PGMD model for SPGM – of D category

Power generating module document model for synchronous power generating modules of D category in accordance with the NRA Order no. 51/17.04.2019 approving the Notification Procedure for connection of power generating units and verification of compliance of power generating units with technical requirements for connection of power generating units to public electricity networks

Annex 6

The technical documentation for power generating units contains the following documents:

(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 power generating unit owner and the third party or aggregator, as appropriate;

(4) the connection point;

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

(6) type of primary energy source;

(7) equipment certificates issued by an approved certification body for the equipment used by the power generating units, together with the results of the tests. These include:

(a) Checking the P - Q capability curve;

(b) fault-ride-through capability;

(c) operation of the power generating unit 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 power generating unit 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 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 or RSO. 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.

(8) 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 RSO relevant to the technical requirements applicable in force, specific to power generating units of category D;

(9) the detailed technical data of the power generating unit, according to Table no. 1D-PGMS as well as the technical project to show: the lengths and technical characteristics of the cables and the connection to the RSO substation / cell, the connection of the power generating unit and the auxiliary installations as well as the single line diagram of the substation and the power plant module;

(10) modeling requirements for permanent and dynamic regime system studies, mathematical models of power generating facilities, as follows:

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

i. the electrical scheme of the power generating unit and the system connection substation;

ii. the length of all LEA or LES between the power generating unit and the system connection substation and the LES in the plant with power generating modules, as appropriate;

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 of 110 kV / MV: 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 stage) and the indication on the required electrical circuit of the installation location of the compensation system;

vi. data on power generating facilities of category D: the number of power generating modules, the rated active power, the P-Q diagram of each

power generating module, the rate of change of the active power;

(b) for calculating the dynamic regime are required:

i. logic operating diagram of the power generating unit;

ii. the mathematical model of the power generating unit 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 power generating unit and the model of the central level control system 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 power generating unit;

(11) studies conducted by the power generating unit 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 RSO;

(12) the active power regulation, reactive power diagrams, in detail, at the power generating unit, 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 power generating unit level is taken;

(13) 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 power generating unit at the connection point (including the contribution of all generating units and auxiliaries) and the V-Q / P_{max};

(14) for the category D of power plants made up of power generating modules, the dynamic

regime study of the power plant and the area to determine the measures to avoid its insularity;

(15) 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:

(a) for the power generating unit:

i. complete technical project (primary and secondary electrical circuits);

ii. generators' internal protection for internal and external defects, adjustments and drive times;

iii. the short-circuit contribution on the MV busbar of the connection substation of each power generating unit that is connected by the same cable to the fault types: single-phase, biphasic, biphasic with earth and three-phase;

iv. the electrical characteristics of the installed power generating units and the related transformers, the operating modes, including the values of the short-circuit currents at the transformer-converter assembly terminals, namely:

– synchronous power generator: manufacturing, type, Sn [MVA], Pn [MW], Un [kV], In [A], Nn [rot/min], cosφn, Xd, Xq, X0, X'd, X'q, X'0, X"d, X"d [%], $T_{launching}$ [s], excitation (type), V_{excit} [kV], I_{excit} [A], $I_{forcing}$ [A], $T_{forcing}$ [s];

– asynchronous power generator: manufacturing, type, Sn [MVA], Pn [MW], Vn [kV], In [A], Nn [rot/min], cosφn, Xd, Xq, X0, X'd, X'q, X'0, X"d, X"d [%];

– photovoltaic panel: type, Pn [kW];

– photovoltaic panel inverter: name, type, manufacturing, Sn [VA], Pn [W], Vn [V], Inac [A], cosφn, Pmax [W], Vcc [V], protection to minimum and maximum voltage;

– two-winding transformer: manufacture, type, tank, core, neutral insulation level, connection unit, Sn [MVA], VnI [kV], Vn_J [kV], $Vscc_{IJ}$ [%], $Igol_I$ [%], $Igol_J$ [%], Pagol [kW], Pascc [kW], Vpmax [kV], Vpmin [kV], Vplot [kV], N (transformation ratio), Vsccmax [%], Vsccmin [%], Vsccn [kV], neutral treatment (mode, impedance values, etc);

– three-winding transformer: manufacturing, type, tank, core, connection unit, neutral insulation level, Sn_1 [MVA], Sn_2 [MVA], Sn_3 [MVA], Vn_1 [kV], Vn_2 [kV], Vn_3 [kV], $Vscc_{IM}$, $Vscc_{MJ}$, $Vscc_{IJ}$ [%] (the power to which they are measured is specified), $Pscc_{IM}$, $Pscc_{IJ}$, $Pscc_{MJ}$ [kW], Igol [%], Pgol [kW], Vp_{max} [kV], Vp_{min} [kV], Vplot [kV], $Vsccp_{max}$ [%], $Vsccp_{min}$ [%], $Vsccp_{med}$ [%], neutral treatment (mode, impedance values, etc);

