverable (part of the foundation will be cut off below seabed level and remain);
- Copper: used in electrical equipment like transformers and generators, amounting to roughly [redacted] tons in total for this Project;
- Aluminum: used in the IACs, amounting to roughly [redacted] tons for this Project;
- Composites: fibre reinforced composites used in blades, amounting to roughly [redacted] tons for all 207 blades; and
- Rare earth metals: used in electronics and particularly the permanent magnets in the large DD generators.

Where the large metal fractions can be recycled easily, the large amount of fibre reinforced composite material used is currently still a challenge and an important topic of research. SGRE continuously works on improving the end-of-life phase of its products. For composites in particular, SGRE takes part in the Horizon 2020 "FiberEUse" project. The FiberEUse project is aimed at applying a holistic approach to different innovation actions to enhance the profitability of composite recycling and re-use in value-added products. The project is based on the realization of three macro use-cases:

- Mechanical recycling and re-use in added-value customized applications as well as emerging manufacturing technologies like UV-assisted 3D-printing;
- Thermal recycling and re-use in high-tech, high-resistance applications through controlled pyrolysis and custom remanufacturing; and
- Inspection, repair and remanufacturing for CFRP products in high-tech applications.

The final fraction of material mentioned here are the rare earth metals, mainly consisting of the permanent magnets in the large DD generator of the SG DD-200. SGRE is internally developing methods to demagnetize these magnets at the end-of-life to allow for recycling of this material.

An inspection will be performed after the decommissioning operation, in order to confirm and inform to all involved parties that all components have been removed as per agreement.

The operational lifetime of the offshore wind farm is planned for [redacted] years. During this period, it is likely that project conditions, decisive for the final decommissioning, will change. At present, the following expected (potential) conditions have been identified and will be taken into account for the decommissioning phase:

- Further tightening of permissible noise levels;
- Improvement of pile removal techniques;
- Migration of seabed levels due to erosion and sedimentation; and formation of valuable biotopes in no-fishing.

Annexes

- Annex 1: Wind Farm lay-out
- Annex 2: CrossWind's Overall Schedule
- Annex 3: Pondera verification

Annex 1

Wind Farm lay-out

[redacted]

Annex 2

CrossWind's Overall Schedule

CrossWind Overall Schedule

Schematical representation of the CrossWind Project Hollandse Kust noord (HKN)

[redacted]

720015
22-04-2020

VERIFICATION DOCUMENT BID HOLLANDSE KUST (NOORD)

CrossWind

Final

Annex 3

Pondera verification

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Title	Verification document Bid Hollandse Kust (noord)
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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Scope of this report

CrossWind asked Pondera Consult BV to verify that their bid for site Hollandse Kust (noord) fulfils the requirements of the Site Decisions. Requirement 3.1.b of the 'Regeling vergunningverlening windenergie op zee' (Staatscourant, jaargang 2019, nr. 68472) stated that the design of the wind farm has to make it plausible that the requirements of the Site Decision will be fulfilled. In this report Pondera Consult BV describes the requirements of the Site Decision in chapter 2 and gives information in chapter 3 on how CrossWind fulfils these requirements.

This verification document applies to CrossWind's bid for the offshore wind farm Hollandse Kust (noord).

1.2 CrossWind

The bid is developed by CrossWind. The CrossWind consortium consists of the Dutch companies Shell and Eneco, together with the selected wind turbine supplier and service partner Siemens Gamesa Renewable Energy and the selected Balance of Plant supplier Van Oord Offshore Wind.

1.3 Pondera Consult BV

Pondera Consult was founded in 2007 with the ambition to contribute to sustainable solutions for energy, climate and environmental challenges. We work with our clients towards the identification and realisation of renewable energy projects. Pondera Consult has extensive experience in the planning and development of large onshore and offshore wind energy projects.

Pondera Consult prepared an Environmental Impact Assessment, Appropriate Assessment and a list of species (under the Flora & Fauna Act) for the Site Decision of Hollandse Kust (noord), on behalf of the Ministry of Economic Affairs and Climate Policy and Rijkswaterstaat. Pondera Consult also prepared an Environmental Impact Assessment and Appropriate Assessment for the Offshore Grid Hollandse Kust (noord) on behalf of TenneT. Pondera also conducted a Wind Resource Assessment (WRA) for Wind Farm Zone Hollandse Kust (noord) on behalf of the Netherlands Enterprise Agency (RVO).

