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Project Reference Code: ERC0222
Submission to the Rule Change Proposal of Generator Technical Performance Standards

Dear Sir or Madam,

Nordex appreciates the changes which are already implemented in the Draft Rule and the thorough explanation of the issues provided in the document Draft Rule Determination from May 31st 2018. We also welcome the second opportunity to provide our comments on the Draft rule.

About us:

The Nordex Group is one of the world's leading suppliers of wind turbines based on DFIG technology with more than 30 years experience in the harnessing of wind energy. The joint company Nordex and Acciona Windpower combine decades of experience in designing, constructing and operating wind turbines, delivering more than 18 GW of sustainable energy worldwide.

1. Comment on S5.2.5.13 (c1) and d(3)

Topic:	Reactive Power control
Draft rule clause:	S5.2.5.13(c1) and d(3)
Question:	What are the appropriate control settings for the performance requirements for operating in power factor and reactive control modes?

Draft rule clause:

S5.2.5.13 (c1)

"A reactive power or power factor control system provided under paragraph (b)(2A) must:

(1) regulate reactive power or power factor (as applicable) at the connection point, an agreed location in the power system or within the generating system, to within 0.5% of its setpoint;"

S5.2.5.13 (d3)

"a generating system's reactive power or power factor control system must:

(i) regulate reactive power or power factor (as applicable) at the connection point, an agreed location in the power system or within the generating system, to within 2% of its setpoint;"

Comment from Nordex:

From our experience the required accuracy/tolerance should be expressed in fixed values of MVAr or as a percentage of some other fixed value (rated active or reactive power of the Wind Farm), and not as a percentage of the setpoint itself. If the tolerance is expressed in a percentage of itself, as it is now (*"to within 0.5% of its setpoint")*, it will lead to a very small and technically challenging tolerance. For example, let us say that a Wind Farm operates in a reactive power control mode. If a Wind Farm gets a setpoint of 1 MVAr, the reactive power should be regulated to within only 5 kVAr of this setpoint. Also, this would mean that if a setpoint is set to 0 MVAr, there is no tolerance allowed.

Small tolerance can be technically challenging because of the following reason:

At some point, where the required reactive power setpoint is very small, the tolerance enters an area which is technically not feasible (for no technology) as the

control can't be better than the applied measurement. To regulate the reactive power, the current must be measured. Figure 1 shows industry standard current transformer diagrams. It clearly states, that the accuracy is getting worse, when measuring smaller currents. According to the requirement in S5.2.5.13 (c1 and d3) if the required value of the reactive power is getting smaller the required tolerance is getting smaller as well. In the same time the measurement is getting proportionally worse until at some point it is no longer possible to reach the required tolerance, like shown in Figure 2.

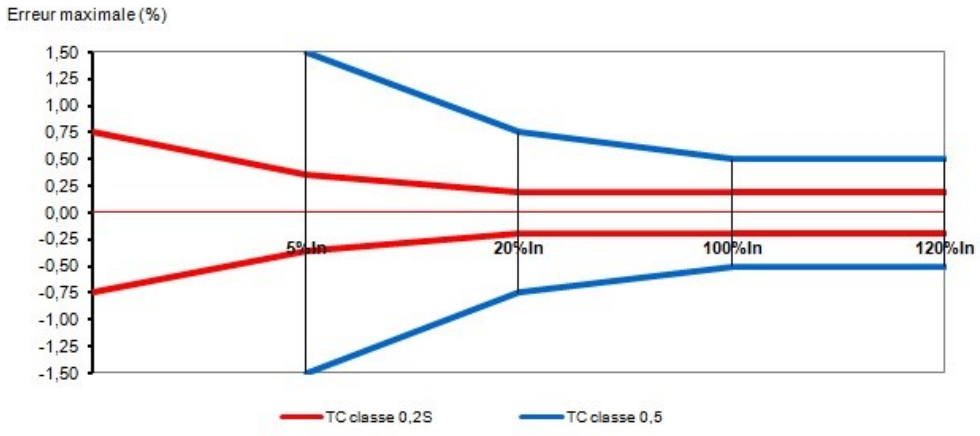

Figure 1: Current transformer accuracy

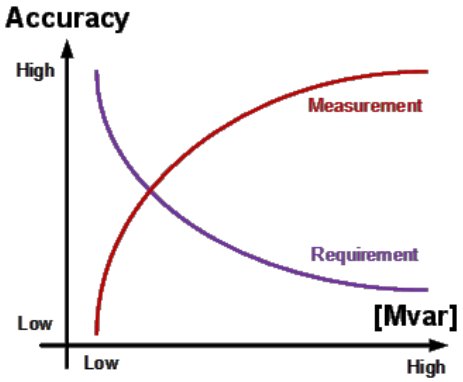

Figure 2: The relationship between the required accuracy of the reactive power and the accuracy of the measurement device

