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BETREFT Testplan op basis van de Verordening (EU) 2017/2196 (NC ER)

Geachte heer Don,

Hierbij ontvangt u het testplan dat TenneT heeft opgesteld op basis van artikel 43 van de Verordening (EU) 2017/2196 tot vaststelling van een netcode voor de noodtoestand en het herstel van het elektriciteitsnet (op basis van de Engelse titel afgekort als: NC ER).

Over dit testplan heeft afstemming plaatsgevonden met de regionale netbeheerder in de gezamenlijke Werkgroep implementatie NC ER. Met representatieve organisaties van netgebruikers heeft afstemming plaatsgehad in een stakeholderbijeenkomst op 8 januari jl.

U wordt verzocht dit testplan goed te keuren op grond van artikel 4, tweede lid, onderdeel g, van de NC ER.

Hoogachtend,
TenneT TSO B.V.

[redacted]

Senior Manager Regulation NL

Test plan

for equipment and capabilities relevant for the system defence plan and the restoration plan related to NCER article 43

TenneT

Contents

1. Scope

For the purposes of safeguarding operational security, preventing the propagation or deterioration of an incident to avoid a widespread disturbance and the blackout state as well to allow for the efficient and rapid restoration of the electricity system from the emergency or blackout states, Regulation (EU) 2017/2196 "Establishing a network code on electricity emergency and restoration" (NC ER) establishes a network code which lays down the requirements on:

(a) the management by TSOs of the emergency, blackout and restoration states;
(b) the coordination of system operation across the European Union in the emergency, blackout and restoration states;
(c) the simulations and tests to guarantee a reliable, efficient and fast restoration of the interconnected transmission systems to the normal state from the emergency or blackout states;
(d) the tools and facilities needed to guarantee a reliable, efficient and fast restoration of the interconnected transmission systems to the normal state from the emergency or blackout states.

Even though each TSO is responsible for maintaining operational security in its control area, the secure and efficient operation of the Union's electricity system is a task shared between all the Union TSOs since all national systems are, to a certain extent, interconnected and a fault in one control area could affect other areas. The efficient operation of the Union's electricity system also requires a close collaboration and coordination between stakeholders. It is therefore necessary to set out harmonised requirements concerning technical and organisational measures in order to prevent the propagation or deterioration of an incident in the national system and to avoid the spread of the disturbance and blackout state to other systems. It is also necessary to set out harmonised procedures that TSOs should implement in order to restore the alert or normal state after the spread of the disturbance or blackout state. Each TSO should support any other TSO in emergency, blackout or restoration state, upon request, where such support does not lead the system of the requested TSO into emergency or blackout state.

This document particularly refers to the implementation of NC ER article 43: Compliance testing of TSO, DSO and SGU capabilities.

2. Definitions and abbreviations

2.1 Abbreviations

The following list of abbreviations is not complete but gives an overview of the most common abbreviations in this document. For further explanation of terminology used, we refer to the relevant regulations and codes.

Abbreviation	Description
DSO	Distribution System Operator
LFDD	Low Frequency Demand Disconnection
NC DCC	Network Code for Requirements for Demand Connection (COMMISSION REGULATION (EU) 2016/1388)
NC ER	Network Code for Emergency and Restoration (COMMISSION REGULATION (EU) 2017/2196)
NC HVDC	Network Code for Requirements for High Voltage DC systems and DC-connected Power Park Modules (COMMISSION REGULATION (EU) 2016/1447)
NC RfG	Network Code for Requirements for Grid Connection Applicable to all Generators (COMMISSION REGULATION (EU) 2016/631)
PGM	Power-Generating Module
PPM	Power Park Module
RSO	Relevant System Operator
SPGM	Synchronous Power Generating Module
TSO	Transmission System Operator

2.2 Definitions

The following list of definitions is not complete but gives an overview of the most common terms in this document. For further explanation of terminology used, we refer to the relevant regulations and codes.
Definitions from European Network Codes:

- **Closed distribution system:** a distribution system classified pursuant to Article 28 of Directive 2009/72/EC as a closed distribution system by national regulatory authorities or by other competent authorities, where so provided by the Member State, which distributes electricity within a geographically confined industrial, commercial or shared services site and does not supply household customers, without prejudice to incidental use by a small number of households located within the area served by the system and with employment or similar associations with the owner of the system [from: NC DCC]
- **Connection agreement:** a contract between the relevant system operator and either the power-

generating facility owner, demand facility owner, distribution system operator or HVDC system owner, which includes the relevant site and specific technical requirements for the power-generating facility, demand facility, distribution system, distribution system connection or HVDC system [from: NC RfG]

