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Subject: NYISO Test Procedure for Evaluating Power Factor Requirements for Wind Generation Interconnection Projects**Background**

FERC Order No. 661 does not require wind generation plants to comply with a power factor standard unless the transmission provider determines, on a case-by-case basis in a system impact study, that such compliance is needed to ensure the safety or reliability of the transmission system. When such a need has been demonstrated, FERC has adopted a standard power factor range of 0.95 leading and 0.95 lagging (+/- 0.95) at the Point of Interconnection (POI) for wind plants (the "Pro Forma Standard" or "PFS"). In addition, if the transmission provider determines that the PFS is insufficient, FERC Order No. 661-A allows the transmission provider to file a non-conforming agreement to essentially request the FERC's approval for a wider power factor range, again, on a case-by-case basis. This document describes the NYISO's procedure to: 1) determine whether or not a wind generation interconnection project ("Wind Project") should be required to comply with a power factor standard to ensure the safety or reliability of the transmission system, and if so, 2) determine whether or not the PFS would be sufficient, or if insufficient, 3) determine the power factor range at the POI that would be needed to ensure the safety or reliability of the transmission system.

Details:**Test Approach, Concepts and Assumptions**

As directed by the FERC, this test procedure will be performed as part of, or in conjunction with the NYISO's Interconnection System Reliability Impact Study (SRIS) performed for the Wind Project. This test procedure will be integrated with the NYISO's standard SRIS practices and procedures.

Power flow analysis will be used to perform the evaluations required by this test procedure. In an SRIS, several power flow cases are used in the performance of thermal and voltage analysis. The SRIS uses a number of pre-project base cases intended to simulate a range of "representative" system conditions, typically: a summer peak load case, a winter peak load case, and a spring light load case. For each pre-project base case, the SRIS uses a corresponding post-project "change" case. Contingency analysis is performed on all these cases to evaluate the thermal and voltage performance of the transmission system with respect to applicable reliability standards, with and without the project, thereby assessing the incremental impact the project may have on system reliability.

The post-project power flow cases model the project in accordance with the information provided by the Developer for the SRIS, including any reactive power (VAr) capability that may be proposed with the project ("proposed VAr capability"). For wind power projects, for example, certain types of wind generators are designed to provide some amount of VAr capability. Therefore, the model for wind projects that use those types of generators would include the VAr capability inherent in the generator design. And if the Developer were to include another form of VAr capability as part of the project, such as a shunt capacitor bank, that too would be included in the model. Since the SRIS is conducted on the basis of project information provided by the Developer, any subsequent change to the project after the SRIS has been completed that the NYISO determines may have a material impact on the SRIS results would require re-study of the

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SRIS, or at least those portions that may be affected by the change. Such re-study would include redo of this test procedure as necessary.

The test procedure has up to three basic steps as follows:

- 1) Determine whether the proposed VAr capability for the Wind Project would be sufficient to ensure the safety or reliability of the transmission system, or whether the Wind Project should be required to comply with a power factor standard. If the latter,
- 2) Determine whether or not the PFS would be sufficient. If not,
- 3) Determine the power factor range at the POI that would be needed to ensure the safety or reliability of the transmission system.

Normally these steps would be performed sequentially, since the results of each step determine the need to perform the subsequent step(s).

The test procedure will be based on the following concepts and assumptions:

- The test results will be determined on the basis of voltage performance of the transmission system.
- The impact of a Wind Project on transmission system voltage performance will be based on the combined impact of adding the project to the system at its maximum megawatt (MW) output and the corresponding assumed generation redispatch modeled in the power flow case.
- If the Wind Project has a significant impact on transmission system voltage performance, the potential for such impact can be detected at the POI and/or the adjacent buses connected to the POI (the “adjacent buses”). Conversely, if the Wind Project is shown to have an insignificant impact on voltage performance at the POI and the adjacent buses, it can be assumed that the Wind Project would have an insignificant impact on the voltage performance of the rest of the transmission system as well. The rationale for evaluation of the adjacent buses is that, in general, injecting active power into a bus (such as injecting power from a new generator at the POI) may or may not have a significant effect on the voltage at the POI itself. However, the power injection will change the power flows on transmission facilities (lines or transformers) connected to the POI, which may result in a significant change in voltage at one or more of the remote end terminals (i.e. the adjacent buses) of those facilities. Therefore, the adjacent buses should be considered in this evaluation.
- For the purpose of this test procedure, a change in voltage at the POI or the adjacent buses of greater than +/- 0.5% of nominal voltage (+/- 0.005 Per Unit) will be considered significant.
- If the Wind Project, with due consideration of any proposed VAr capability, is shown to have a significant impact on voltage at the POI or adjacent buses, either up or down on a pre-contingency basis, or in the direction of the voltage change on a post-contingency basis, it is reasonable to conclude that such impact has the potential to cause or contribute to a significant adverse impact on transmission system voltage performance (e.g. voltage limit violations, or adverse impact on power quality) at the extreme ends of

