MEMO

TO

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Foreword and guide

As a Transmission System Operator (TSO), it is TenneT's legal duty is to monitor the stability of the Dutch electricity system. To do this, TenneT purchases ancillary services provided by market parties. One service that is used to maintain the reactive power balance in the Netherlands is stationary reactive power. Stationary reactive power is mainly used to keep the voltage in the EHV high voltage grid (380 kV and 220 kV) and the HV high voltage grid (150 kV and 110 kV) within the required bandwidth, as well as staying within required bandwidths for the exchange of reactive power with adjacent TSOs.

This document describes processes and requirements relating to the stationary reactive power product.

Version management

The document is split up into different chapters that describe the specific elements of reactive power. The version management table describes changes at the chapter level, making items that have been modified easier to find.

Version	Date	Description of amendments
V 0.6	5/8/2019	New document
V 0.9	17/10/2019	First draft.
V 1.0	3/12/2019	Comments by SON-SY and SON-TS have been incorporated. First published version

1. Definitions and abbreviations

Definition/abbreviation	Description
MW, Mvar	Units of active power and reactive power, respectively
Reactive Power Capability	'P-Q capability diagram': a diagram showing the reactive power capability of an electricity generation facility with varying active power at the connection point.

2. Explanation of voltage control system in the Netherlands, in respect of reactive power

2.1 What is reactive power?

In the alternating current (AC) grids, the power flows that run along the high voltage lines can be broken down arithmetically into active power flows (MW) and reactive power flows (Mvar). Although reactive power runs through the high voltage line, it is 90° out of phase with the voltage and therefore does not contribute to the active power output. Hence it is called "reactive power.

Although reactive power does not add to active power, it does play a significant role in the voltage level of the AC grid. To keep the voltage within the required bandwidth, the grid operator needs to continuously make sure that the reactive power in the grid is at the correct level, which is achieved by switching sources of reactive power on or off. For this purpose, the grid operator uses its own sources such as shunt reactors and capacitor banks, but it may also request generators or Power Park Modules[1] to offset the transferred value of reactive power exchange at the connection point. This is usually the agreed value of 0 Mvar.

In high voltage grids, voltage and reactive power are strongly location-specific. It is generally not efficient to transmit reactive power due to the characteristics of the AC grid. It is therefore preferable to use reactive power where there is local demand for voltage support.
TenneT makes an annual regional estimate of the amount of reactive power required for the coming year. Based on this estimate, an invitation to tender is issued for the supply contracts relating to stationary reactive power produced by generators and Power Park Modules.

2.2 How does the voltage control system work in the high voltage grid?

[1] 'Power park module': a unit or set of units generating electricity, connected to the system either in a non-synchronous way or through power electronics, and with a single point of connection to a transmission system, a distribution system (including a closed distribution system) or an HVDC system

In the Netherlands, the voltage control system in the high voltage grid is broken down into the primary and secondary voltage control systems.

- primary voltage control is designed to respond quickly and automatically in the event of a disturbance in the high voltage grid, and it is performed by generators and Power Park Modules;
- secondary voltage control is designed to ensure optimum use of stationary facilities for reactive power support during uninterrupted operation of the high voltage grid, and it is performed by the grid operator.

Primary voltage control system

The primary voltage control system of a generator or Power Park Module ensures the robustness of the power supply system in the event of a fault, such as the failure of a power line or a part of a high voltage substation. In the event of such a failure, the primary voltage controls of generators and Power Park Modules will provide an instantaneous response in the form of reactive power infeed or consumption at the connection point, depending on the local voltage changes in the grid. Since a fault can occur at any time, the primary voltage control on generators and Power Park Modules must be active at all times. The settings of the primary voltage control, including the voltage droop,[2] are specified by the grid operator.

The connected party is obliged to keep the primary voltage control active in accordance with the settings[3] specified by the grid operator and, in the event of a fault, to provide support for at least 15 minutes by generating or consuming reactive power.
Since the voltage control system is active at all times, the reactive power injection or consumption at the point of connection will vary continuously.[4] If the injection or consumption falls outside an agreed[5] bandwidth, it must be returned to the agreed value by the generator or Power Park Module within the agreed time. The grid operator will not give the connected party any compensation for primary voltage control.