- **Connection Point:** the interface at which the Power-Generating Module, demand facility, distribution system or HVDC system is connected to a transmission system, offshore network, distribution system, including closed distribution systems, or HVDC system, as identified in the connection agreement [from: NC RfG]
- **Demand facility**: a facility which consumes electrical energy and is connected at one or more connection points to the transmission or distribution system. A distribution system and/or auxiliary supplies of a power generating module do no constitute a demand facility [from: NC DCC]
- **Low Frequency Demand Disconnection (LFDD)**: an action where demand is disconnected during a low frequency event in order to recover the balance between demand and generation and restore system frequency to acceptable limits [from: NC DCC]
- **Low Voltage Demand Disconnection (LVDD)**: a restoration action where demand is disconnected during a low voltage event in order to recover voltage to acceptable limits [from: NC DCC]
- **HVDC system**: an electrical power system which transfers energy in the form of high-voltage direct current between two or more alternating current (AC) buses and comprises at least two HVDC converter stations with DC transmission lines or cables between the HVDC converter stations [from: NC HVDC]
- **Maximum Capacity (P_{max}):** the maximum continuous active power which a Power-Generating Module can produce, less any demand associated solely with facilitating the operation of that Power-Generating Module and not fed into the network as specified in the connection agreement or as agreed between the relevant system operator and the Power-Generating Facility Owner [from: NC RfG]
- **Minimum Regulating Level:** the minimum active power, as specified in the connection agreement or as agreed between the relevant system operator and the Power-Generating Facility Owner, down to which the power- generating module can control active power [from: NC RfG]
- **Power-Generating Module (PGM):** either a synchronous Power-Generating Module or a Power Park Module [from: NC RfG]
- **Synchronous Power-Generating Module (SPGM):** an indivisible set of installations which can generate electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in synchronism [from: NC RfG]
- **Power Park Module (PPM):** a unit or ensemble of units generating electricity, which is either non-synchronously connected to the network or connected through power electronics, and that also has a single Connection Point to a transmission system, distribution system including closed distribution system or HVDC system [from: NC RfG]
- **Offshore Power Park Module (OPPM):** a Power Park Module located offshore with an offshore Connection Point [from: NC RfG]
- **Power-Generating Facility:** a facility that converts primary energy into electrical energy and which consists of one or more Power-Generating Modules connected to a network at one or more

Connection Points [from: NC RfG]

- **Power-Generating Facility Owner (PGFO):** a natural or legal entity owning a Power-Generating Facility [from: NC RfG]
- **Relevant TSO:** the TSO in whose control area a Power-Generating Module, a demand facility, a distribution system or a HVDC system is or will be connected to the network at any voltage level [from: NC RfG]
- **Relevant System Operator (RSO):** the transmission system operator or distribution system operator to whose system a Power-Generating Module, demand facility, distribution system or HVDC system is or will be connected [from: NC RfG]
- **Significant Grid User (SGU):** a grid user as mentioned in NCER article 2.2
- **Transmission-connected demand facility**: a demand facility which has a connection point to a transmission system [from: NC DCC]
- **Transmission-connected distribution facility**: a distribution system connection or the electrical plant and equipment used at the connection to the transmission system [from: NC DCC]
- **Transmission-connected distribution system**: a distribution system connected to a transmission system, including transmission-connected distribution facilities [from: NC DCC]

3. System defence plan and restoration plan

Each TSO should establish a system defence plan and a restoration plan, through a three steps approach: a design phase, consisting of defining the detailed content of the plan; an implementation phase, consisting in the development and installation of all necessary means and services for the activation of the plan; and an activation phase, consisting of operational use of one or more measure(s) from the plan.

The harmonisation of the requirements for the establishment by TSOs of their respective system defence plan and restoration plan should ensure the overall efficiency of those plans at Union level.

The system defence plan shall include at least the following technical and organisational measures specified in Section 2 of NC ER Chapter II (articles 15 through 22):

(a) system protection schemes including at least:
  (i) automatic under-frequency control scheme;
  (ii) automatic over-frequency control scheme; and
  (iii) automatic scheme against voltage collapse.
(b) system defence plan procedures, including at least:
  (i) frequency deviation management procedure;
  (ii) voltage deviation management procedure;
  (iii) power flow management procedure;
  (iv) assistance for active power procedure; and
  (v) manual demand disconnection procedure.

The restoration plan shall include at least the following technical and organisational measures specified in NC ER Chapter III:

(a) re-energisation procedure, in accordance with Section 2;
(b) frequency management procedure, in accordance with Section 3; and
(c) resynchronisation procedure, in accordance with Section 4.

4. NC ER 43: Compliance testing of TSO, DSO and SGU capabilities

According to NC ER Article 43 each TSO shall periodically assess the proper functioning of all equipment and capabilities considered in the system defence plan and the restoration plan. To this end, each TSO shall periodically verify the compliance of such equipment and capabilities. Each TSO shall define a test plan to identify the equipment and capabilities relevant for the system defence plan and the restoration plan that have to be tested.

In line with NCER article 4, sub 2,g any future revisions of this testplan, will be aligned with the concerned parties (GEN-members) and will be submitted to the national regulator (ACM) for approval, by TenneT NL.

The test plan shall include the periodicity and conditions of the tests, following the minimum requirements outlined in NC ER Articles 44 to 47. The test plan shall follow the methodology laid down in NC RfG, NC DCC and NC HVDC for the corresponding tested capability. For SGUs that are not subject to these NC's, the test plan shall follow the provisions of national law.

Each TSO, DSO, SGU, defence service provider and restoration service provider shall not endanger the operational security of the transmission system and of the interconnected transmission system during the test. The test shall be conducted in a way that minimises the impact on system users.

The test is deemed to be successful when it fulfils the conditions established by the relevant system operator. As long as a test fails to fulfil these criteria, the TSO, DSO, SGU, defence service provider and restoration service provider shall repeat the test.

The compliance testing outlined in NC ER Articles 44 to 47 are:

- Article 44: Compliance testing of power generating module capabilities:
  - black start capability test, following NC RfG Article 45(5);
  - tripping to houseload test, following NC RfG Article 45(6);
- Article 45: Compliance testing of demand facilities providing demand side response:
  - demand modification test, following NC DCC Article 41(1);
  - remote disconnection test, following NC DCC Article 37(4);
- Article 46: Compliance testing of HVDC capabilities:
  - black start capability test, following NC HVDC Article 71(11);
- Article 47: Compliance testing of low frequency demand disconnection relays:
  - low frequency demand disconnection relays test, following NC DCC Articles 37(6) and 39(5).

The tests are carried out by and at the expense of the DSO or SGU.

Test-evaluation reports of the mentioned tests are delivered to TenneT in case

- determined in the code or
- determined in a bilateral contract or
- on request of TenneT.

