Compulsory technical requirements for a wind farm in order to begin the commissioning tests for the component wind generating units

List of technical documents and data which must be submitted to DEN (Transelectrica) and the necessary technical requirements to be met before energizing wind generating (GGE) are the following:

1. Copy of the Technical connection approval (ATR)and Connection contract, if these have been issued by the distribution operators;
2. The technical data needed in order to fill in table 1.1 from the Technical norm 51: „Technical conditions to connect wind farms to electricity networks of public interest “, ANRE code: 51.1.017.0.00.03/04/09 (Annex 1);
3. Wind farm draft technical project showing clearly- the length and technical characteristics of cables; the manner in which turbines and auxiliary installations will be connected, as well as the electrical diagram of the substation and of the wind farm (Annex 2);
4. Control diagrams (in detail) for active power, reactive power, voltage, power factor at wind farm level in view of pointing out the manner in which:
   - the frequency is measured;
   - the frequency - power ratio is implemented according to art. 10 of the Technical norm 51;
   - the P, Q, U, cos φ set values are read and modified, while also selecting the operational regimes at the wind farm level;
5. Setting limits that CEED is obliged to provide for adjustment of U, Q, cosφ are:
   - Continuous voltage adjustment will be achieved within the limits of voltage variation in PCC (eg, for 400 kV PCC between 380 and 420 kV) using all CEED PQ diagram calculated in PCC and all tapes control transformers;
   - Continuous adjustment of reactive power in the PCC will be achieved within the PQ diagram of the PCC (the equivalent generator) using a fully reactive power which can may be provided by GGE;
   - Cosφ continuous adjustment will be achieved at least 0.95 in inductive / capacitive;
6. The mathematical model of the units, the entire power plant and the means offsetting the reactive power to 0.95 inductive ÷ 0.95 capacitive in the connection point (Annex 2);
7. The network study to calculate the need of reactive power in the connection point with a view to carry out the requirements of art. 16 from the Technical norm 51 (at least 0.95 inductive ÷ 0.95 capacitive) within the entire active power range, while providing the exchange of null reactive with the system when the active power generated is null. The P - Q diagram of the wind farm in the connection point performed as sum of individual GGE PQ diagrams and contribution off all equipment (coils, capacitors etc.) and all cables and transformers in own internal network (of CEE), will be attached;

8. All the technical data needed to perform the calculations of steady state and dynamic regimes (Annex 2);
9. All the technical parameters of primary equipment- the 110 kV MV transformer; the MV/LV transformers for turbines and wind generating units including the electrical parameters and control diagrams (pitch control, yaw control, ride trough, converter, possible limitations), as well as the proper protections (Annex 3);
10. Each type of wind turbine to be installed will be accompanied by copies of the documents and check-up certificates issued by specific international companies, providing:
    - Checking up the P – Q capacity curve, P – wind speed;
    - low voltage ride-through;
    - Operation of the individual unit in the frequency range (47.5 ÷ 52) Hz at frequency variation speed of 0.5 Hz/sec, at voltage fluctuations of (0.9 ÷ 1.1) x Un (articles 8 & 9 of the Technical Norm 51);

    Certificates will be accompanied by the registrations made under such unit tests. The type of verification tests for the units in the system will be also provided.
11. All the technical data required for the calculations of protection controls (Annexes 3 and 4);
12. The main communication path between the wind farm and the system connection substation will be achieved with optical fibre and a back-up path being also provided;
13. The technical characteristics of the electricity quality analyser, which will be installed in the connection point. This has to be in Class A, PSL certified and capable to transmit SQL, PQDIF, txt or xls files in the structure required by Transelectrica's monitoring system for electricity quality;

    The electricity quality analyzer will be in operation from the first wind turbine commissioned, and if at the moment there will be no connection to the monitoring system for electricity quality, the data will be sent to the NPD by e-mail;
14. The commissioning procedure of the wind turbines supplier;
15. Annex 1 of this document will contain, for each of the NT51 article, Technical data sheet referenced to both GGE and ancillary equipment. They will be accompanied by supporting documents under paragraph 9. Mandatory is to complete Table 1.1 and Table 1.2 of the NT51, tables relating to fluctuations in voltage data obtained from measurements performed by specialized laboratories, recognized throughout Europe.