2 SITE DECISION REQUIREMENTS

2.1 Overview of requirements

In the Wind Farm Site Decision Hollandse Kust (noord) Wind Farm Zone Site V (HKNWFS V) (Staatscourant 2019 nrs. 24545, 9 May 2019), chapter 3, seven types of requirements can be found:

1. Definition of terms;
2. Wind farm and bandwidth;
3. The permit;
4. Mitigating measures;
5. Monitoring and evaluation programme;
6. Removal;
7. Financial certainty.

Some of these requirements are subdivided into several other requirements. The following chapter describes how CrossWind fulfils these requirements.

2.2 Changes in relation to HKZ Site IV

For information, the following regulations have been changed in relation to the site decision of Hollandse Kust (zuid) Site IV:

- Requirement 2.1 – 2.3: other co-ordinates of the wind farm, trace to TenneT platform and maintenance zones.
- Requirement 2.5: the maximum number of turbines is 95 instead of 63.
- Requirement 2.6: the maximum total swept area permitted is 2,913,840 m^2 instead of 1.461.542 m^2.
- Requirement 2.7: the minimum installed capacity of turbines is 8 MW each instead of 6 MW each.
- Requirement 2.11: the cables from the wind turbines must be connected to the Hollandse Kust (noord) platform instead of platform HKZ Beta.
- Requirement 2.15 in the site decision HKZ Site IV is deleted: "The permit holder must make demonstrable efforts to design and build the wind farm in such a way that it actively enhances the sea's ecosystem, helping to foster conservation efforts and goals relating to sustainable use of species and habitats that occur naturally in the Netherlands. In this respect the permit holder is required to create an action plan, to be submitted to the Minister of Economic Affairs and Climate Policy no later than eight weeks before the commencement of the construction. Construction work must adhere to this plan."
- Requirement 2.15 in the site decision of HKN, about strengthening the local and regional economy, is almost the same as requirement 2.16 of the site decision of HKZ Site IV, but the requirement about reporting is different. Unlike the site decision HKZ Site IV, where a plan of action was required prior to the start of construction, in the site decision of HKN the license holder must provide annual insight into the contracts awarded to local and regional companies for the design, construction and operation of the wind farm, broken down to suppliers, ports, (sub) contractors and supporting service providers and the resulting turnover and employment.

- Requirement 2.16: During the repair and maintenance of cables and pipelines, the number of rotations per minute per wind turbine, for the wind turbines situated within a radius of 1,000 metres of the repair and maintenance location, must be reduced to less than two (instead of less than one).
- Requirement 4.2a: allowed underwater sound levels during pile-driving work are different.
- Requirement 4.3a: At night (between sunset and sunrise), during the period in which mass bird migration effectively takes place, to be specified by the Minister of Economic Affairs and Climate Policy, the number of rotations per minute per wind turbine will be reduced to less than two (instead of less than one).
- Requirement 4.4b: In case of a wind speed of less than 5.0 m/s at axis height during the period referred to in subparagraph a, the permit holder will reduce the number of rotations per minute per wind turbine to less than two (instead of less than one).
- Requirement 4.8 is new: measures to increase the suitable habitat for species native to the North Sea by means of hollows and cracks of various sizes and settlement substrate.
- Requirement 4.9 is new: measure to ensure the safe accessibility of mining platform Q4C, by helicopter for the purposes of employee transport and Search and Rescue (SAR) operations.

3 VERIFICATION REQUIREMENTS

3.1 Introduction

For each of the seven types of requirements, the following table gives information on how they are fulfilled. In the left column the requirements are presented. The next column presents whether the requirement is fulfilled and the last column presents the evidence thereof or declaration that it is or will be fulfilled.