– LEA/LES: type (material), R+ [Ω/km], R0 [Ω/km], Rm0 [Ω/km], X+ [Ω/km], X0 [Ω/km], Xm0 [Ω/km], C+ [μF/km], C0 [μF/km], S [mm], Vn [kV];

v. Electrical characteristics, self-protection with related adjustments and connection / disconnection automation of reactive power compensation elements;

(b) for the RED / RET connection substation:

i. the complete technical project (primary and secondary electrical circuits) for the electrical connection of the power generating unit;

ii. the electrical characteristics of the power transformers, the documentation, the software and the settings of their protection terminals;

iii. complete documentation and software for protection terminals of the connection line / lines;

iv. the electrical and geometric characteristics of the FO-OPGW for each line section (electrical resistance specific at 20 ° C [Ω / Km], nominal section [mmp], conductor radius [cm]), if FO-OPGW was mounted at the time of energisation for the beginning of the testing period of the power generating unit;

(c) for the substations adjacent to the connecting substation of the power generating unit:

i. full documentation of the technical design (electrical part - primary and secondary circuits, block diagram of the protections and tripping matrix) if, in order to supply voltage for the sample period of the power generating unit, primary equipment replacements and / or additions to the line protection scheme;

ii. complete documentation and software for the protection terminals to be installed on the 110 kV side in the substations adjacent to the power generating unit;

(16) (a) for power generating units connected to the RET, the main communication path between the power generating unit and the connection point to the EMS-SCADA system of the TSO is made on optical fiber, and a spare path is also provided. Telecommunication projects must be endorsed in the CTES meeting.

(b) for power generating units connected to RED, the primary communication path used for integration into DMS-SCADA is the transmission of settlement data extracted from the settlement counter. Telecommunication projects must be endorsed at the CTES meeting of the RSO;

(17) the technical characteristics of the power quality analyzer to be mounted at the connection point when the power generating unit is connected to a substation belonging to TSO. 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. These requirements do not apply to synchronous power generating modules;

(18) the procedure of the equipment supplier for energisation for the beginning of the testing period of the power generating unit;

(19) studies on:

(a) the capability to island operation;

(b) the capability to provide reactive power at the connection point, including compensation of reactive power at the connection point when the active power produced is zero, the V-Q / P_{max} diagram, the P-Q diagram;

(c) coordination of protection, with RSO agreement on the protection schemes at the connection point;

(d) permanent and dynamic performance at the level of detail required by RSO:

i. certificates of conformity for the main equipment (wind turbine, inverter, motor generator, generator, battery) or model simulations for these;

ii. mathematical models and simulation models of the power generating unit made in the software indicated by RSO and TSO and possibly integrated into mathematical models used by DSO and TSO. The list of supported software is submitted to the manager by RSO.

Table no. 1D-PGMS: *Data for synchronous power generating modules of category D*

Description of the data	**Unit of measurement**

Point of connection / delimitation, as appropriate	Text, scheme
The standard environmental conditions for which technical data has been determined	Text
Nominal voltage at the point of connection / delimitation, as appropriate	kV
Maximum short-circuit current value at the connection / delimitation point, as appropriate:	
- Symmetric (three-phase)	kA
- Non-symmetric (biphasic, biphasic with earth, single phase)	kA
Minimum short-circuit current value at the connection / delimitation point, as appropriate:	
- Symmetric (three-phase)	kA
- Non-symmetric (biphasic, biphasic with earth, single phase)	kA
Synchronous power generating module:	
Nominal apparent power	MVA
Nominal power factor ($\cos \varphi_n$)	
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 services at peak power output at terminals	MW
Maximum reactive power at terminals	MVAr
Minimum reactive power at terminals	MVAr
Minimum active power produced	MW
Capability of LVRT fault-ride-through	Diagram
Turbo-generating inertia constant (H) or moment of inertia (GD^2)	MWs/MVA

Rated speed	rpm
Short-circuit ratio	
Rated stator current	A
Diagram of variation of active power produced by deviations from standard environmental conditions	
Internal protection	
Saturated and unsaturated reactances	
Rated reactance [rated voltage^2 / nominal rated power]	Ω
Longitudinal synchronous reactance [% of nominal reactance]	%
Longitudinal transient reactance [% of nominal reactance]	%
Longitudinal supra-transient reactance [% of nominal reactance]	%
Synchronous transverse reactance [% of nominal reactance]	%
Transverse transverse reactance [% of nominal reactance]	%
Transversal over-transient reactance [% of nominal reactance]	%
Stator leakage reactance [% of nominal reactance]	%
Zero sequence reactance [% of nominal reactance]	%
Negative sequence reactance [% of nominal reactance]	%
Potier Reactance * [% of nominal reactance]	%
Time constants	
Transient time constant of the excitation winding with the stator closed (T_d')	s
The over-transient time constant of the damping winding with the stator closed (T_d")	s
Transient time constant of the excitation winding with the open stator (T_{d0}')	s
The over-transient time constant of the damping winding with the open stator (T_{d0}")	s
Transient time constant of the excitation winding with the	s

