PGMD model for DC-connected power park modules

Power generating module document model in accordance with the NRA Order no. 220 of 11.12.2019 approving the Notification Procedure for the connection of HVDC systems and direct current connected power park modules and verification of compliance of HVDC systems and direct current connected power park modules with technical requirements for connection to the public electricity networks

The power generating module document (PGMD) for direct current-connected power park modules contains the following documents:

a) request for the energisation for the beginning of the testing period, elaborated with respect of the provisions of Annex no. 2 - section 2.1 from the NRA Order;
b) the electrical single line scheme of the DC-connected power park modules;
c) an itemised statement of compliance by points relating to:
   (i) equipaments;
   (ii) reactive power exchange in the conmection point;
d) technical data according to the provisions of Annex no. 2 - section 2.1 from the NRA Order;
e) equipement certificates issued by an authorised certifier, for the DC-connected power park modules, if they are invoked as part of the evidence of compliance;
f) simulation models or equivalent informations provided in the connection technical Norm and required by TSO, which completely simulates the behavior of the DC-connected power park modules, in stationary and dynamic conditions, including for transient electromagnetic phenomena, exchange of active and reactive power in the connection point, power quality provided in the connection point, as appropriate. The format and calculation program in which the provided models, specified by TSO, are: Eurostag or PSSE. Other programs may be used with the condition that one of the three specified programs is provided for a converter. The content of mathematical models includes conditions / settings for permanent and dynamic regimes, network topology and single line diagram. The data shall be transmitted at least one month before the date predicted by the applicant for energisation for the beginning of the testing period.
g) studies demonstrating expected performance on a permanent and dynamic regime, including reactive power exchange studies in the connection point;
h) the tests program and the details of the practical method used in performing the verification tests of conformity, their performer and the technical data of the measuring equipment with which he performs the tests;
i) the results of the verification tests for the functioning of the communication path and the integration of the EMS-SCADA system;
j) documents attesting the completion of the preceding works of the energisation for the beginning of the testing period, in conformity with the provisions in Annex no. 2 - section 2.2 from the NRA Order;

k) request for the issuance of the FON.

ANNEX 2

Section 2.1 Technical documentation of the DC-connected power park modules

(1) ATR copy;

(2) the establishment authorization granted by NRA, or, as the case may be, the commercial exploitation license;

(3) the contact details of the DC-connected power park module owner;

(4) the connection point;

(5) the expected date of the energisation for the beginning of the testing period;

(6) equipment certificates issued by an approved certification body for the equipment used by the DC-connected power park module, together with the tests results. These include:

(a) Checking the P - Q capability curve;

(b) fault-ride-through capability;

(c) operation of the DC-connected power park module in the frequency range (47,5 ÷ 51,5) Hz at a RoCoF of 2 Hz / sec for a 500 ms time window, of 1,5 Hz / s for a 1 s window and 1.25 Hz / s for a 2 s time window, the reduction of active power to the maximum active power produced in the case of a frequency drop below 49.5 Hz and 49 Hz respectively, the capability of providing limited response frequency capacities above the 50 Hz nominal capability, capability of providing limited response to frequency drops below the rated 50 Hz, ability to constantly maintain active power mobilized irrespective of frequency variations, within the power limit provided by the primary source, capability of automatic reconnection of the DC-connected power park module at voltage variations of (0,85 ÷ 1,1) Vn;

(d) electrical disturbances according to EN 50160 edition in force, communicated by the manufacturer of the builder unit, confirmed by bulletins issued by laboratories certified at European level or measured at the point of connection by an economic operator holding an A3 certificate issued by NRA. The power quality energy measurements shall be completed by measuring report, with the data extracted from the Class A quality analyzer;

(e) response mode to the setpoints of active and reactive power variations.

(7) in the case of equipment used for which a certificate has not been received, information (tests and their results, carried out by approved certification bodies, etc.) shall be provided in accordance with the instructions given by TSO, relevant to the technical

requirements applicable in force, specific to DC-connected power park module;

(8) the detailed technical data of the DC-connected power park module, according to Table no. 1-DC-PPM as well as the technical project to show: the lengths and technical characteristics of the cables and the connection to the TSO substation / cell, the connection mode of the DC-connected power park module and the auxiliary installations as well as the single line diagram;

(9) modeling requirements for permanent and dynamic regime system studies, mathematical models of DC-connected power park module, as follows:

(a) for the calculation of stationary and short-circuit currents are required:

i. the electrical scheme and the system connection substation;

ii. the length of all LEA or LES between the DC-connected power park module and the system connection substation;

iii. electrical parameters specific to all cables and lines: type, R_+ [Ω/km], R_0 [Ω/km], Rm_0 [Ω/km], X_+ [Ω/km], X_0 [Ω/km], Xm_0 [Ω/km], C_+ [μF/km], C_0 [μF/km], S [mm], V_n [kV] etc.