Also, in accordance with the provisions of the Technical Code of the Electricity Transmission Grid, part III- Regulation for the dispatcher management of the Romanian Power System (RPS) (article 19/page 96, chapter 23.7/page 126 articles 181 ÷ 185), the following documents have to be issued by the dispatcher center with decision-taking authority on the respective network in order to achieve the operational management of the wind farm:

- Comprising the new power objective (wind farm) within the RPS;
- The dispatcher management authority investing order;

To this respect the following has to be transmitted:

- The single line diagram of RPS (Romanian Power System - SEN) connection, specifying the main parameters of the new equipment in the diagram;
- Data regarding the dispatcher center providing the operation of the wind farm. This has to provide a permanent location (address), control room, direct phone connection between this address and the dispatcher center with direct control over the wind farm and over the substation, back-up phone connection (to all phone networks), fax, permanent authorized operational personnel operating the farm 24 h/day;
- Proposal of a normal diagram;

Mention should be made that the operational personnel of the dispatcher center providing the wind farm operation has at least the following attributions of operational control from the very test period, after commissioning minimum 60% of the wind turbines:

- Receiving and controlling the dispatcher order to load / unload active power;
- Receiving and carrying out the startup / stop dispatcher order;
- Receiving and controlling the reactive power loading / unloading, voltage and power factor control orders;

- Sending operational applications for outages (power reduction) for works and/or commissioning. The applications will be elaborated according to chap. 22/page 113 from the Technical Code of the Electricity Transmission Grid, part III- Regulation for the dispatcher management of the RPS;
- Confirming operatively the taking out of operation and starting up the operation;
- Sending the data required for the operation and modification on the Balancing market platform;
- Sending hourly data: P [MW] and Q [MVAr] at a set time (it can be also performed automatically);
- Sending the active power for 24 h at the end of each day (D), but no later than 06:00 h of the D + 1;
- Other information about the wind farm operation requested by the dispatcher center;
- Operative communication of non conformities and/or unavailability occurred within the wind farm in real time;

Before energizing the substation please comply with these requirements:

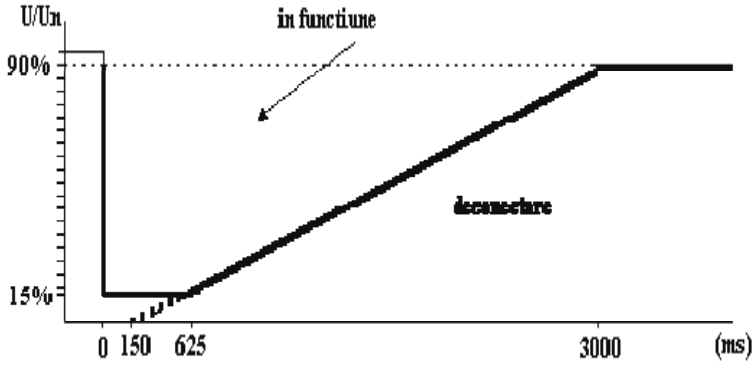
a. The forecast data of the wind farm power will be transmitted both for 24 h and during the day and for the following 4 – 6 ore, in the format agreed with Teletrans (Annex 5);
b. The internal commissioning procedures for the units and the wind farm will be sent to the NPD in order to agree on the test schedule according to the Technical norm 51;
c. The staged commissioning schedule for the wind farm, beginning with the commissioning of the substation detailed by levels of installed capacity and type of internal tests performed;
d. Integrating the wind farm into the SCADA system while providing and checking the exchange of signals;