Secondary voltage control

The purpose of the secondary voltage control system is to achieve the required stationary voltage profile in the high voltage grids and to make sure that the exchange of reactive power across borders remains within the agreed values.

In the Netherlands, secondary voltage control is performed by the adequate deployment of available means for stationary reactive power support. The grid operator has access to shunt reactors and capacitor banks as well as contracts for static reactive power from generators and Power Park Modules.

When generators and Power Park Modules are called upon to supply reactive power, the amount of reactive

[2] The voltage droop shows how great the change in reactive power input needs to be in the event of a given change in voltage.
[3] Grid Code Article 3.15(5)
[4] The changes in reactive power input caused by the voltage control system being in operation are referred to as 'dynamic reactive power'.
[5] The agreed bandwidth within which the dynamic reactive power must remain before having to be corrected back to the agreed value is laid down in the operating appendix of the connection and transmission agreement (ATO).

power called for at the delivery point becomes the new reference value instead of the default value of 0 Mvar.

The signing of a contract or calling on a contract is unrelated to whether or not the primary voltage control system has been activated. The primary control system must be active at all times, and after detecting a disturbance, support must first be given for 15 minutes. After this, the reactive power must be returned to 0 Mvar or to the called value if contracted reactive power was called up from the unit.

2.3 Reactive power product and type of contract

Reactive power available at generators and Power Park Modules

Reactive power is supplied by generators and Power Park Modules connected to the high voltage grid. The required reactive power capacity is laid down in European legislation[6] and the Dutch Grid Code for electricity regarding non-exhaustive requirements[7]. A distinction is made between existing production facilities (to which the European Regulation does not apply) and new production facilities (to which European legislation is applicable).
The reactive power capacity is shown by means of a U-Q/Pmax profile. The amount of reactive power, both inductive (supply to the grid) and capacity (withdrawing from the grid) is linked to the maximum active power of the generator or Power Park Module.
The reactive power that will be contracted by TenneT to maintain the stationary reactive power balance relates to a section of the full reactive power range. The rest must remain available for voltage support in the event of a fault (primary voltage control system).

Distinction between onshore and offshore

Until the end of 2020, TenneT will only contract reactive power services on onshore[8] grid connections. The contract value is based on the onshore point of connection. In 2020, the first offshore Power Park Modules will become operational. They will be connected to the offshore platform. However, as the offshore Power Park Modules, together with the line to the offshore platform and its associated installations, e.g. reactors and capacitors, are all controlled by a single reactive power control system, any contracting beyond the support that is required through the Power Park Modules will be defined differently than is the case with onshore connections.

Reactive power contract form

The contracting provides TenneT with a defined range of the total reactive power capacity of each contracted production facility, should it be operational. The defined range is broken down into an inductive part (the supply of reactive power to the grid) and a capacitive part (the drawing of reactive power from the grid).

[6] COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators
[7] This relates to how the Netherlands specifically interprets the requirements of European legislation.
[8] Until 2020, offshore wind farms will have onshore points of connection to TenneT's grid; only wind farms connected to TenneT's offshore platforms (Borssele, Hollandse Kust Zuid) will be considered to be offshore connections.

The contracting for production units may be done for a particular period or for a particular situation. Generally, the maximum period for an uninterrupted supply of reactive power is limited to part of the day (e.g. during the night, when there is increased grid voltage due to the reduced load on the grid); however, call-ups for more than 24 consecutive hours are also possible, provided that the production facility remains in operation throughout this period.

TenneT must be notified of any non-availability of contracted reactive power at a contracted generator or Power Park Module as soon as this is known.

The calling up of contracted reactive power is carried out by telephone or an electronically transmitted request.
The reaction time should be as brief as possible, but must not exceed 15 minutes[9].

The call for contracted reactive power is location-specific. The call is made in the region where there is a need for reactive power.

Contracts are awarded through an annual tendering process. The standard duration of contracts is one year. Specific contractual terms and conditions are included in the contract.