iv. for transformer units: rated winding power, nominal voltages, loose losses, copper losses, short-circuit voltage, idle current, connection unit, voltage setting (type of adjustment, including the number of the nominal plot, the maximum plot number), neutral treatment;

v. data on the reactive power compensation system (e.g. if capacitor batteries are installed: the number of steps, the power installed on each step) and the indication on the required electrical circuit of the installation location of the compensation system;

vi. data on DC-connected power park module: the nominal active power, the each P-Q diagram, the rate of change of the active power;

(b) for calculating the dynamic regime are required:

i. logic operating diagram of the DC-connected power park module;

ii. the mathematical model of the DC-connected power park modules and its parameters;

iii. electrical control system: control schemes and parameters for active power control and reactive power control and, where applicable, voltage at terminals or at the connection point;

iv. the mathematical model of the active power, reactive power and voltage control systems for the DC-connected power park modules, in the form of

diagrams (including mathematical functions) and the corresponding set of parameters. Alternatively, you can specify assimilation with a generic model from one of the PSSE v32 applications (".dll" will mandatory be provided) or Eurostag v4.5 for which the parameters are provided. If the model includes additional control functions or specific features, these will be mentioned and graphics will be added;

v. Protection against voltage variations: "fault-ride-through - low voltage" (LVRT, ZVRT);

vi. other special functions: "low voltage power logic", participation in frequency control etc;

vii. the dynamic equivalent of the DC-connected power park module;

(10) studies conducted by the DC-connected power park module owner, including model simulations, to demonstrate the steady-state and dynamic performances, including the use of measured factory values during testing at the level of detail required by TSO;

(11) the active power regulation, reactive power diagrams, in detail, at the DC-connected power park module level, in order to highlight the way in which:

(a) active power and reactive power setpoints are taken and modified;

(b) the reactive power measure at the DC-connected power park module level is taken;

(12) the network study for calculating the reactive power requirement at the connection point to meet the reactive power requirements at the connection point (0.9 inductive ÷ 0.9 capacitive) across the entire active power range, with zero reactive power exchange with the system when the active power produced is zero. Attach the P-Q diagram of the DC-connected power park module at the connection point and the V-Q / Pmax diagram;

(13) the dynamic regime study of the DC-connected power park module and of the area to determine the measures to avoid its insularity;

(14) the data required for the calculations of protection adjustment, which are sent to the TSO at least one month before the date when the energisation for the beginning of the testing period is requested: complete technical project, the own protections for internal and external defects, adjustments and response times, the electrical characteristics of DC-connected power park module and related transformers, the electrical characteristics, the own protections with the related settings and the automations of connection/disconnection of the reactive power compensation elements;

(15) the technical characteristics of the power quality analyzer to be mounted at the connection point. The analyzer must be Class A certified PSL and be capable of

transmitting "SQL", "PQDIF", ".txt" or ".xls" files to the structure required by TSO's electrical quality monitoring system. It integrates into TSO's electricity quality monitoring system.

(16) documents on the technical characteristics of the communication path and of the integration equipments in EMS-SCADA system, as well as contracts for the realization and maintenance of the communication path;

(17) the results of the verification tests for the functioning of the communication path and integration of the new installation in EMS-SCADA system;

(18) static and dynamic stability studies or system integration, if applicable and if they were not performed at the stage of establishing the connection solution to the electrical network;

Table no. 1-DC-PPM: Data for the DC-connected power park module

Description of the data	**Unit of measurement**
Point of connection / delimitation, as appropriate	Text, diagram
The standard environmental conditions for which technical data has been determined	Text
Rated voltage at the point of connection / delimitation, as appropriate	kV
The value of the short-circuit current at the connection / delimitation point, as the case may be, provided by the DC-connected power park module (before the power electronics / after the power electronics equipment) to a fault:	
- Symmetric (three-phase)	kA
-Non-symmetric (biphasic, biphasic with earth, single-phase)	kA
The value of the minimum short-circuit current at the connection / delimitation point, as the case may be, provided by the DC-connected power park module (before the power electronics / after the power electronics equipment) to a fault:	
- Symmetric (three-phase)	kA

-Non-symmetric (biphasic, biphasic with earth, single-phase)	kA
Generation mode that is part of the power park module:	
Nominal apparent power	MVA
Nominal power factor (cos φ_n)	
Net power	MW
The nominal active power produced at the terminals	MW
The maximum active power produced at the terminals	MW
Nominal voltage	kV
Maximum / minimum frequency of operation at nominal parameters	Hz
Consumption of own / internal services at peak power output at terminals	MW
Maximum reactive power produced at the terminals	MVAr
Minimum reactive power produced at the terminals	MVAr
Minimum active power produced	
Capability of LVRT fault-ride-through	Diagram
Short-circuit ratio	

Diagrams	
P-Q capability diagram	Graphical data
Diagram of variation of technical data according to deviations from standard environmental conditions	
Decreased frequency response	Diagram
Increased frequency response	Diagram
Setting range of statism	%