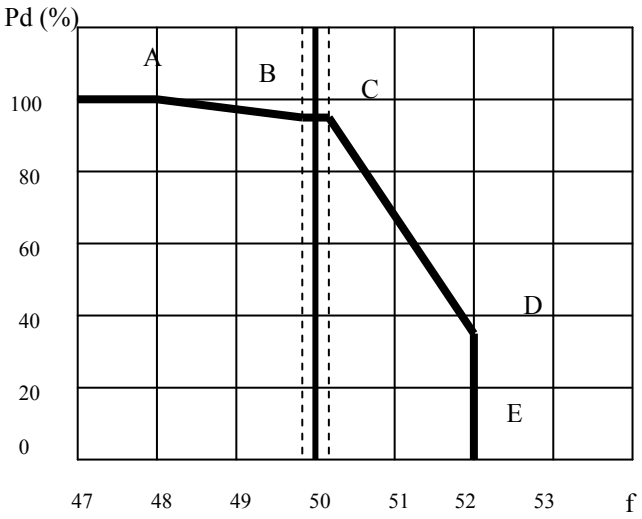
As regards the conditions to test the compliance with the requirements of the Technical norm 51 based on which the TSO issues the observance and compliance notice with the ETG Code requirements and the provisions of the Technical connection approval, we would like to inform you that the technical project should provide:

- During the testing period, the possibility to serial connection of equipment registering the P, Q, U, f values of control-simulation and metering;
- The extraction from Wind Farm SCADA of the set values $P_{control}$, $Q_{control}$, $U_{control}$ and simulated frequency at the analogue outputs in aim to be recorded in an independent device. These recordings from independent device represent the test recordings for analyzing the Wind Farm compliance with the Norm 51 requirements.
- Home tests before to ask representatives of Transelectrica to participate.

All the requirements included in the Technical norm 51 are obligatory. In case the beneficiary will transmit documents for each type of generator used certified by independent laboratories according to point 16, no more individual test for wind turbines will be conducted. Transelectrica will participate to the final tests of the wind farm.

ANNEX 1

Article from the Technical norm	Requirement	Unit / wind farm performance provided by the equipment supplier	The requirement is / is not provided / comments
Art. 7	(1) The wind farm has to be capable: a) to operate continuously at frequency values ranging 47.5 ÷ 52 Hz;		
	b) to stay connected to the electrical network at frequency values ranging 47.0 ÷ 47.5 Hz for minimum 20 seconds;		
	c) to stay connected to the electrical network when frequency variations occur at speeds up to 0.5 Hz/second;		
	d) to operate continuously at voltage values ranging 0.90 ÷ 1.10 Un in the connection point;		
Art. 8	(1) The wind turbine has to stay in operation: a) at frequency variations in the range 49.5 ÷ 47.5 Hz. When frequency drops below 49.5 Hz a linear reduction of the available active power is admitted proportional to the frequency deviation;		
	b) upon frequency variations at speeds up to 0.5 Hz/s and/or voltage variations ranging 0.90 ÷ 1.10 Un;		
	(2) The operation at abnormal voltage or frequency values should not lead to a reduced available active power of the wind turbine by more than 20%		
Art. 9	The wind turbine should remain in operation upon voltage gaps and variations on one or on all phases in the connection point, similar to those shown in figure 1:  Figure 1: Shape of the voltage gaps at which the wind turbine should stay in operation		
	(2) During the voltage gaps the wind farm should generate active power according to the level of remaining voltage and maximise the reactive current injected, without exceeding the operational limits of the wind farm. The wind farm should be capable of generating the maximum reactive power for minimum 3 s.		
	(3) From the moment the voltage of the electrical network is restored to its normal operational limits the wind farm should generate the whole available active power within the shortest possible time, with a load variation gradient of at least 20% of the installed capacity per second (MW / sec).		