We would therefore like to suggest changing the mentioned requirement and using one of the following forms:

Suggestion 1: *Fixed MVAr value*

Requirement S5.2.5.13(c1)
A reactive power or power factor control system provided under paragraph (b)(2A) must:

(1) regulate reactive power or power factor (as applicable) at the connection point, an agreed location in the power system or within the generating system, *to within x MVAr of the setpoint;*

Suggestion 2: *Percentage of fixed value*

A reactive power or power factor control system provided under paragraph (b)(2A) must:

(1) regulate reactive power or power factor (as applicable) at the connection point, an agreed location in the power system or within the generating system, *to within y% of the rated reactive power of the generating system;*

Suggestion 3: *Compromise between the percentage of the setpoint and the percentage of some other fixed value*

A reactive power or power factor control system provided under paragraph (b)(2A) must:

(1) regulate reactive power or power factor (as applicable) at the connection point, an agreed location in the power system or within the generating system, *to within 0.5% of its setpoint or to within z % of the rated power, depending on which yields the highest tolerance;*

Parameters x, y, and z can be set to a desired value. We suggest a value of 0.5% of rated reactive power.

2. Comment on S5.2.5.13 (b- 2B) (i) and (d – 2B) (i)

Topic:	Reactive Power control
Draft rule clause:	S5.2.5.13(b-2B) and (d-2B)

Draft rule clause:

S5.2.5.13 (b - 2B) (i):

"*a generating system must have a voltage control system that:*

(i) *regulates voltage at the connection point or another agreed location in the power system (including within the generating system) to within 0.5% of the setpoint, where that setpoint may be droop-adjusted to incorporate any voltage droop agreed with AEMO and the Network Service Provider;"*

S5.2.5.13 (d - 2B) (i):

"a voltage control system for a generating system must:

(i) regulate voltage at the connection point, an agreed location in the power system or within the generating system, to within 2% of the setpoint, where that setpoint may be droop-adjusted to incorporate any voltage droop agreed with AEMO and the Network Service Provider;"

Comment from Nordex:

As described in the Draft Rule Determination (page 119) and shown in Figure 3, there are two ways of voltage control, "PI" and droop control.

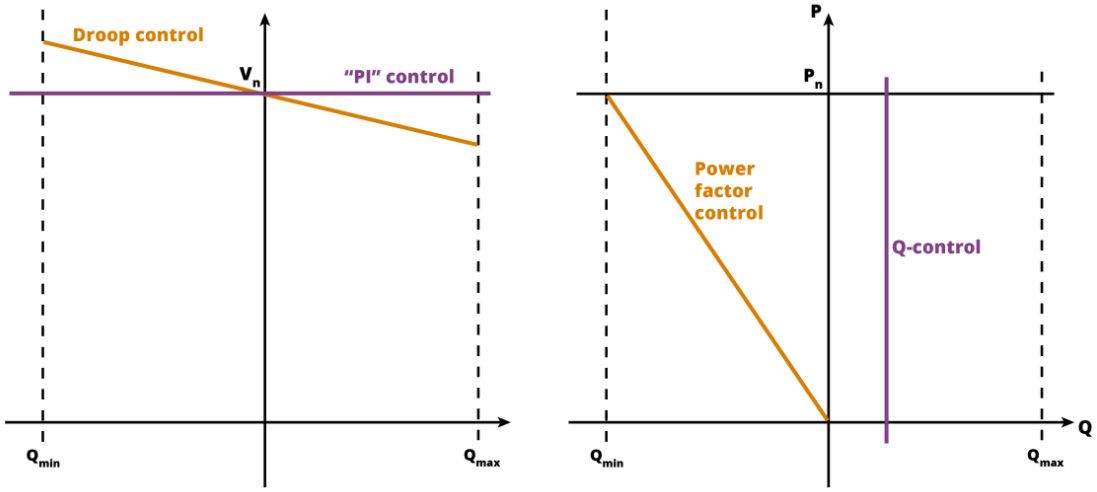

Figure 3: Reactive power control modes – voltage, reactive and power factor control [Draft Rule Determination, page 119]

Whereas the requirements S5.2.5.13 b-2B (i) and d-2B (i) are reasonable for direct "PI" control, we would like to suggest changing the mentioned requirements in case of voltage droop control. For a voltage control with a droop, the tolerance of 0.5% (or 2% for minimum access standard) should relate to the resulting reactive power, and not to the voltage setpoint itself.