the range of possible system conditions. This “significant incremental impact” approach is consistent with the scope and intent of an SRIS and reflects the fact that the SRIS is not a “design study.” In a typical design study, the analyst would develop many more power flow cases than are used in an SRIS, in an attempt to capture the full range of possible local system conditions over a full range of time frames, such as: maximum and minimum local load and/or line flow conditions, local maintenance outage conditions, various seasons (e.g. summer, winter, spring), time-of-day (e.g. day-time vs. night-time), day-of-week (e.g. week-day vs. week-end or holiday), etc. Adding all this analysis to an SRIS would significantly alter the nature of the study and substantially increase the time and cost to complete the study. Therefore, because an SRIS, by its inherent nature, is not a design study, the “significant incremental impact” approach described herein is appropriate.

- The Wind Project would be required to provide additional VAR capability (i.e. comply with a power factor standard) when necessary to mitigate a significant impact on transmission system voltage performance due to the Wind Project. The Wind Project would not be required to provide additional VAR capability to address a pre-existing voltage performance issue, but would be required to provide additional VAR capability only if found to have a significant incremental impact on transmission system performance.

Step 1 Test Procedure

The first step of the test procedure is to determine whether or not the Wind Project should be required to provide additional VAR capability to ensure the safety or reliability of the transmission system. As a matter of convention, a “positive result” of this test will mean that the Wind Project would be required to provide additional VAR capability, and a “negative result” will mean the Wind Project would not be required to provide additional VAR capability.

A number of tests will be required to complete this step. A positive result of any test performed for this step will be considered an overall positive result of this step, resulting in a determination that the Wind Project will be required to provide additional VAR capability, and no additional tests for this step would be necessary. Therefore, all tests performed for this step would need to yield a negative result in order for the overall result of this step to be negative, resulting in a determination that the Wind Project would not be required to provide additional VAR capability.

Pre-contingency Tests:

A series of pre-contingency tests will be performed on each of the pre-project and corresponding post-project power flow cases (Summer Peak Load, Winter Peak Load, and Spring Light Load) as follows:

- 1) Modify each of the post-project cases as necessary to use the proposed VAR capability that was modeled as part of the Wind Project to regulate voltage at the POI bus at, or as near as possible, to the value in the corresponding pre-project base case.
- 2) For each case, compute the change in voltage at the POI bus and adjacent buses in the pre-project case vs. the corresponding post-project case. (Ordinarily a POI bus would not exist in a pre-project case if the proposed interconnection is on a line rather than a substation. However, in preparing the base cases for an SRIS, it is a standard practice of the NYISO to insert a POI bus into the pre-project base cases for a proposed line connection. This does not affect the results of analysis performed on the pre-project

cases, but conveniently provides a POI bus in the pre-project case where otherwise one would not exist.)

- 3) If the voltage change at the POI bus for any pair of cases is significant (i.e. greater than +/- 0.005 Per Unit), the result of that test is positive. If not, check the adjacent buses. If the voltage change at an adjacent bus is significant and not all the proposed VAr capability has been used, use the remaining VAr capability to try to mitigate the voltage change at the adjacent bus. If the VAr capability is insufficient to mitigate any significant voltage changes observed at the adjacent buses, the result of the test is positive. But if the proposed VAr capability is found to be sufficient to mitigate any significant voltage changes at the POI bus and adjacent buses, the test result is negative. As previously stated, a positive result for any case will be considered an overall positive test result.

Post-Contingency Tests:

If the pre-contingency test results are negative, a series of post-contingency tests will be performed on the pre-project and post-project power flow cases as follows. (If the pre-contingency test results were positive, the post-contingency tests are not needed):

- 1) Identify the “critical” contingencies from the voltage analysis performed in the SRIS for the pre-project and post-project cases. The critical contingencies include the contingencies that result in the greatest voltage increase or decrease at the POI and/or adjacent buses. At least two critical contingencies should be identified for each pre-project and post-project case: the contingency that causes the greatest voltage increase and the contingency that causes the greatest voltage decrease. Normally only one contingency in each direction would be identified as the worst case, but it’s possible that more than one contingency may be identified as critical due to their relative impacts on different buses. The critical contingencies identified in the post-project cases may be the same or different than those identified in the corresponding pre-project case.
- 2) Modify each of the post-project, critical contingency cases as necessary to use the proposed VAr capability that was modeled as part of the Wind Project to regulate voltage at the POI bus at, or as near as possible, to the value in the corresponding pre-project pre-contingency base case.
- 3) Compute the change in post-contingency voltage at the POI bus and adjacent buses in the pre-project critical contingency case vs. the corresponding post-project critical contingency case. Note that the critical contingencies that result in a voltage increase vs. those that result in a voltage decrease must be compared separately.
- 4) If the voltage change at the POI bus or adjacent buses for any pair of cases is significant and adverse (i.e. greater than 0.005 Per Unit in the direction of the voltage change in the applicable pre-project critical contingency case), the result of that test is positive. If not, the test result is negative. As previously stated, a positive result for any case will be considered an overall positive test result.