Article from the Technical norm	Requirement	Unit / wind farm performance provided by the equipment supplier	The requirement is / is not provided / comments
Art. 10	(1) The wind farm will be provided with a system of automatic control for the active power depending on frequency (f/P automatic control). This will operate according to a response curve frequency / active power illustrated in figure 2, where P_d represents the *available active power*. The coordinates of points A, B, C, D and E depend on the frequency value, of the active power that the wind farm can generate and on the set value to which the active power is limited, within the ranges: A (50-47 Hz), B (50-47 Hz), C (50-52 Hz), DE (50-52 Hz). The position of the point is set as per the requirements of the network operator.  		
	(2) Changing the active power generated because of the frequency variations will be achieved as much as possible by proportionally modifying the active power generated by each turbine of the wind farm and not by starting up or shutting down units. The response speed of each wind turbine in operation should be at least 60% from the nominal power per minute (MW/min).		
	(3) In case the frequency value reaches to a higher value than that corresponding to segment „D – E" of the characteristic curve given in figure 2, the disconnection of the wind farm is admitted. Any wind turbine disconnected will be put in operation as soon as possible in technical terms.		
	(4) Upon frequency variations within the RPS the wind farm should: a) provide the reduction of active power by at least 40% of the installed power / Hz when frequency grows above 50.2 Hz;		
	b) provide the growth of active power up to the maximum limit of the available active power when frequency drops below 49.8 Hz;		
Art. 11	(1) The active power generated by a wind farm has to be limited to a set value		
	(2) The magnitude of the set value has to be set locally or automatically taken over from remote point during the interval between the minimum technical power and the installed capacity of the wind farm.		
	(3) The wind farm should provide the active power control in the connection point with ±5% accuracy of the installed capacity (as mean power per 10 minutes)		

Article from the Technical norm	Requirement	Unit / wind farm performance provided by the equipment supplier	The requirement is / is not provided / comments
Art. 12	(1) Upon normal operation the wind farm should be able to: (a) set the increase / linear reduction rate of the active power generated at the value required by the network operator (MW/minute);		
	(b) upon the network operator's order, reduce the active power generated to the requested value (including the shut down) while observing the variation rate (loading / unloading) determined. The power variation rate should be observed both in case of natural power fluctuation (increased wind speed) and in case the power set value varies. The above provisions do not refer to unexpected shutdowns.		
	(2) The value of the power variation rate should be set in a range going from 10% of the installed capacity per minute and the maximum admissible rate provided by the manufacturer.		
Art. 16	(1) When voltage in the connection point provides values in the admissible range, the reactive power generated / absorbed by a wind farm should be continuously controlled according to a power factor placed at least in the range of 0.95 capacitive and 0.95 inductive.		
	(2) The wind farm should provide the automatic voltage / reactive power control in the connection point in any one of the modes: (a) voltage control;		
	(b) controlling the reactive power exchanged with the RPS;		
	(c) power factor control;		
	(4) The response speed of the voltage control system should be of minimum 95% from the available reactive power per second;		
Art. 17	Under a normal operational regime of the network, the wind farm should not generate fast voltage variations higher than ± 5% from the nominal voltage in the connection point.		
Art. 23	The wind farm will be endowed with systems metering and monitoring the operation and the electricity quality in the connection point. Only analysers class A will be used in order to monitor electricity quality, according to the definitions of standards applicable on the commissioning date		
Art. 27	(1) The wind farm should be remotely supervised and controlled; this will allow receiving and using on-line set values and orders. (2) The control functions and the metered values will placed at the disposal of the network operator, upon request, in the interface point with the EMS-SCADA system. The protocol to interface the wind farm will observe that of the EMS- SCADA (3) The amount of minimum information exchanged on-line by the systems will include- active and reactive power generated; voltage; frequency; the position of switching elements in the connection point; active energy generated; f/P control (yes/no); wind speed and direction; atmospheric pressure; temperature.		