Overview of current and expected future defence measures related to low frequency and load reduction in The Netherlands:

Phenomenon	Required action	Status	Implementation
Serious national unbalance, grid problems or frequency deviation	Manually remote controlled load shedding, by agreement	Possible future	NC ER 18(5), NC ER 45
Serious national unbalance and grid problems	Manually remote controlled load shedding, by instruction	Current	NC ER 18(4), Netcode elektriciteit Article 9.2.11
Fast frequency drop	Automatic, LFDD	Current	NC ER 15(5), NC ER 47, NC ER 50, Netcode elektriciteit Article 9.26

Overview applicable measures related to NC ER Articles 44–47 in The Netherlands:

NC ER Article	Status	Implementation
44(1) PGM Black start	Current	
44(2) Tripping to houseload	Current	
45(1) Demand modification	Possible future	For emergency purposes
45(2) Manually low frequency demand disconnection	Possible future	For emergency purposes, manually, see NC ER 18(5)
46 HVDC black start	Not expected	
47 LFDD relays	Current	Steps and triggers will be changed, see NC ER 15(5)

4.1 NC ER 44(1): PGM black start capability test

Applicable to: SPGM type C and type D and delivering black start service
Requirement: NC RfG Article 15(5)(a)
Netcode elektriciteit Article: 3.17(8)(a), 3.24, sub 8 and 9, 9.28
Test: NC RfG Article 45(5) (SPGM)
Simulation: if required by TSO
Periodicity: every year

NC ER Article 44(1): Each restoration service provider which is a power generating module delivering black start service shall execute a black start capability test, at least every three years, following the methodology laid down in NC RfG Article 45(5).

Requirement to be verified

NC RfG Article 45: Compliance tests for type C synchronous power-generating modules

5. With regard to the black start capability test the following requirements shall apply:
   (a) for power-generating modules with black start capability, this technical capability to start from shut down without any external electrical energy supply shall be demonstrated;
   (b) the test shall be deemed successful if the start-up time is kept within the time frame set out in point (iii) of [RfG] Article 15(5)(a).

NC RfG Article 15: General requirements for type C Power-Generating Modules

5.Type C Power-Generating Modules shall fulfil the following requirements relating to system restoration:
   (a) with regard to black start capability:
      (i) black start capability is not mandatory without prejudice to the Member State's rights to introduce obligatory rules in order to ensure system security;
      (ii) Power-Generating Facility Owners shall, at the request of the relevant TSO, provide a quotation for providing black start capability. The relevant TSO may make such a request if it considers system security to be at risk due to a lack of black start capability in its control area;
      (iii) a Power-Generating Module with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a time frame specified by the relevant system operator in coordination with the relevant TSO;
      (iv) a Power-Generating Module with black start capability shall be able to synchronise within the frequency limits laid down in point (a) of Article 13(1) and, where applicable, voltage limits specified by the relevant system operator or in Article 16(2);
      (v) a Power-Generating Module with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand;
      (vi) a Power-Generating Module with black start capability shall:
         - be capable of regulating load connections in block load,

- be capable of operating in LFSM-O and LFSM-U, as specified in point (c) of [RfG Article 15] paragraph 2 and [RfG] Article 13(2),
- control frequency in case of overfrequency and underfrequency within the whole active power output range between minimum regulating level and maximum capacity as well as at houseload level,
- be capable of parallel operation of a few Power-Generating Modules within one island, and
- control voltage automatically during the system restoration phase;

The frequency limits laid down in Netcode elektriciteit Article 3.17(8)(b) are: 47,5 Hz – 51,0 Hz.

The voltage limits laid down in Netcode elektriciteit Article 3.17(8)(a) are:

- type C 0,90 pu – 1,10 pu;

The voltage limits laid down in NC RfG Article 16(2) for unlimited time are:

- type D 110 kV up to 300 kV: 0,90 pu – 1,118 pu;
- type D 300 kV to 400 kV: 0,90 pu – 1,05 pu.

According to Netcode elektriciteit Article: 3.24, sub 8 and 9:

8. The PGM with black-start functionality is capable to start from a complete shutdown according to the specifications published by the RSO.
9. The PGM with black-start functionality is capable to synchronise according to the specifications published by the RSO.

According to proposed Netcode elektriciteit Article: 9.28:

The TSO acquires black-start possibilities in a size to be determined by him. He determines the preferred locations and he uses the product specifications as referred to in Article 4, second paragraph, part b, of the NC ER, as included in Appendix 5.

According to the Synchronous Area Framework Agreement for Entso-E Regional Group Continental Europe it is recommended to test PGMs with Black Start Capability as follows:

- Simple start test for general checking the capability of service by means of remote command or at least via phone call from the TSO control room to local power generating facility control room. The PGM should be able to run to the nominal speed and voltage as quick as possible and operate in this no load operation state minimum 30 minutes.
- Complex start test in order to check the capability of full service for system restoration. In addition to simple start test the PGM with Black Start Capability should be able to regulate the frequency and voltage on a separated network island connected to the PGM providing Black Start Capability and balance the active and reactive load switching (on and off) by means of connecting lines and suitable load (e.g. pump-storages, auxiliaries/in-house load of PGMs or power plants, contracted load as ancillary services) in some steps. About the duration of the test and the magnitude of the load should be agreed with the Black Start Capability providers in advance.

