Statnett

NVF guide to offshore wind installations

1.1 INTRODUCTION

For utility owners wishing to connect to the Norwegian power grid, the technical requirements are currently described in the fos §14[1] supplementary document *Nasjonal veileder for funksjonskrav i kraftsystemet* (NVF)[2], which is a guideline for all owners and developers who plan to:

a) install new electrical facilities
b) perform changes to existing electrical facilities

Statnett, as the system operator, is currently mandated to make individual resolutions for approving the electrical functionality of the installation. This process starts with the facility owner initiating a formal fos §14 application. The NVF version that applies for the facility is determined in the final fos §14 approval document. Updated requirements in new revisions of the NVF are not enforced retroactively but will apply when changes or updates are made to the facility.

In this document, Statnett as system operator aims to give a brief introduction to offshore wind developers on the technical requirements in the Norwegian power system, where the requirements can be found in the NVF, and how they are practiced by Statnett. It should be noted that the requirements themselves are not given in this document, and it is referred to the main NVF-document[2] for details regarding these.

This document will be updated should new information arise, for example through updated technical requirements or change in common practice. Relevant updates or changes will be documented in the revision log presented below.

More detailed information regarding the fos §14 application process can be found on the Statnett homepage (Norwegian only).

Date	***Description***
10.03.2023	*First issue*
14.09.2023	*Chapter 1.4 V. – elaboration of system operator requirements for redundancy and reference to other relevant national regulations*

[1] Forskrift om systemansvaret i kraftsystemet

[2] NVF: Only available in Norwegian. An unofficial translation of chapters 14 and 15 of the 2021 NVF version can be provided upon request.

1.2 NVF and European network codes

The European network codes are not implemented into Norwegian law, however, the NVF captures a majority of the requirements described in the European network codes Requirements for Generators (RfG) and High Voltage Direct Current Connections (HVDC) respectively.

1.3 What does the NVF contain?

The NVF describes the technical requirements for, but not limited to:

- Voltage and frequency tolerance
- Frequency dependent active power regulation
- Reactive power regulation
- Reactive power capability
- Fault ride through capability
- Fast fault current injection
- Design of flexibility/redundancy in substations

The below table shows the relevant NVF chapters for different connection topologies for offshore power park modules.

Connection type	Technical requirements	Documentation requirements
AC connected	Chapter 14	Chapter 16
DC connected	Chapter 15 (for power park only)	Chapter 16
	Chapter 18 (for HVDC system only)	Chapter 19

Tolerance-, regulation- and capability requirements shall be met in either the point of common coupling or point of connection, defined as follows:

Point of common coupling (PCC)	Primary side of the power park main transformer.
Point of connection (POC)	Point where the ownership transfers from utility owner to grid owner (TSO or DSO).

PCC and POC can either coincide or be at different locations, depending on ownership boundaries. See Appendix 1 for examples on various base cases (AC and DC connected power park modules). The examples illustrated are simplified and the exact PCC/POC may vary, depending on the connection topology and complexity.

1.4 Relevant topics - common practice and future requirements

In the following sections, clarifications are provided for the common practice and developments of the requirements regarding:

I. Reactive power regulation
II. Reactive power capability
III. Frequency dependent active power regulation
IV. Grid forming capabilities
V. Redundancy in substations

I. Reactive power regulation

Unless otherwise decided by Statnett, a power park controller shall always be set to automatic voltage control mode (Q(U) mode) without deadband.

II. Reactive power capability

Reactive power capability is normally required at the PCC. However, in case of a long AC subsea cable, Statnett may decide that the requirements shall be met at the onshore side of the transmission cable.

The reactive power capability of $Q/P_{max} \geq 0{,}33$ is the requirement historically practiced by Statnett. However, with large amounts of renewable generation,today's practice may change to align the reactive power capability requirements for power park modules with those of the synchronous power plants ($Q/P_{max} \geq 0{,}46$ at the PCC). When wind power generation input to the system is at a maximum, the input from synchronous generators is at a minimum, and the system operator must ensure that there are sufficient reactive reserves available in case of system disturbances. Therefore, it is plausible that Statnett will require a reactive power capability in the range of 0,33-0,46. The exact value will be decided for each case until a new common practice has been agreed upon.