Overall Result of this Step:

If the results of either the pre-contingency tests or the post-contingency test are positive, the overall Step 1 result is positive, indicating that the Wind Project should be required to provide additional VAr capability. Otherwise, the overall Step 1 result is negative, indicating the Wind Project should not be required to provide additional VAr capability. If the overall Step 1 result is

positive, it will be necessary to perform Step 2 of this test procedure. But if the overall result of Step 1 is negative, it would not be necessary to perform the subsequent steps of this test procedure.

Step 2 Test Procedure

The second step of the test procedure is to determine whether or not the FERC PFS (a power factor range of +/- 0.95 at the POI) would be sufficient. As a matter of convention, a “positive result” of this test will mean that the PFS would be sufficient. A “negative result” will mean the PFS would not be sufficient to ensure the safety or reliability of the transmission system.

Pre-contingency Tests:

If the overall result of the pre-contingency tests in Steps 1 was negative, it would not be necessary to perform pre-contingency tests in this step. Essentially, the objective of this test is to determine whether the PFS VAR capability is sufficient to mitigate significant voltage changes at the POI and adjacent buses observed in Step 1. The procedure for this step is as follows:

- 1) Modify each of the post-project cases (Summer Peak Load, Winter Peak Load, and Spring Light Load) to model the Wind Project as having VAR capability that meets the PFS. Note that, since the PFS is +/- 0.95 at the POI, the VAR capability for the generator will likely require a power factor range at the generator terminals significantly greater than +/- 0.95. This will result in a set of “post-project with PFS” cases.
- 2) Rerun the power flow for each post-project case, using the PFS reactive capability of the project to regulate voltage at the POI bus at its pre-project level, and determine whether or not the significant voltage changes identified in Step 1 have been mitigated in all cases.
- 3) If the overall conclusion of this analysis is that the PFS would be adequate to mitigate the previously observed significant impact of the Wind Project on pre-contingency transmission system voltage, the result of this test would be positive. Otherwise, the result would be negative.

Post-Contingency Test:

If the overall result of the post-contingency tests in Step 1 was negative, it would not be necessary to perform post-contingency tests in this step. Essentially, the objective of this test is to determine whether the PFS VAR capability is sufficient to mitigate significant adverse voltage changes at the POI and adjacent buses observed in Step 1. The procedure for this test is as follows:

- 1) For those cases that showed a significant adverse impact in Step 1, modify the post-project critical contingency power flow cases to model the Wind Project as having VAR capability that meets the PFS.
- 2) Rerun the power flow for each of the “critical” contingencies, using the PFS reactive capability of the project to regulate voltage at the POI bus at its pre-contingency schedule, and determine whether or not all significant adverse impacts identified in Step 1 have been fully mitigated in all cases.

- 3) If the overall conclusion of this analysis is that the PFS would be adequate to mitigate the previously observed significant adverse impact of the Wind Project on post-contingency transmission system voltage performance, the result of this test would be positive. Otherwise, the result would be negative.

Overall Result of Step 2:

In this case, the results of both the pre-contingency and post-contingency test must be positive for the overall Step 2 result to be positive, indicating that meeting the PFS would be sufficient. If the results of either the pre-contingency test or post-contingency test are negative, the overall Step 2 result would be negative, indicating that the PFS is insufficient to mitigate the adverse impact of the Wind Project on transmission system voltage performance.

Step 3 Test Procedure

The third step of this test procedure, if required, is to determine the power factor range at the POI would be needed to ensure the safety or reliability of the transmission system. The procedure for this step is as follows:

- 1) Increase the VAr capability modeled for the Wind Project in the post-project cases by incremental amounts and repeat the previous critical pre-contingency and/or post-contingency analyses until the previously observed significant adverse impact on transmission system voltage performance has been mitigated.
- 2) Express the determined VAr requirement in terms of power factor range at the POI.

The NYISO tentatively anticipates that this Technical Bulletin will be rolled into the Transmission Expansion & Interconnection Manual during its next available recertification period.