Objective

With regard to the black start capability test the following requirements shall apply:

- for a PGM with black start capability, this technical capability to start from shut down without any external electrical energy supply shall be demonstrated;
- to demonstrate that the PGM is able to energise a de-energised substation in limited time;
- to demonstrate that the PGM is able to energise a de-energised network as indicated by the TSO;
- to demonstrate that the PGM is able to run at low load during a significant time;

4.1.1 Black start capability Tests

Test procedure

- Al steps including all necessary switching actions are laid down in the detailed test protocol as part of the black start agreement;
- The PGM with black start capability must be at complete standstill, without any connection to the Connection Point or any other external electrical energy supply;
    - All the auxiliary gas turbines and/or auxiliary diesel engines in the facility in which that PGM with black start capability is situated, shall be shut down;
    - The relevant PGM with black start capability shall be de-loaded and de-synchronised and all alternating current electrical supplies to its auxiliary system shall be disconnected;
- The emergency generator may start automatically;
- The auxiliary gas turbine(s) or auxiliary diesel engine(s) to the relevant PGM with black start capability shall be started, and shall re-energise the auxiliary system of the relevant PGM;
- Energise the step-up transformer according to the energising method that is described in the detailed test protocol;
- The relevant PGM will connect to a de-energised grid-section and to maintain this section at a stable voltage of 100% Un or lower if agreed
- The relevant PGM will soft-energize the grid-section if agreed.
- Energise the designated network section according to the energising method that is described in the detailed test protocol.

Documentation/measurements

The following signals (as a function of time) should be recorded as a minimum:

- speed, voltage, active and reactive power output of auxiliary gas turbine/diesel generators for black start function;
- terminal voltages of auxiliary MV and LV switchgear;
- auxiliary power output of emergency generators;
- turbine speed, -terminal voltage and active and reactive power output of the (gas)turbine that is started;
- active and reactive power output at the Connection Point;
- voltage and frequency at the Connection Point

- lead time internal sub-steps between start and energisation.

Test evaluation criteria

- The PGM with black start capability successfully:
  - energises the designated network section to be energised;
  - injects or absorbs the reactive power of the designated network section to be energised;
  - in island mode maintains the energised network section at a stable voltage of 100% U_n or lower;
  - outputs active power according to the black-start agreement;
  - powers up to the minimum regulating level with a mean increment as stated in the black start agreement;
  - increases the active power output to the agreed level;
- The test shall be deemed successful if the start-up time is kept within the time frame set out in the black-start agreement and if the PGM runs stable.

4.1.2 Black start capability simulation

The TSO can request the PFGO to conduct a simulation study to demonstrate the capability to energise the TSO network.

4.2 NC ER 44(2): PGM Tripping to houseload test

Applicable to: SPGM type C and type D
Requirement: NC RfG Article 15(5)(c)
Netcode elektriciteit Article: 3.20
Test: NC RfG Article 45(6)
Simulation: none

NC ER Article 44(2): Each restoration service provider which is a power generating module delivering a quick re-synchronisation service shall execute tripping to houseload test after any changes of equipment having an impact on its houseload operation capability, or after two unsuccessful consecutive tripping in real operation, following the methodology laid down in NC RfG Article 45(6).

Requirement to be verified

NC RfG Article 45(6): With regard to the tripping to houseload test the following requirements shall apply:

(a) the power-generating modules' technical capability to trip to and stably operate on house load shall be demonstrated;
(b) the test shall be carried out at the maximum capacity and nominal reactive power of the power-generating module before load shedding;
(c) the relevant system operator shall have the right to set additional conditions, taking into account point (c) of Article 15(5);
(d) the test shall be deemed successful if tripping to house load is successful, stable houseload operation has been demonstrated in the time period set out in point (c) of Article 15(5) and re-synchronisation to the network has been performed successfully.

NC RfG Article 15: General requirements for type C Power-Generating Modules; also applicable to type D:
5. Type C Power-Generating Modules shall fulfil the following requirements relating to system restoration:
(c) with regard to quick re-synchronisation capability:
(i) in case of disconnection of the Power-Generating Module from the network, the Power-Generating Module shall be capable of quick re-synchronisation in line with the protection strategy agreed between the relevant system operator in coordination with the relevant TSO and the Power-Generating Facility;
(ii) a Power-Generating Module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the system operator's switchgear position signals;
(iii) Power-Generating Modules shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system operator in coordination with the relevant TSO, taking into

consideration the specific characteristics of prime mover technology.

Netcode elektriciteit, Article 3.20:

1. If the Power-Generating Module with a maximum capacity of more than 5 MW, connected to a medium or high-voltage grid, is disconnected from the grid by a short-circuit in the grid, the Power-Generating Module is capable of running stable operation parallel to the grid with all generators in operation, within 30 minutes after the voltage returns. This requirement only applies if the grid voltage returns within 60 minutes.
2. If the period of 30 minutes is not technically possible, the relevant producer must explain this to the TSO. It must also be mentioned to the TSO within which time the stable operation will be possible.

Objective

To prove that the SPGM is capable to successfully trip to houseload from any operating point in its P-Q-capability diagram and continues to run in stable operation.

4.2.1.1 Tripping to houseload Tests for PGM's that are subject to NC RfG

Periodicity: after any changes of equipment having an impact on its houseload operation capability, or after two unsuccessful consecutive tripping in real operation

Test procedure

- The tests will be executed for maximum capacity and nominal reactive power within the network constraints;
- The SPGM will be disconnected from the network by opening the main circuit breaker;
- The SPGM will successfully go into island mode and will run stable for 1 hr;
- 1 hr after disconnection, the SPGM will be synchronised and reconnected to the network;
- Within 30 minutes after reconnection the SPGM will be able to run stable at minimum regulating level;
- The SPGM will be able to run stable at minimum regulating level for 1 hr after the 30 minutes for reaching the minimum regulating level have passed.

Documentation/measurements

The following signals will be reported as time functions:

- At the Connection Point: power (P, Q), Voltage (V), Current (I);
- Synchronisation of units.

Test evaluation criteria

The test shall be deemed successful:

- If tripping to house load is successful;
- If stable houseload operation has been demonstrated for the period of 1 hr;
- If re-synchronisation to the network and stable running at minimum regulating level has been performed successfully during one hour.