Value of statism	%
Dead band frequency	mHz
Delay time (dead time t1)	s
Response time (t2)	s
Insensitivity area	mHz
Islanding capability	Yes/No
Details of the speed control shown in the block diagram regarding the transfer functions associated with the individual elements and units of measure	Diagram
Equivalent, possibly standardized transfer function of voltage control, values and units of measurement	Text
Transformer units:	
Number of windings	Text
The rated power on each winding	MVA
Nominal transformer ratio	kV/kV
Short-circuit voltages per winding pairs	% of V_{nom}
Losses on no load	kW
Load losses	kW
The magnetizing current	%
Connection unit	Text
Adjustment range	kV-kV
Adjustment scheme (longitudinal or long-transverse)	Text, diagram
Size of the adjustment step and number of sockets	%
Under load adjustment	YES/NO
Treating the neutral	Text, diagram
Saturation curve	Diagram

Data for wind power generating modules	
Type of wind unit (horizontal / vertical axis)	Description
Rotor diameter	m
The height of the rotor shaft	m

The blade control system (pitch/stall)	Text
Speed control system (fixed / two-speed / variable)	Text
Type of power generator	Description
Inverters type certificates accompanied by the results of tests performed by recognized laboratories at European level for: variations in frequency, voltage and fault-ride-through	certificates
Type of frequency converter and nominal parameters	
Rate of change of active power	MW/min
Reactive power	kVAr
Nominal current	A
Nominal voltage	V
Cut-in wind speed	m/s
Nominal wind speed (corresponding to nominal active power)	m/s
Cut-off wind speed	m/s
Variation of active power generated at wind speed	Table
Parameters of power quality for DC-connected power park module	
Continuous flicker coefficient	
Stage flicker for switching operations	
Voltage variation factor	
Maximum number of switching operations at 10 minutes	
Maximum number of switching operations at 2 hours	

Data relating to inverters and photovoltaic panels	
Number of photovoltaic panels	Number
The type of photovoltaic panels	Name
The rated active power of the photovoltaic panel (c.c.)	kW
The maximum active power of the photovoltaic panel (c.c.)	kW
Data relating to the inverters used by the DC-connected power park module	
Number of inverters	Number
Type of inverter	Description
Inverters type certificates accompanied by the results of tests performed by recognized laboratories at European level for: variations in frequency, voltage and fault-ride-through	Certificates
Nominal input power (c.c.)	kW
Recommended maximum input power (c.c.)	kW
Input voltage range (c.c.)	V
Maximum input voltage (c.c.)	V
Maximum input current (c.c.)	A
Active nominal output power (c.a.)	kW
Active maximum output power (c.a.)	kW
Reactive nominal output power (c.a.)	kVAr
Nominal output voltage (c.a.)	V, kV
Nominal output current (c.a.)	A
Operating frequency range	Hz
Power factor adjustment range	
Maximum consumption (c.a.)	W
Consumption at night (c.a.)	W
Power quality parameters of DC-connected power park module with photovoltaic power generating modules	
Maximum power variation (ΔS / Ssc) per minute	
Maximum value for fast voltage variations	
Total electrical distortion factor	
Harmonic current (up to harmonic 50)	
Total voltage distortion factor	

Voltage harmonics (up to harmonic 50)	
Negative voltage sequence unbalance factor	

1. The owner of the DC-connected power park modules has the obligation to transmit to the TSO the technical data provided in table 1 in accordance with the provisions of this technical norm.
2. In the notification procedure, the TSO can ask for additional data for each notification and verification conformity stage.
3. The standard planning data (S), communicated in the connection request and used in the solution studies (forms) represent all the general technical data which characterise the DC-connected power park modules.
4. The detailed planning data (D) are technical data enabling special analysis of static and transient stability, the sizing of automation installations and protection control, as well as other necessary data for operative scheduling; the detailed planning data (D) are transmitted to the TSO by minimum 6 month before commissioning.
5. The data validated and filled in upon commissioning are confirmed during the verification of conformity with the connection requirements (R).

Section 2.2 Documentation demonstrating the performance of preceding works of the energisation for the beginning of the testing period for the DC-connected power park module

The documentation contains:

(1) evidence of an agreement on the protection schemes applicable at the connection point between the TSO and the DC-connected power park module owner;

(2) the documents attesting the implementation of the aggregation and integration solution in EMS-SCADA system agreed with TSO, as appropriate. The integration refers at least to the integration of the measures P (active power), Q (reactive power), V (voltage) and frequency as well as the P, Q, V setpoints;

(3) the program of energisation for the beginning of the testing period of the DC-connected power park module, and the expected date for the energisation of the DC-connected power park module, up to the ATR approved specific to the specific phase in ATR / staged, for the DC-connected power park module.

(4) the operating agreement between the TSO and the DC-connected power park module owner, the dossier of the installation manual and the minutes that confirm receipt at the completion of the work on the connection installation;

(5) the document proving the existence and the mounting of the reactive power compensation facilities at the connection point, if this emerges from the reactive power study;

(6) evidence of setting up a local central dispatcher or integrating the DC-connected power park module into an existing DLC;

(7) evidence of obtaining an investment order;

(8) evidence of registration in the energy market.