stator closed, on the q axis ($T_{q0}^{`}$)	
The over-transient time constant of the damping winding with the open stator, on the q axis ($T_{q0}^{"}$)	s
Diagrams	
Capability diagram	Graphical data
Diagram of variation of technical data according to deviations from standard environmental conditions	
Capability in terms of reactive power:	
Reactive power in inductive mode at maximum active power generated	Generated MVAr
Reactive power in inductive mode at minimum active power generated	Generated MVAr
Reactive short-time inductive power at nominal values for power, voltage and frequency	MVAr
P-Q diagram according to V	Graphical data
Capacitive reactive power at maximum / minimum power generated	MVAr absorbit
Excitation system	
Excitation system type	Text
Nominal Rotor Voltage (Excitation)	V
Maximum Rotor Voltage (the excitation ceiling)	V
The maximum allowable length of the excitation ceiling	s
Excitation adjustment scheme	V/V
Maximum rate of increase of excitation voltage	V/s
Maximum speed to reduce excitation voltage	V/s
Dynamics of over-excitation characteristics	Text
The dynamics of under-excitation characteristics	Text
Excitation limitation	Block diagram
Speed governor (RAV):	
Equivalent, possibly standardized, function of the speed regulator, values and units of measurement	Text
The equivalent transfer function, values and units of	Text

measurement, according to the technical design	
Closing / opening time of the turbine control valve	s
The response to the frequency drop	diagram
Response to frequency increase	diagram
Setting range for the offset characteristic	%
The value of the offset characteristic s_1	%
Frequency dead band	mHz
Delay time (dead time $-t_1$)	s
Response time (t_2)	s
The insensitivity zone	mHz
Insularity capability	MW
Details of the speed controller presented in the block diagram of the transfer functions associated with the individual elements and related units of measurement	Schema
Block diagram and parameters for the automatic generator-turbine speed controller, (possibly boiler), the thermoelectric and nuclear units.	Text
Automatic Voltage Regulator (AVR):	
Regulator type	Text
The equivalent transfer function, possibly standardized voltage regulator, values and units of measurement	Text
The equivalent transfer function, values and units of measurement, according to the technical project	Text
Protection data:	
Possibility of asynchronous operation without excitation (loss of excitation) - maximum active power and duration	Text
Minimum excitation	Text, diagram
Maximum excitation	Text, diagram
Differential	Text
Protection against asynchronous operation with connected excitation	Text
Setting of the adjustment of:	

The maximum excitation limit	Text, diagram
The minimum excitation limit	Text, diagram
Stator current limiter	Text, diagram
Transformer units:	
Number of windings	Text
The rated power on each winding	MVA
Nominal transformer ratio	kV/kV
Short-circuit voltages per winding pairs	% din 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

Note: Depending on the needs on operating security of the NPS, the RSO may request additional information from the owner of the synchronous power generating module of category D, from the 1D-PGMS table.

Annex 7

Documentation demonstrating the performance of preceding works of the energisation for the beginning of the testing period for power generating units of category D

The documentation contains:

(1) evidence of an agreement on the protection schemes applicable at the point of connection between the RSO and the power generating unit owner;

(2) the documents attesting the realization of the communication paths with DMS-SCADA (a communication path), if applicable;

(3) the documents attesting the implementation of the EMS-SCADA aggregation and integration solution agreed with TSO, as the case may be. Integration refers at least to

the integration of measures P (active power), Q (reactive power), V (voltage) and frequency as well as P, Q, V;

(4) the documents attesting integration into the forecasting system of the TSO;

(5) the program of energisation for the beginning of the testing period of the power generating unit, in the sequence of energisation for the beginning of the testing period of the component power generating modules, as appropriate, and the expected date for the energisation of the power generating unit , up to the ATR approved specific to the specific phase in ATR / staged, for the power generating unit, starting with the startup of the power plant, the connection of the power generating unit. The program is detailed on installed power levels; (if applicable) TSO has the obligation to publish this program on its own website;

(6) the operating agreement between the RSO and the power generating unit owner, the dossier of the installation manual and the minutes that confirm receipt at the completion of the work on the connection installation;

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

(8) evidence of setting up a local central dispatcher or integrating the power generating unit into an existing DLC;

(9) evidence of obtaining an investment order;

(10) evidence of registration in the energy market as a unit tests.