4.2.1.2 Tripping to houseload Tests for PGM's connected to 110 kV and higher that are not subject to NC RfG

Periodicity: after any changes of equipment having an impact on its houseload operation capability.

Test procedure

- The tests will be executed for at least 85% of maximum capacity and nominal reactive power within the network constraints;
- The SPGM will be disconnected from the network by opening the main circuit breaker;
- 1 hr after disconnection, the SPGM will be synchronised and reconnected to the network;
- Within 30 minutes after reconnection the SPGM will be able to run stable at minimum regulating level;
- The SPGM will be able to run stable at minimum regulating level for 1 hr after the 30 minutes for reaching the minimum regulating level have passed.

Documentation/measurements

The following signals will be reported as time functions:

- At the Connection Point: power (P, Q), Voltage (V), Current (I);
- Synchronisation of units.

Test evaluation criteria

The test shall be deemed successful:

- If re-synchronisation to the network and stable running at minimum regulating level has been performed successfully during one hour.

4.3 NC ER 45(1): Demand modification test

Applicable to: Transmission-connected distribution facilities and Transmission-connected demand facilities which are providing emergency-demand site response.
Requirement: NC DCC Article 28(2)
Netcode elektriciteit Article: 4.11
Test: NC DCC Article 41(1)
Simulation: none
Periodicity: after two consecutive unsuccessful responses in real operation or at least every year

NC ER Article 45(1): Each defence service provider delivering demand response shall execute a demand modification test, after two consecutive unsuccessful responses in real operation or at least every year, following the methodology laid down in NC DCC Article 41(1).

Requirement to be verified

NC DCC Article 41: Compliance testing for demand units with demand response active power control, reactive power control and transmission constraint management

1. With regard to the demand modification test:
   (a) the technical capability of the demand unit used by a demand facility or a closed distribution system to provide demand response active power control, demand response reactive power control or demand response transmission constraint management to modify its power consumption, after receiving an instruction from the relevant system operator or relevant TSO, within the range, duration and time frame previously agreed and established in accordance with [DCC] Article 28, shall be demonstrated, either individually or collectively as part of demand aggregation through a third party;
   (b) the test shall be carried out either by an instruction or alternatively by simulating the receipt of an instruction from the relevant system operator or relevant TSO and adjusting the power demand of the demand facility or the closed distribution system;
   (c) the test shall be deemed passed, provided that the conditions specified by the relevant system operator or relevant TSO pursuant to [DCC] Article 28(2)(d)(f)(g)(h)(k) and (l) are fulfilled;
   (d) an equipment certificate may be used instead of part of the tests provided for in [DCC Article 41] paragraph 1(b), on the condition that it is provided to the relevant system operator or relevant TSO.

NC DCC Article 28(2): Demand units with demand response active power control, demand response reactive power control, or demand response transmission constraint management shall comply with the following requirements, either individually or, where it is not part of a transmission-connected demand facility, collectively as part of demand aggregation through a third party:

(a) be capable of operating across the frequency ranges specified in [DCC] Article 12(1) and the extended range specified in [DCC] Article 12(2);

(b) be capable of operating across the voltage ranges specified in [DCC] Article 13 if connected at a voltage level at or above 110 kV;
(c) be capable of operating across the normal operational voltage range of the system at the connection point, specified by the relevant system operator, if connected at a voltage level below 110 kV. This range shall take into account existing standards and shall, prior to approval in accordance with [DCC] Article 6, be subject to consultation with the relevant stakeholders in accordance with [DCC] Article 9(1);
(d) be capable of controlling power consumption from the network in a range equal to the range contracted, directly or indirectly through a third party, by the relevant TSO;
(e) be equipped to receive instructions, directly or indirectly through a third party, from the relevant system operator or the relevant TSO to modify their demand and to transfer the necessary information. The relevant system operator shall make publicly available the technical specifications approved to enable this transfer of information. For demand units connected at a voltage level below 110 kV, these specifications shall, prior to approval in accordance with [DCC] Article 6, be subject to consultation with the relevant stakeholders in accordance with [DCC] Article 9(1);
(f) be capable of adjusting its power consumption within a time period specified by the relevant system operator or the relevant TSO. For demand units connected at a voltage level below 110 kV, these specifications shall, prior to approval in accordance with [DCC] Article 6, be subject to consultation with the relevant stakeholders in accordance with [DCC] Article 9(1);
(g) be capable of full execution of an instruction issued by the relevant system operator or the relevant TSO to modify its power consumption to the limits of the electrical protection safeguards, unless a contractually agreed method is in place with the relevant system operator or relevant TSO for the replacement of their contribution (including aggregated demand facilities' contribution through a third party);
(h) once a modification to power consumption has taken place and for the duration of the requested modification, only modify the demand used to provide the service if required by the relevant system operator or relevant TSO to the limits of the electrical protection safeguards, unless a contractually agreed method is in place with the relevant system operator or relevant TSO for the replacement of their contribution (including aggregated demand facilities' contribution through a third party). Instructions to modify power consumption may have immediate or delayed effects;
(i) notify the relevant system operator or relevant TSO of the modification of demand response capacity. The relevant system operator or relevant TSO shall specify the modalities of the notification;
(j) where the relevant system operator or the relevant TSO, directly or indirectly through a third party, command the modification of the power consumption, enable the modification of a part of its demand in response to an instruction by the relevant system operator or the relevant TSO, within the limits agreed with the demand facility owner or the CDSO and according to the demand unit settings;
(k) have the withstand capability to not disconnect from the system due to the rate-of-change-of-frequency up to a value specified by the relevant TSO. With regard to this withstand capability, the value of rate-of-change-of- frequency shall be calculated over a 500 ms time frame. For demand units connected at a voltage level below 110 kV, these specifications shall, prior to approval in accordance with [DCC] Article 6, be subject to consultation with the relevant stakeholders in accordance with [DCC] Article 9(1);
(l) where modification to the power consumption is specified via frequency or voltage control, or both, and

via pre- alert signal sent by the relevant system operator or the relevant TSO, be equipped to receive, directly or indirectly through a third party, the instructions from the relevant system operator or the relevant TSO, to measure the frequency or voltage value, or both, to command the demand trip and to transfer the information. The relevant system operator shall specify and publish the technical specifications approved to enable this transfer of information. For demand units connected at a voltage level below 110 kV, these specifications shall, prior to approval in accordance with [DCC] Article 6, be subject to consultation with the relevant stakeholders in accordance with [DCC] Article 9(1).