3.2 Requirements verification

#	Requirement	Fulfilled ✓ or ✗	Evidence and/or declaration
	Decision Wind Farm Site V in the Hollandse Kust (noord) Wind Farm Zone (HKNWFZ) is designated as the location for a wind farm with a total installed capacity of a minimum of 693 MW and a maximum of 760 MW. The coordinates of the boundaries of Wind Farm Site V are presented in Regulation 2(1) of this Decision.	✓	69 x 11 MW = 759 MW. See chapter 2.2 of project plan (appendix 1).
1.	**Definition of terms**		No evidence needed.
2.	**Wind farm and bandwidth**		
	1. The wind farm will be situated within the contours of the coordinates listed in requirement 2.1 of the Site Decision.	✓	For the proposed wind turbine locations see Appendix 06 – Table of wind turbine details and locations HKN.xlsx Map 1 (appendix of this report) shows that the wind farm is located within the contours of the coordinates listed in requirement 2.1 of the Site Decision.
	2. The route of the grid connection and the TenneT Hollandse Kust (noord) platform is within the coordinates listed in requirement 2.2 of the Site Decision.	✓	For the proposed route of the grid connection and the TenneT Hollandse Kust (noord) platform see the appendix of this report. Map 2 (appendix of this report) shows that the route of the grid connection and the TenneT Hollandse Kust (noord) platform is within the coordinates listed in requirement 2.2 of the Site Decision.
	3. No wind turbines will be installed in maintenance zones of the TAT 14 Segment J and UK-NL 14 telecommunications cables. No wind turbines will be installed in the maintenance zones of the Wintershall Q4B-Q4A gas pipelines and the Petrogas E&P Q1 Helm-IJmuiden oil pipeline. These zones are bounded by the coordinates listed in requirement 2.3 of the Site Decision.	✓	Map 1 shows that no wind turbines will be installed in the maintenance zones of the TAT 14 Segment J and UK-NL 14 telecommunications cables. Also, no wind turbines will be installed in the maintenance zones of the Wintershall Q4B-Q4A gas pipelines and the Petrogas E&P Q1 Helm-IJmuiden oil pipeline.
	4. The rotor blades of the wind turbines must remain within the contours cited in 2.1 and completely outside the maintenance zones mentioned in 2.3.	✓	Map 1 shows that the rotor blades of the wind turbines remain completely within the contours mentioned in 2.1 and outside the maintenance zones mentioned in 2.3.
	5. The maximum number of turbines to be installed is 95.	✓	The number of turbines to be installed is 69.

#	Requirement	Fulfilled ✓ or ✗	Evidence and/or declaration
6.	The maximum total swept area permitted is: 2.913.840 m^2.	✓	See chapter 2.2 of project plan (appendix 1). The total swept area is phi*200,10m²*69 = 2.169.867 m^2. See: Appendix 01 - Summary description of realisation, operation and decommissioning 2.2 Wind Turbine Generator type and capacity. See Table 1.
7.	Only wind turbines with an installed capacity of at least 8 MW are to be installed in the wind farm.		The minimum nominal capacity is 11.00 MW per turbine. See Appendix 01 - Summary description of realisation, operation and decommissioning 2.2 Wind Turbine Generator type and capacity. See Table 1.
8.	The minimum distance between the wind turbines must be four times the rotor diameter expressed in metres.	✓	The minimum distance between wind turbines is [redacted] See chapter 2.2 of project plan, table 1. See also the appendix of this report for detailed distances.
9.	The minimum tip lowest level is 25 metres above sea level (MSL).	✓	See: Appendix 01 - Summary description of realisation, operation and decommissioning 2.2 Wind Turbine Generator type and capacity. See Table 1. Minimum blade tip height is 25.45 m MSL.
10.	The maximum tip highest level is 251 metres above sea level (MSL).	✓	See: Appendix 01 - Summary description of realisation, operation and decommissioning 2.2 Wind Turbine Generator type and capacity. See Table 1. Siemens Gamesa SG DD-200 hub height is 125.50 m MSL; with rotor radius 200.10/2 = 100.05, tip height is 225.55 m MSL.
11.	The cables from the wind turbines must be connected to the Hollandse Kust (noord) platform.	✓	Map 2 in the appendix in this document shows that the cables from the wind turbines are connected to the Hollandse Kust (noord) platform.
12.	The foundations permitted for the wind turbines are: monopile, tripod, jacket, gravity-based and suction bucket. If the permit holder wishes to deploy a type of foundation that is not cited in this paragraph, the environmental impact of that type must be determined. An analysis of the environmental impact must be submitted to the Minister of Economic Affairs and Climate Policy. The environmental impact must not exceed the limits set out in this Decision.	✓	See Appendix 01 - Summary description of realisation, operation and decommissioning – 3.2.1. Foundation, scour protection and inter-array cables. The proposed foundation design fits the permitted foundations. Therefore, no additional environmental impact study is needed.
13.	If sacrificial anodes are used as cathodic protection of steel structures, these must consist of aluminium or magnesium alloys. The alloys may contain small amounts (< 5 weight %) of other metals.	✓	See Appendix 11 - Description of measures to secure cost efficiency paragraph F.2.1.1 Location-specific design solutions: "The foundation design relies on Impressed Current Cathodic Protection (ICCP) in combination with coating to provide corrosion protection. This removes the need for sacrificial anodes and their associated impact on the environment."