Draft Rule Determination states the following (page 119):

"PI voltage control uses the full reactive power capability of the generating system to control the voltage at the connection point to the desired setpoint. The control system achieves this to the extent possible by minimizing the error between the desired voltage setpoint and the measured voltage at the connection point.

Droop voltage control, on the other hand, regulates the generating system's reactive power in proportion to the change in the connection point voltage from the voltage setpoint. In contrast to PI control, Figure 8.1 shows droop control as varying reactive power with connection point voltage according to a defined slope."

As already explained in the Draft Rule Determination, the droop voltage control is only reacting to voltage deviations. It is not regulating the voltage to an exact voltage setpoint as "PI" control. The allowed tolerance, if expressed in percentage of the voltage setpoint, therefore cannot always be reached. Solution could be expressing the allowed tolerance as the percentage of the reactive power, like shown in Figure 4.

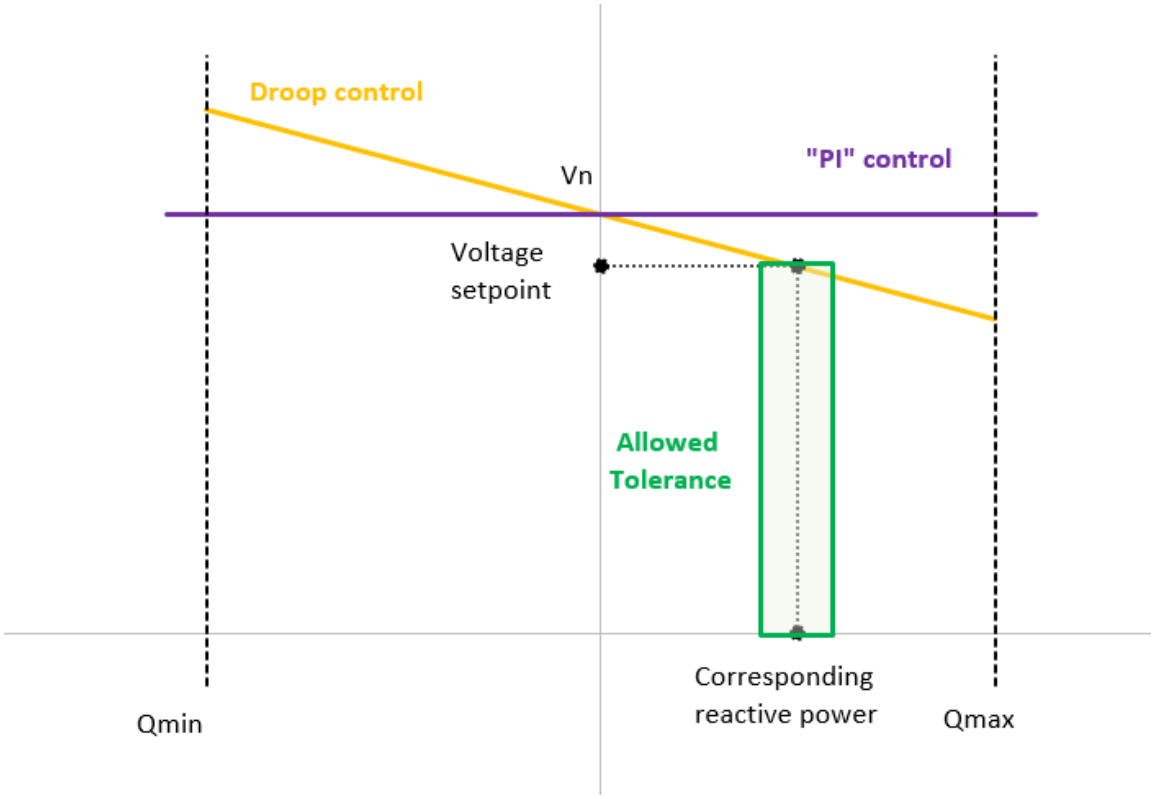

Figure 4: Example of voltage droop control

Suggestion:

S5.2.5.13 (b - 2B) (i):

a generating system must have a voltage control system that:

(i) regulates voltage at the connection point or another agreed location in the power system (including within the generating system*) with the reactive power tolerance band of 0.5% of the rated reactive power*, where that setpoint may be droop-adjusted to incorporate any voltage droop agreed with AEMO and the Network Service Provider;

S5.2.5.13 (d - 2B) (i):

a voltage control system for a generating system must:

(ii) regulate voltage at the connection point, an agreed location in the power system or within the generating system, *with the reactive power tolerance band of 2% of the rated reactive power setpoint,* where that setpoint may be droop-adjusted to incorporate any voltage droop agreed with AEMO and the Network Service Provider;

3. Comment on S5.2.5.1

Topic:	Reactive power capability
Draft rule clause:	S5.2.5.1

Draft rule clause:

S5.2.5.1

"Automatic access standard

(a) The automatic access standard is a generating system operating at:

(1) any level of active power output; and

(2) any voltage at the connection point within the limits established under clause S5.1a.4 without a contingency event,

must be capable of supplying and absorbing continuously at its connection point an amount of reactive power of at least the amount equal to the product of the rated active power of the generating system and 0.395.

Minimum access standard

(b) The minimum access standard is a generating system operating at any voltage at the connection point within the limits established under clause S5.1a.4 without a contingency event, must be capable of supplying and absorbing continuously at its connection point an amount of reactive power of at least the amount equal to zero."

Comment from Nordex:

We welcomed the previous rule proposal for the Automatic access standard S5.2.5.1a(1) which had the following part: *"any level of active power output greater than 10% of its maximum operating level;"* The current Draft Rule does not contain the mentioned sentence anymore. We would like to point out that providing the required reactive power, while the active power is very small or equal to zero, is possible only with additional reactive power compensation.

Minimum access standard requires reactive power at the connection point equal to zero. This would also mean that the Wind Farm may need additional reactive power compensation when the active power is very small or equal to zero. While the required reactive power at the point of connection is zero, the turbines still need to provide reactive power in order to compensate for the losses in the cables and transformers.

In order to fulfil the requirement Wind Farms would need to install external compensation unit or provide STATCOM which is an additional cost.

Suggestion:

We suggest the following:

S5.2.5.1

Automatic access standard
(a) The automatic access standard is a generating system operating at:
(1) any level of active power output *greater than 10% of its maximum operating level;and*
(2) any voltage at the connection point within the limits established under clause S5.1a.4 without a contingency event, must be capable of supplying and absorbing continuously at its connection point an amount of reactive power of at least the amount equal to the product of the rated active power of the generating system and 0.395.

Minimum access standard

(b) The minimum access standard is a generating system operating at any voltage at the connection point within the limits established under clause S5.1a.4 without a contingency event *and level of active power output greater than 10% of its maximum operating level,* must be capable of supplying and absorbing continuously at its connection point an amount of reactive power of at least the amount equal to zero.

4. Comment on S5.2.5.5(c) (1A)

Topic:	Generating system response to disturbances following contingency events **Multiple disturbances**
Draft rule clause:	S5.2.5.5(c)1A

Draft rule clause:

S5.2.5.5 (c) (1A):

"a generating system and each of its generating units must remain in continuous uninterrupted operation for a series of up to six disturbances within any five minute period caused by any combination of the events described in subparagraph (1) where:

(i) up to three of the disturbances cause the voltage at the connection point to drop below 50% of normal voltage;
(ii) up to one disturbance is cleared by a breaker fail protection system or similar back-up protection system;
(iii) up to one disturbance causes the voltage at the connection point to vary within the ranges agreed by AEMO and the Network Service Provider under subparagraphs (a)(7), (a)(8), (b)(4) or (b)(5) (as appropriate) of clause S5.2.5.4;
(iv) the time difference between the clearance of one disturbance and commencement of the next disturbance exceeds 200 milliseconds; and
(v) all disturbances are caused by faults other than three phase faults,
provided that none of the events would result in:
provided that none of the events would result in:
(vi) the islanding of the generation system or cause a material reduction in power transfer capability by removing network elements from service;
(vii) the cumulative time that voltage at the connection point is lower than 90% of normal voltage exceeding 1,000 milliseconds within any five minute period; or
(viii) the time integral, within any five minute period, of the difference between 90% of normal voltage and the voltage at the connection point when the voltage at the connection point is lower than 90% of normal voltage exceeding 0.5 pu second,

and there is a minimum of 30 minutes where no disturbances occur following a five minute period of multiple disturbances;"

Comment from Nordex:

Nordex explained in detail the characteristics of a DFIG wind turbine during occurrence of multiple disturbances during the first consultation stage. We thank you very much for the consideration of our statements! We would just like to ask you to

add a supplementary event to the draft clause. This event is essential to avoid a swinging up of mechanical oscillations.