ANNEX 2

1. Data required calculating the steady state regimes and short-circuiting currents

a. The electrical diagram of the entire wind farm and of the system connecting substation;
b. The length of all cables within the wind farm and the OHL length between the wind farm and the system connection substation;
c. The specific electrical parameters of all cables and lines;

Parameters of the lines and/or cables	
Type (material)	
R_+ [Ω/km] at 20°C	
X_+ [Ω/km]	
C_+ [μFarad/km]	
R_0 [Ω/km]	
X_0 [Ω/km]	
S [mm^2]	
U_n [kV]	

d. Data with respect to wind turbines from the wind farm- their number, nominal active power on the generator, the P-Q diagram of each type of generator and in the system connection point, variation rate of active power;
e. For the MV/110kV, MV/MV kV transformer units- the nominal power of the windings, nominal voltage values, idle run losses, copper losses, short-circuit voltage, idle run current, connection group, voltage control (control type, control range including the number of the nominal plot, maximum number of plots), neutral treatment;
f. Data regarding the reactive offsetting system (for instance whether there are condenser batteries installed- number of steps, installed capacity of each step) and indicating the place in which the offsetting system is installed on the requested electrical diagram (first requirement);

2. Dynamic data:

a. Type of wind turbine-generator (WTG)- asynchronous generator with double supply, synchronous generator with full conversion etc.
b. Nominal power;
c. Logical operational diagram of the WTG;
d. The model of the generator and its parameters if it does not provide full conversion;
e. Electric control system- control diagrams and parameters;
f. Parameters to model the converter; diagram and parameters for current limits to the converter;
g. The model of the turbine and control system- diagrams, parameters;
h. Control systems for the wind farm- control diagrams, parameters;
i. Measures for low voltage ride through (dynamic braking to the turbine etc); dynamic model, parameters;
j. Protections for voltage variations- low voltage ride through (LVRT, ZVRT);
k. Other special functions- “low voltage power logic” (LVPL), participation to frequency control etc.;
l. Dynamic equivalent of the wind farm, if any (parameters);
m. The model of the wind turbine-generator unit and the model of control systems at wind farm level as diagrams (including the mathematical functions) and the corresponding set of parameters. As alternative you can specify the homologation with a generic model form one of the PSSE v32 applications or Eurostag v4.5 for which you should provide the parameters. In case your model includes additional control functions or specific characteristics, kindly please mention them and add also graphical diagrams.

ANNEX 3

Data required for protection calculations

At least 30 days before the requested date to begin the system connection tests for the wind farm we are kindly asking you to send the following:

A. for the wind farm:

1. The full technical project (primary and secondary electric circuits) of the wind farm;
2. The electrical characteristics of wind generators installed and of the related transformers, operational regimes including the values of three-phase short-circuit currents to the terminals of the assembly generator + converters + transformer (in the MV part);
3. The own protections of wind farm generators to internal and external defects, their controls and drive times;
4. The contribution to short-circuit on the MV bus bar of the substation connecting the wind farm of each group of wind turbines connected on the same feeder;
5. The electrical characteristics, own protections and their controls as well as the connection / disconnection automations of the reactive power offsetting elements;

B. for the substation connecting it to the distribution / transmission network:

1. The full technical project (primary and secondary electric circuits) of the substation making the connection to the distribution / transmission network;
2. The electric characteristics of 110/MV generators, their documentation, software and protection terminal controls;
3. Full documentation and the related software of protection terminals for the connection line(s);
4. The electrical and geometrical characteristics of the optical fibre- underground cable for each line segment (specific electric resistance at 20°C [Ω/Km], nominal section [mm2], conductor ray [cm]), whether the optical fibre underground cable has been installed on the occasion of the wind farm commissioning;

C. for the substations adjacent to that making the wind farm connection (if any):

1. The complete documentation of the technical project (electrical part- primary and secondary circuits, block diagram of the protections and the tripping matrix) if replacements of primary equipment and/or additions in the protection diagram of the respective lines with a view to the wind farm commissioning;
2. The complete documentation and the software related to the protection terminals to be installed in the 110 kV part of the adjacent substations to the connecting one;

ANNEX 4

MODEL OF GENERATOR DATA
(synchronous machine)

Generator:
Manufacture:
Type:

S_{nom}:	MVA	P_{nom}:	MW	U_{nom}:	V	I_{nom}: A
N_{nom}:	71.5 rot/min	cosFi $_{nom}$:	0.90			
X_d:	%	X_{dprim}:	%	X_{dsec}	%	
X_q:	%	X_{qprim}:	%	X_{qsec}:	%	
X_{hom}:	%	X_{invers}:	%	$T_{lansare}$:	s	
$I_{nom\ rotoric}$: A		$I_{max\ rotoric}$:	A			

Excitation: **Manufacture:** **Type:**
U_{excit}: V I_{excit}: A $I_{forţare}$: A $T_{forţare}$: s

MODEL OF ASYNCHRONOUS GENERATOR DATA
WITH DOUBLE SUPPLY

Generator:
Manufacture:
Type:

S_{nom}:	MVA
P_{nom}:	MW
U_{nom}:	V
I_{nom}:	A
N_{nom}:	rot/min
cosFi $_{nom}$	
X_d:	%
X_d':	%
X_d'':	%
X_q:	%
X_q':	%
X_q'':	%
X_{invers} (X2):	%

***The short-circuit value of currents I_3, I_1 compared to the voltage of the MV winding of the transformer for an assembly generator + LV/MV transformer + converter.**

MODEL OF TRANSFORMER DATA WITH 3 WINDINGS

Transformer:
Manufacture : **Type :**
Tank **Core : columns** **No. wind:** **Conex:**
S_{nom1}: MVA **U_{nom1}: kV** ***$U_{sc.IM}$: %** **Psc.IM: kW**
S_{nom2}: MVA **U_{nom2}: kV** ***$U_{sc.IJ}$: %** **Psc.IJ: kW**
S_{nom3}: MVA **U_{nom3}: kV** ***$U_{sc.MJ}$: %** **Psc.MJ: kW**

*** (specify the power to which they are metered)**

I_{gol}: % **P_{gol}: kW**
Inf. control :
Voltage control: **U_{pmax}: kV** **U_{pmin}: kV** **U_{plot}: kV**
U_{scpmax}: % **U_{scpmin}: %** **U_{scpmed}: %**

Level neutral insulation : **Neutral treatment: #**

 # Note: In case the neutral of the transformer stars is grounded by means of impedance, the values of the resistance and reactance of grounding impedance will be specified.

MODEL OF TRANSFORMER DATA WITH 2 WINDINGS

Manufacture : **Type :**
No. wind : **Level neutral insulation:** **Conex:**
S_{nom}: MVA **$U_{nom\ I}$: kV** **$U_{nom\ J}$: kV** **$U_{scc.IJ}$: %**
$I_{gol\ I}$: % **$I_{gol\ J}$: %**
P_{agol}: kW **$P_{ascc.IJ}$: kW**
U_{pmax}: kV **U_{pmin}: kV** **U_{plot}: kV** **Rap. Tens. IJ:**
$U_{scc.max}$: % **$U_{scc.min}$: %** **$U_{scc.\ Nom.}$: %**
Neutral treatment: #

 # Note: In case the neutral of the transformer stars is grounded by means of impedance, the values of the resistance and reactance of grounding impedance will be specified.

MODEL OF CABLE DATA

Cable: (Cu or Al) **Manufacture :** **Type :** **Section:**
U_n:
Parameters of direct and earth fault sequence (specify the V at which they are metered)
R_+ = Ω/m **X_+ = Ω/m** **C_+ = μFarad/m**
R_0 = Ω/m **X_0 = Ω/m** **C_0 = μFarad/m**
Parameters of mutual coupling (where need be)
Coupling length:
R_{m0} = Ω/m **X_{m0} = Ω/m**

ANNEX 5

Power forecast

Forecast files are transmitted to the wind farm using a FTP on the AlphaDen server from the Transelectrica network (there will be a dedicated server in the future).

1. To make such a transfer the wind farm should send an e-mail to atudose@teletrans.ro containing the IP-s from which the files will be transmitted.
2. Transelectrica commits, through TELETRANS, to provide a single user and a password using which the wind farm could access the director dedicated to the forecast.

Contact person from TELETRANS: Monica PEREA – mperea@teletrans.ro - 0213016063