#	Requirement	Fulfilled ✓ or ✗	Evidence and/or declaration
	14. Vessels used by or on behalf of the permit holder must take into account the presence of seals in the shallow waters/sandbank areas and designated resting areas, as well as any bird concentrations present. The measures cited in the Voordelta Management Plan, the Delta Water Management Plan, the Wadden Sea Management Plan, and the Noth Sea Coastal Zone Management Plan, must be taken into account. The terms used in the appropriate Management Plans are defined in the appendix to these regulations. This Regulation will be withdrawn once vessels as cited in the first sentence are incorporated as extant use in the Voordelta Management Plan, the Delta Water Management Plan, the Wadden Sea Management Plan, and the North Sea Coastal Zone Management Plan.	✓	CrossWind declare that the vessels used will also monitor and take into account the presence of seals on the plates and designated areas as well as the presence of bird concentrations. See chapter 3.4.1 of Appendix 1.
	15. The Government considers it important that the wind farm contributes to the local and regional economy. Every year, the permit holder shall provide insight into assignments related to the design, construction, and operation of the wind farm awarded to local and regional businesses, including specification of the suppliers, ports, contractors, subcontractors, and support services involved, in addition to the turnover and job opportunities generated. The first report shall be presented to the Minister of Economic Affairs and Climate Policy within two years of the date of issue of the permit. The last report shall be presented eight years after the date of issue of the permit.	✓	CrossWind will, in accordance with the Site Decision, provide insight into assignments related to the design, construction, and operation of the wind farm awarded to local and regional businesses, including specification of the suppliers, ports, contractors, subcontractors, and support services involved, in addition to the turnover and job opportunities generated. The first report will be presented to the Minister of Economic Affairs and Climate Policy within two years of the date of issue of the permit. The last report will be presented eight years after the date of issue of the permit. See 2.1 of Appendix 1.
	16. During the repair and maintenance of cables and pipelines, the number of rotations per minute per wind turbine, for the wind turbines situated within a radius of 1,000 metres of the repair and maintenance location, must be reduced to less than two.	✓	"During the operational phase CrossWind will liaise with owners of neighbouring assets to coordinate vessel movements and maintenance activities. In particular, when cable or pipeline owners will perform repair or maintenance on the cables in the maintenance zones intersecting the Hollandse Kust (noord) site, the turbines located within a distance of 1000m of the maintenance activity will be set to idling mode." This in order to be compliant with the site decision. See chapter 4 of Appendix 1. Map 3 in this report shows all relevant wind turbines within 1000m of a telecommunication cable and pipeline.
3.	**The permit** The permit as referred to in Section 12 of the Offshore Wind Energy Act will be issued for a period of 30 years.		No evidence needed.
4.	**Mitigating measures**		
	1. Measures for the prevention of permanent physical harm and/or effects to porpoises and seals and the mortality of fish	✓	CrossWind declares that they take the described mitigation measures and shall create a piling plan and submit it to the Minister of Economic Affairs and Climate Policy. The work will be