Suggestion:

Please add the following event to the existing ones:

S5.2.5.5 (c) (1A):

(ix) no more than three disturbances occur within 30 seconds.

5. Comment on S5.2.5.5(c) 3 (ii) and S5.2.5.5 (i) 5

Topic:	Generating system response to disturbances following contingency events **Active and reactive current consumption**
Draft rule clause:	S5.2.5.5(c)3(ii) and S5.2.5.5(i)5
Question:	On the occurrence of a fault, what is the appropriate limit on consumption of active power and reactive power?

Draft rule clause:

S5.2.5.5 (c) 3 (ii):

"(ii) return to at least 95% of the pre-fault active power output, after clearance of the fault, within a period of time agreed by the Connection Applicant, AEMO and the Network Service Provider,

provided that any active current consumption immediately upon the occurrence of a fault does not exceed 10% of the maximum continuous current of the generating system and is limited to 60 milliseconds;"

and S5.2.5.5 (i) 5:

"(5) any reactive current consumption immediately upon the occurrence of a fault must not exceed 5% of the maximum continuous current of the generating system and is limited to the duration of rise time;"

Comment from Nordex:

Due to the direct connection of the stator to the grid, a DFIG wind turbine has a transient oscillation in the active and reactive current at the beginning of the fault. This oscillation can't be avoided and is state of the art. Due to this oscillation a reactive current consumption of up to 15% *of the maximum continuous current* can occur depending on the type of disturbance (occurrence by asymmetrical faults only). This consumption can't be avoided and is limited to a duration of 10ms.
A consumption of active current can occur up to 20 % *of the maximum continuous current* and can't be avoided either. The consumption of active current will not take place if the wind turbine is operating at full load. It's limited to the sub-synchronous operation mode.

Suggestion:

We suggest the following:

S5.2.5.5 (c) 3 (ii):

(ii) return to at least 95% of the pre-fault active power output, after clearance of the fault, within a period of time agreed by the Connection Applicant, AEMO and the Network Service Provider,

provided that any active current consumption immediately upon the occurrence of a fault does not exceed 20% of the maximum continuous current of the generating system and is limited to 60 milliseconds;

and S5.2.5.5 (i) 5:

(5) any reactive current consumption immediately upon the occurrence of a fault must not exceed 15% of the maximum continuous current of the generating system and is limited to the duration of rise time;

6. Comment on S5.2.5.5(c)4 and Glossary

Topic:	Generating system response to disturbances following contingency events **Rise and settling time**
Draft rule clause:	S5.2.5.5(c)4

Draft rule clause:

S5.2.5.5 (c) 4

"(4) for the purpose of subparagraph (c)(3), the reactive current response must have a rise time of no greater than 40 milliseconds and a settling time of no greater than 70 milliseconds and must be adequately damped, except that where a duration of greater than two seconds is required, the reactive current rise time must be as soon as practicable, and in any event, no longer than 180 milliseconds;"

Comment from Nordex:

Due to the transient current oscillations at the beginning of the fault as already explained above, a settling time of 70 ms can only be guaranteed if the tolerance band will be increased. Please, allow a higher upper tolerance of up to + 20% of the maximum continuous current of the generating system. This will help to handle the transient oscillations and to fulfil a settling time of 70 ms and will not limit the feed in of the reactive current as only the upper tolerance band is enlarged. The lower tolerance band has to be at least -10% of the maximum continuous current of the generating system.

Suggestion:

We suggest the following change in the Glossary:

10. Glossary

Settling time - In relation to a control system, the time measured from initiation of a step change in an input quantity to the time when the magnitude of error between the output quantity and its final settling value remains less than 10% of:

(1) if the sustained change in the quantity is less than half of the maximum change in that output quantity, the maximum change induced in that output quantity; or

(2) the sustained change induced in that output quantity.