Examples of requested support

Example 1
After the trip of a line in the high voltage grid, the reactive power balance in the grid is disturbed and the voltage drops. In order to bring the voltage back up to the correct level, the grid operator checks which facilities are available near the location and which can best be used. If it is a generator or Power Park Module, then it is called in accordance with the terms and conditions of the contract. Currently, this is usually done by telephone[10].
Example 2
At the end of the working day, there is a reduction in high voltage transmissions, resulting in an increased voltage level in the high voltage grid. In order to bring the voltage back up to an acceptable level, the grid operator checks which means that are available near the location and which can best be used. If it is a generator or Power Park Module, then it is called in accordance with the terms and conditions of the contract.

[9] This period is linked to requirements set out in the Grid Code for mandatory support of reactive power as a primary response following a fault on the grid. Within 15 minutes, a TenneT operator must have taken effective action to ensure the voltage is no longer dependent on the primary voltage support.
[10] TenneT aims to use set-point transmission as its means of calling reactive power electronically. This standard is currently being included in the basic design of new connections.

3. Specifications and use of contracted reactive power

3.1 Generic specifications

Supply direction

A distinction is made between the 'inductive' supply direction (supply of reactive power to the grid) and the 'capacitive' supply direction (withdrawing reactive power from the grid). In the case of an inductive supply direction, the voltage in the grid will be increased, and in the case of a capacitive supply direction, the voltage in the grid will be reduced.
Inductive and capacitive reactive power products are specified separately in the reactive power contract.

Magnitude of the supply

The magnitude of the supply is expressed in Mvar per supply direction. The magnitude is defined as the maximum possible supply or through a limited, staggered two-stage supply (e.g. depending on system requirements of the production facility or Power Park Module). It must be possible to guarantee the magnitude of the supply throughout its duration.

Maximum magnitude of the supply in relation to single failure reserve.

The N-1 reserve is taken into account during the operation of the high voltage grid. A maximum of 250 Mvar is used as a limit for the reactive power withdraw or supply that may be lost in the event of a single fault. As this value is valid at the delivery point, the impact on a transformer's reactive power and any cable connection must be taken into consideration.

Examples (contract value is at delivery point)

Situation	Mvar cable	Mvar production facility	Mvar point of delivery	Maximum delta in case of Mvar failure
Standard	+100	-100	0	100
Supply (1 prod. facility)	+100	+150	+250	250 (cable + unit)
Withdraw (1 prod. facility)	+100	-250	-150	250 (1 unit)
Withdraw (2 prod. facilities)	+100	-250 & -100	-250	250 (1 unit or cable)

Start of supply

The start of supply is defined as the moment when the whole of the requested reactive power support has been achieved. The *Response time* must be as brief as possible, however full activation must always be achieved within 15 minutes of the call (by telephone or electronic means).

End of supply

The end of supply is defined as the moment the requested reactive power supply is terminated, either by the termination of the call by TenneT (by telephone or electronic means) or by technical limitations of the production facility due to a disruption or termination of the active power production.

Duration of supply
The duration of supply is defined as the period between the start of supply and the end of supply.

Specific contractual terms and conditions
Specific contractual terms and conditions covering the inability to supply reactive power are included in the contract.

3.2 Operational product requirements

Call-up activation
The operation of the production facility must be able to receive and handle a reactive power activation 24/7.

Availability of supply
The starting point for the contracted reactive power contracts is the availability if the contract throughout the contract year. TenneT must in all cases be notified by the Supplier of the non-availability or limited availability of reactive power using a Non-availability Report (GNB).

3.3 Verification of supply

TenneT verifies the supply of reactive power it calls up using operating measurements at the point of connection. If the requested supply has not been met, TenneT and the contracting party will discuss the matter, since it would constitute a defective response.
Examples of this are the Supplier's failure to meet the call in whole or in part within the Response Period while the Production Facility is operational, except in the case of a GNB or the termination of supply before TenneT has called for it to be terminated.

3.4 Settlement
The volume of reactive power that is compensated is calculated according to the contractual terms and conditions.

4. Prequalification procedure for reactive power

4.1 Existing production facilities.
No prequalification process currently exists for existing production facilities.

4.2 New production facilities

An organisation is entitled to offer reactive power if compliance tests have shown that it is capable of doing so.