Netcode elektriciteit Article 4.11.1: The time period at which the facility is capable of adjusting its power consumption after instruction from the RSO is recorded in the connection agreement.

Objective

The test shall demonstrate that the demand facility or closed distribution system is capable of providing demand response active power control, reactive power control or transmission constraint management within the ranges, timeframe and duration as specified in the connection agreement.

Test procedure

The following steps shall be executed:

- The power consumption will be in the middle of the power range as specified in the connection agreement;
- The maximum time period for adjusting the power consumption is as specified in the connection agreement;
- If the demand response comprises active power consumption:
    - An instruction to decrease the active power consumption by half of the range as specified in the connection agreement will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
    - The system will hold for at least 15 minutes;
    - An instruction to increase the active power consumption to the original value will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
    - The system will hold for at least 15 minutes;
    - An instruction to increase the active power consumption by half of the range as specified in the connection agreement will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
    - The system will hold for at least 15 minutes;
    - An instruction to decrease the active power consumption to the original value will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
    - The system will hold for at least 15 minutes;
- If the demand response comprises reactive power consumption:
    - An instruction to decrease the reactive power consumption by half of the range as specified

in the connection agreement will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
- The system will hold for at least 15 minutes;
- An instruction to increase the reactive power consumption to the original value will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
- The system will hold for at least 15 minutes;
- An instruction to increase the reactive power consumption by half of the range as specified in the connection agreement will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
- The system will hold for at least 15 minutes;
- An instruction to decrease the reactive power consumption to the original value will be issued by the RSO; the power consumption will be adjusted within the specified maximum time period;
- The system will hold for at least 15 minutes.

Documentation/measurements

- The remote instruction signal shall be recorded as a function of the time;
- P, Q, V shall be measured as function of the time at the Connection Point.

Test evaluation criteria

The test shall be deemed successful if the following conditions are fulfilled:

- The facility modifies the active and/or reactive power consumption from the system to the received instruction within the time specified in the connection agreement.

4.4 NC ER 45(2): Remote disconnection test

Applicable to: Transmission-connected distribution facilities and Transmission-connected demand facilities which are providing emergency-demand site response
Requirement: NC DCC Article 19(4)(c)
Netcode elektriciteit Article: 4.8
Test: NC DCC Article 37(4) (distribution), 39(4) (demand)
Simulation: none
Periodicity: after two consecutive unsuccessful responses in real operation or at least every year

NC ER Article 45(2): Each defence service provider delivering demand response low frequency demand disconnection shall execute a low frequency demand disconnection test within a period to be defined at national level and following the methodology laid down in NC DCC Article 37(4) for transmission connected demand facilities or according to a similar methodology defined by the relevant system operator for other demand facilities.

NC ER Article 18(4): Each TSO shall be entitled to disconnect SGUs and defence service providers, directly or indirectly through DSOs. SGUs and defence service providers shall remain disconnected until further instructions are issued. Where SGUs are directly disconnected, the TSO shall inform the relevant DSOs without undue delay. Within 30 days of the incident, the TSO shall prepare a report containing a detailed explanation of the rationale, implementation and impact of this action and submit it to the relevant regulatory authority in accordance with Article 37 of Directive 2009/72/EC as well as make it available to the significantly affected system users.

NC ER Article 18(5): Prior to the activation of the automatic low frequency demand disconnection scheme set out in Article 15 and provided that the rate of change of frequency allows it, each TSO shall, directly or indirectly through DSOs, activate demand response from the relevant defence service providers and:

(a) switch energy storage units acting as load to generation mode at an active power set-point established by the TSO in the system defence plan; or
(b) when the energy storage unit is not capable of switching fast enough to stabilise frequency, manually disconnect the energy storage unit.

Requirement to be verified

NC DCC Article 37(4): With regard to the remote disconnection test, the transmission-connected distribution facility's technical capability for remote disconnection at the connection point or points from the transmission system when required by the relevant TSO and within the time specified by the relevant TSO shall be demonstrated.

NC DCC Article 39(4): With regard to the remote disconnection test, the transmission-connected demand

facility's technical capability for remote disconnection at the connection point or points from the transmission system when required by the relevant TSO and within the time specified by the relevant TSO shall be demonstrated.

NC DCC Article 19(4)(c): a transmission-connected demand facility or a transmission-connected distribution facility shall be capable of being remotely disconnected from the transmission system when required by the relevant TSO. If required, the automated disconnection equipment for reconfiguration of the system in preparation for block loading shall be specified by the relevant TSO. The relevant TSO shall specify the time required for remote disconnection.

Netcode elektriciteit Article 4.8.5: Automated disconnection equipment and the required time for disconnection after a trigger signal shall be specified and recorded in the connection agreement.

Objective

The test shall demonstrate that the transmission-connected distribution facility or transmission-connected demand facility is capable to remotely disconnect demand as agreed in the connection agreement.