(3) in case of S5.2.5.5: -10% and +20 % of the maximum continuous current of the generating system.

7. Comment on S5.2.5.5(i)1 and (i)6

Topic:	Generating system response to disturbances following contingency events
Draft rule clause:	S5.2.5.5(i)1 and (i)6
Question:	Are there physical limits that apply to the capability of generators to maintain total current at a given level on a fault at all times?

Draft rule clause:

S5.2.5.5 (i) 1

"(1) the reactive current contribution may be limited to the maximum continuous current of a *generating system*, including its operating *asynchronous generating units*;

S5.2.5.5 (i) 6

(6) notwithstanding the amount of reactive current injected or absorbed during voltage disturbances, the maximum continuous current of the generating system including all operating generating units (in the absence of a disturbance) must be available at all times, except that AEMO and the Network Service Provider may agree limits on active current injection where required to maintain power system security and the quality of supply to other Network Users."

Comment from Nordex:

The requirements from above are understood that a reactive current of up to 100% of the maximum continuous current of a generating system plus an active current of up to 100% of the maximum continuous current of a generating system has to be fed during a disturbance. Please, take into account that a DFIG wind turbine is also contributing in a negative sequence reactive current beside the positive sequence reactive current during asymmetrical faults. As a DFIG wind turbine is directly connected to the grid via stator side, this reactive current contribution can't be suppressed. The negative sequence reactive current will help to symmetrize the voltages during an asymmetrical fault.
Due to the positive effect of negative sequence reactive current contribution due to an asymmetrical fault, the feed in of negative sequence reactive current during asymmetrical faults became a grid code requirement in many European grid codes, lately.

Please, consider the reactive current contribution as fulfilled if the absolute value of negative sequence reactive current contribution plus the absolute value of positive sequence reactive current equals the amount of the maximum continuous current of a generating system.

Suggestion:

We suggest the following:

S5.2.5.5 (i) 1

(1) the reactive current contribution (sum of the absolute value of positive and negative sequence reactive current) may be limited to the maximum continuous current of a *generating system*, including its operating *asynchronous generating units*;

8. Comment on S5.2.5.5(i)4

Topic:	Generating system response to disturbances following contingency events
Draft rule clause:	S5.2.5.5(i)4
Question:	What are the appropriate ride through threshold ranges?

Draft rule clause:

"S5.2.5.5 (i) 4

for the purpose of subparagraphs (b)(3)(i) and (c)(3)(i), separate thresholds for activation of the reactive current contribution must be set within the ranges of 85% to 90% and 110% to 112% of the nominal voltage at the terminals of a generating unit, with the actual thresholds to be agreed between AEMO and the Network Service Provider and recorded as the performance standards;"

Comment from Nordex:

As the grid strength and conditions differ from project to project, we would like to keep the flexibility and be able to set the threshold parameters project specific, possibly outside of the mentioned limits. We suggest adding a clause that the threshold parameters can be negotiated with AEMO project specific.

9. Comment on S5.2.5.5

Topic:	Generating system response to disturbances following contingency events
Draft rule clause:	S5.2.5.5
Question:	Do the requirements for asynchronous units established under S5.2.5.5 create barriers to the connection of type 3 wind generators, or other doubly fed induction machines?

Comment from Nordex:

Yes, please refer to comments: 4, 5, 6 and 7

10. Comment on S5.2.5.13 2B(5)

Topic:	Generating system response to disturbances following contingency events
Draft rule clause	S5.2.5.13 2B 5

Draft rule clause:

S5.2.5.13 2B(5)

"(2B) a generating system must have a voltage control system that:

(v) has a power system stabiliser with sufficient flexibility to enable damping performance to be maximised, with characteristics as described in paragraph (c);"

Comment from Nordex:

Although it seemed that the power system stabiliser was no longer a requirement for asynchronous machines, it is again appearing in the chapter S5.2.5.13 (2B), which is to our understanding valid for all generating systems. S5.2.5.13 (4), the requirements only for asynchronous machines do not mention the same requirement.

We would like to point out that wind farms do not have a power system stabilizer. We would kindly like to ask you to clarify your expectations regarding this topic when it comes to Wind Farms.

Nordex would like to thank you in advance for considering the suggestions above. Please, don't hesitate to contact us in case of any questions and please keep us informed about updates regarding the rule change request.

Yours sincerely,

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