At least 85% of the required reactive capability at the PCC shall be dynamic, i.e. not to be provided from step-wise regulating components such as capacitor banks. Static (non-rotating) components with dynamic regulating abilities, typically VSC/STATCOM, could be required onshore to meet the dynamic capability requirements.

There shall be no functionality that actively limits the reactive power capability to the minimum reactive power capability requirement when operating in $P < P_{max}$ (power park) or $P_{max,export} < P < P_{max,import}$ (HVDC system).

III. Frequency dependent active power regulation

Power park modules are required to have functionality for frequency regulation (P(f) mode) as described in the NVF, however they are currently exempt from having this regulation mode activated[3].

For participation in upcoming market-based frequency containment reserves (FCR), it is referred to a separate prequalification process with corresponding technical requirements.

IV. Grid forming capabilities

Statnett may decide if HVDC systems and power park modules of type C and D[4] are required to have grid forming capabilities. Grid forming capabilities can for instance be understood as being able to act as a voltage source behind an internal impedance at the connection point, being capable of smooth transition to and from island mode operation and/or being able to rapidly adjust active power during high/low frequency incidents.

For power park modules, the current NVF introduces the same requirements as described in the RfG, and future revisions will be adapted to align with future revisions of the RfG. Although it is up to each TSO to decide the functionality to date, the functionality will be a requirement after a transitional period of maximum 3 years after the next RfG enters into force. Hence it can be expected that new facilities are required to provide grid forming capabilities as early as 2028.

[3] Vedtak om levering og betaling for systemtjenester 2022, jf. forskrift om systemansvaret i kraftsystemet (fos) §§ 9 og 27

[4] Type C: 10 MW $\leq P_{max} <$ 30 MW. Type D: $P_{max} \geq$ 30 MW or grid connection where $U_n \geq$ 110 kV

If grid forming capabilities cannot be provided for HVDC systems (or power park modules within the required timeframe), synchronous condensers at the point of connection can be considered as an alternative in order to provide necessary inertia and short circuit power in areas vulnerable to island mode operation. This could be realised through investment contributions (Norw.: "anleggsbidrag") according to existing models.

V. Redundancy in substations

NVF chapter 5 describes the requirements regarding redundancy design in substations for different nominal voltage levels.

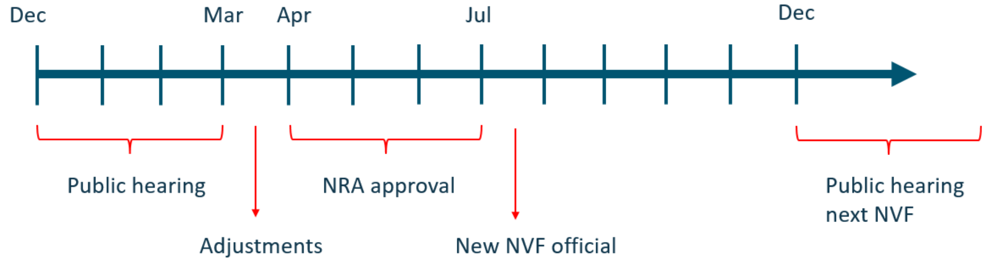
Offshore facilities could be required to comply with the highest degree of redundancy if these are deemed to be of major importance in the integrated power system, regardless of its nominal voltage level. Highest degree of redundancy means that Statnett as system operator can require a substation design that ensures uninterrupted power supply during planned or unplanned outages. This is normally provided through redundancy in switchgear and current transformers. Note that this also implies a two-busbar solution.

Redundancy for additional grid components and separate classifications for power generating facilities and substations (class 1-3) is not outlined in the fos §14 regulation, but a separate regulation for emergency preparedness in the power system[5]. The latter regulation is managed by The Norwegian Water Resources and Energy Directorate (NVE), and relevant questions shall be directed to this authority.

1.5 NVF UPDATE PROCESS

Currently the NVF is being revised on a yearly basis, with new revisions made public for a 3-month hearing process starting from 1st December, during which feedback on the proposed changes will be provided. Note that it is possible to give feedback to existing NVF requirements at any time and enter dialogue with Statnett to clarify and/or improve technical requirements for future revisions of the NVF.