Test procedure

The trip signal line to the input of the switch/circuit breaker that is designated to disconnect the transmission-connected distribution facility or transmission-connected demand facility will be interrupted.
A trigger signal for remote disconnection will be sent by the TSO and will be recorded.
The trip signal of the switch/circuit breaker that is designated to disconnect the transmission-connected distribution facility or transmission-connected demand facility will arrive at the interrupted switch/circuit breaker input port and will be recorded.

Documentation/measurements

- P, Q, V shall be measured as a function of the time at the Connection Point;
- The remote disconnection trigger signal shall be recorded as a function of the time;
- The switch/circuit breaker trip signal will be recorded as a function of the time.

Test evaluation criteria

The test shall be deemed successful if the following conditions are fulfilled:

- The remote disconnection trigger signal is properly received by the demand facility or transmission-connected distribution facility;
- The switch/circuit breaker trip signal will be available within the specified time interval after the remote disconnection trigger signal has been sent.

4.5 NC ER 46: HVDC system black start capability test

Applicable to: HVDC Systems delivering a black start service
NC HVDC Article: 37
Netcode elektriciteit Article: 6.25
Test: NC HVDC Article: 71(11)
Simulation: NC HVDC Article: none
Periodicity: at least every three years

NC ER Article 46: Each restoration service provider which is an HVDC system delivering a black start service shall execute a black start capability test, at least every three years, following the methodology laid down in NC HVDC Article 70(11). [reference to 70(11) is not correct: should be 71(11)]

Requirement to be verified

NC HVDC Article 71(11): With regard to the black start test, if applicable:

(a) the HVDC system shall demonstrate its technical capability to energise the busbar of the remote AC substation to which it is connected, within a time frame specified by the relevant TSO, according to Article 37(2);
(b) the test shall be carried out while the HVDC system starts from shut down;
(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:
    (i) the HVDC system has demonstrated being able to energise the busbar of the remote AC-substation to which it is connected;
    (ii) the HVDC system operates from a stable operating point at agreed capacity, according to the procedure of Article 37(3).

NC HVDC Article 37:

1. The relevant TSO may obtain a quote for black start capability from an HVDC system owner.
2. An HVDC system with black start capability shall be able, in case one converter station is energised, to energise the busbar of the AC-substation to which another converter station is connected, within a timeframe after shut down of the HVDC system determined by the relevant TSOs. The HVDC system shall be able to synchronise within the frequency limits set out in Article 11 and within the voltage limits specified by the relevant TSO or as provided for in Article 18, where applicable. Wider frequency and voltage ranges can be specified by the relevant TSO where needed in order to restore system security.
3. The relevant TSO and the HVDC system owner shall agree on the capacity and availability of the black start capability and the operational procedure.

The frequency limits laid down in NC HVDC Article 11 (Annex I) and Netcode elektriciteit Article 6.2 for unlimited time are: 49 Hz – 51 Hz.
The voltage limits laid down in NC HVDC Article 18 (Annex III) and Netcode elektriciteit Article 6.7 for unlimited time are: 0,85 pu – 1,118 pu (for voltages below 300 kV) and 0,85 pu – 1,05 pu (for voltages of 300 kV and above).

Netcode elektriciteit Article 6.25:

1. The time to activate the HVDC system will be agreed and will be recorded in the Connection Agreement
2. The HVDC system is capable to switch to the normal operating mode without interruption of the supply.

Objective

NC HVDC Article 71(11)(a): The HVDC system shall demonstrate its technical capability to energise the busbar of the remote AC substation to which it is connected, within a time frame specified by the relevant TSO, according to NC HVDC Article 37(2).

Test procedure

Al steps including all necessary switching actions are laid down in the detailed test protocol as part of the black start agreement, which is the elaboration of the following general activities:

- The test shall be carried out while the HVDC system starts from shut down;
- One converter station of the HVDC system will be energised from the AC network where it is connected;
- The remote HVDC-converter station will be energised;
- The busbar of the remote AC substation to which the remote HVDC-converter station is connected will be energised;
- Synchronisation to the remote AC network;
- The remote HVDC-converter station will be set to the operating mode which is used for non-blackstart interconnected operation;
- The HVDC system will be set to an operating point, as mentioned in the detailed test protocol;
- The HVDC system operates stable for the duration as mentioned in the detailed test protocol.

Documentation/calculated parameters

The following signals (as a function of time) should be recorded as a minimum:

- Phasor angle, frequency, voltage, active and reactive power of both HVDC system converter stations Connection Points;
- Voltage, phasor angle and frequency at the Connection Point;
- Time to energise the HVDC system;
- Time to energise the remote AC substation.

Simulation evaluation criteria

The test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

- the HVDC system has demonstrated being able to energise the busbar of the remote AC-substation to which it is connected;
- The HVDC system switches to the normal operating mode without interruption of the supply;
- the HVDC system operates from a stable operating point at agreed capacity, according to the procedure of NC HVDC Article 37(3).

4.6 NC ER 47: Low frequency demand disconnection relays test

Applicable to: Transmission-connected distribution facilities, Transmission-connected demand facilities
Requirement: NC DCC Article 19(1)
Netcode elektriciteit Article: 4.8. 5.1, 9.26
Test: NC DCC Article 37(6) (distribution), 39(5) (demand)
Simulation: none
Periodicity: minimal once every 3 years, unless it is substantiated on the basis of condition-dependent maintenance that a longer period up to a maximum of once in 8 years is sufficient

NC ER Article 47: Each DSO and TSO shall execute testing on the low frequency demand disconnection relays implemented on its installations, within a period to be defined at national level and following the methodology laid down in NC DCC Article 37(6) and NC DCC Article 39(5).