The timeline for the update process is illustrated in the figure below. New hearing versions of the NVF are published on the Statnett homepage.



[5] Forskrift om sikkerhet og beredskap i kraftforsyningen (kraftberedskapsforskriften)

Appendix 1

AC connected power park modules

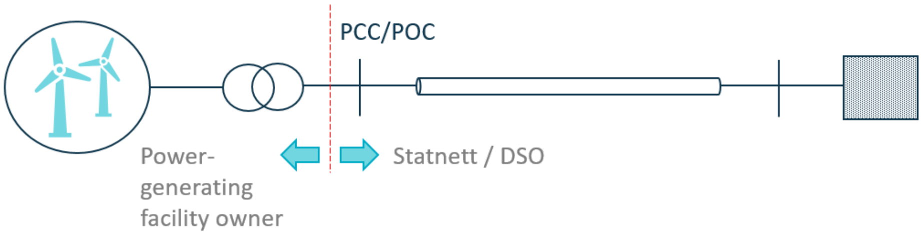


Figure 1: Subsea cable owned by TSO or DSO. PCC and POC coincide.

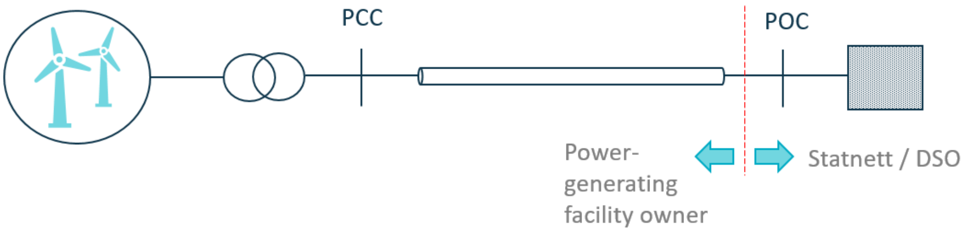


Figure 2: Subsea cable owned by the facility owner. PCC and POC are located at different points; offshore side and onshore side of the subsea cable.

DC connected power park modules

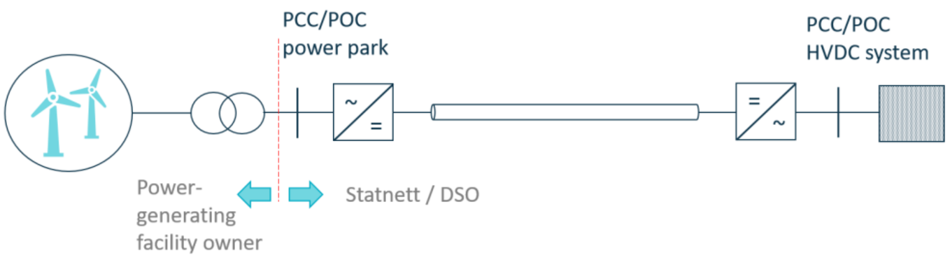


Figure 3: HVDC system owned by TSO or DSO. PCC and POC coincides for the facility owner. The TSO/DSO is responsible for the HVDC system meeting the technical requirements.

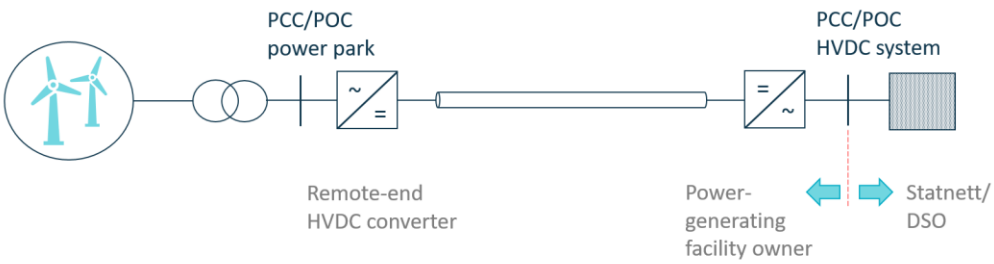


Figure 4: HVDC system owned by the facility owner, whom must meet the technical requirements in two sets of PCC/POCs; one for the power park itself and one for the HVDC system.