Requirement to be verified

NC DCC Article 37(6): With regard to the low frequency demand disconnection relays test, the transmission-connected distribution facility's technical capability to operate from a nominal AC supply input shall be demonstrated in accordance with Article 19(1) and (2). This AC supply input shall be specified by the relevant TSO.

NC DCC Article 39(5): With regard to the low frequency demand disconnection relays test, the transmission-connected demand facility's technical capability to operate from a nominal AC input shall be demonstrated in accordance with Article 19(1) and (2). This AC supply input shall be specified by the relevant TSO.

NC DCC Article 19(1): All transmission-connected demand facilities and transmission-connected distribution systems shall fulfil the following requirements related to low frequency demand disconnection functional capabilities:

(a) each transmission-connected distribution system operator and, where specified by the TSO, transmission-connected demand facility owner, shall provide capabilities that enable automatic 'low frequency' disconnection of a specified proportion of their demand. The relevant TSO may specify a disconnection trigger based on a combination of low frequency and rate-of-change-of-frequency;
(b) the low frequency demand disconnection functional capabilities shall allow for disconnecting demand in stages for a range of operational frequencies;
(c) the low frequency demand disconnection functional capabilities shall allow for operation from a nominal Alternating Current ('AC') input to be specified by the relevant system operator, and shall meet the following requirements:
    (i) frequency range: at least between 47-50 Hz, adjustable in steps of 0,05 Hz;
    (ii) operating time: no more than 150 ms after triggering the frequency setpoint;
    (iii) voltage lock-out: blocking of the functional capability shall be possible when the voltage is within a range of 30 to 90 % of reference 1 pu voltage;
    (iv) provide the direction of active power flow at the point of disconnection;

(d) the AC voltage supply used in providing low frequency demand disconnection functional capabilities, shall be provided from the network at the frequency signal measuring point, as used in providing functional capabilities in accordance with [DCC Article 19] paragraph 1(c), so that the frequency of the low frequency demand disconnection functional capabilities supply voltage is the same as the one of the network.

NC DCC Article 19(2): Low voltage demand disconnection: not applicable.

Netcode elektriciteit Article 4.8.1: All transmission-connected demand facilities shall provide capabilities that enable automatic 'low frequency' disconnection of a specified proportion of their demand. The way of disconnection has been specified in Regulation (EU) 2017/2196 (NC ER).

Netcode elektriciteit Article 4.8.2: The disconnection trigger is based on low frequency.

From Netcode elektriciteit Article 5.1: The requirements of article 4.8 also apply to distribution systems.

Netcode elektriciteit Article 9.26:

1. In the case of frequency drops to 49,0 Hz and lower values, using frequency relays the regional network operators automatically switch off part of the load according to the following scheme:
   (a) First disconnection: at 49,0 Hz disconnect 15% of the original total load;
   (b) Second disconnection: at 48,7 Hz, in addition to the amount referred to in (b), disconnect 15% of the original total load;
   (c) Third disconnection: at 48,4 Hz, in addition to the amount referred to in (b) and (c), disconnect 20% of the original total load.
2. When determining the amount of load to be disconnected, any electricity generation units that might be switched off are taken into account.
3. The frequency relay is set such that:
   (a) Within 100 ms after exceeding the frequency thresholds mentioned in the first paragraph a switch-off command follows;
   (b) The operation of the relay is blocked if the measured voltage falls below 70% of the nominal voltage.
4. The measurement inaccuracy of the relay may not exceed 10 mHz.
5. The fault sensitivity of the relay is adapted to the installation in which it is used, but meets at least IEC 1000-4 class 3.

Objective

The test shall demonstrate that the low frequency demand disconnection relays installed in the transmission-connected distribution/demand facility are functioning as specified in the relevant requirements.

Test procedure

The test shall demonstrate that all relays react to the frequency drop and send out the tripping signal (testing the relay as an action component).
The disconnection scheme has been set to the demand facility. In most cases for selected transformers one relay will switch the load of the transformer at one particular frequency.

- A test signal with nominal voltage and varying frequency will be connected to the Alternating Current supply input. At the start of the test the test frequency shall be 50.00 Hz.
    - The test signal frequency will be ramp-wise lowered with a gradient of 0,01 Hz/sec;
    - At appropriate frequencie the relay will trip according to the disconnection scheme;
    - At 47.00 Hz the lowering of the test signal frequency stops or earlier in case of tripping;

- The test will be repeated using a test signal with the voltage lock-out value + 2%;

- The test signal will be reset to the nominal voltage and frequency and the relays will be reset to the normal operating positions;
- A test signal with varying voltage and varying frequency will be connected to the Alternating Current supply input.
    - The test signal voltage will be ramp-wise lowered with a gradient of 0,01 pu per second;
    - At an appropriate voltage the relay will be blocking its functional capability (voltage lock-out);
    - If the voltage lock-out value has been triggered, the lowering of the test signal voltage stops;
      The test signal frequency will be ramp-wise lowered with a gradient of 0,01 Hz/sec;
    - During the lowering of the test signal frequency no relay action will occur;
    - At 47.00 Hz the lowering of the test signal frequency stops.

<u>Documentation/measurements</u>

- Substantiation in case the test-frequency is lower than once every 3 years.
- The simulated frequency shall be measured as a function of the time;
- The AC supply input signal voltage shall be measured as a function of the time;
- The voltage lock-out signal shall be measured as a function of the time;
- V shall be measured as a function of the time at the Connection Point.

Test evaluation criteria

The test shall be deemed successful if:

- The relay will trip at lowering frequency according to the set value of the disconnection frequency;
- For distribution facilities and transmission-connected demand facilities the applicable time-response requirements as mentioned in the Netcode and NC DDC respectively will be tested and verified.
- The relay will be blocking its functional capability during voltage lock-out according to the set value of the voltage lock-out.