Public Service of New Hampshire
The Northeast Utilities System

Intra Company Memo

From: Steven D. Hall
X720-3211

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Subject: Feasibility Study
IPP 275 Groton Wind

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PSNH's System Planning and Strategy Department performed a Feasibility Study for Independent Power Producer 275-Groton Wind. This study was conducted to determine the feasibility, maximum size, and operating constraints for a proposed wind generation facility to be located in Groton, NH.

This information, based on a preliminary study performed on the PSNH 34.5kV distribution system, is intended to provide project feasibility and guidance for interconnection onto the PSNH system. A more detailed interconnection study is required by PSNH to identify specific interconnection requirements based upon detailed project data provided by the developer.

Background:

The proposed IPP interconnection point will either be PSNH's Ashland Substation 34.5 kV bus, PSNH's Beebe River Substation 34.5 kV bus, or both. The distance of 34.5 kV line, which will be constructed by the developer, from the generation facility to either interconnection point is approximately 12.5 miles.

Power Technologies Inc.'s PSS/E 30.3 software was used for modeling PSNH's system and the interconnection. Steady state and transient analyses were performed on varying PSNH load levels to determine feasibility.

Steady state analysis is performed to verify that the proposed generation facility does not adversely affect system voltages or exceed thermal limits of the distribution system. PSNH is required by the New Hampshire Public Utilities Commission to maintain specific nominal customer voltages.

Transient analysis is performed to verify that the proposed generation facility does not adversely affect customer power quality. This is completed by studying the loss of the complete generating facility, simulating a sudden separation from the utility at the facility metering point. This simulates the "flicker," or noticeable blinking of lights, seen by customers on that system. To limit exposure to its customers from power quality problems caused by Independent Power Producers, PSNH allows no greater than a 3 % voltage variation.

This study was initiated to determine the maximum amount of generation that IPP 275-Groton Wind can interconnect directly to PSNH's 34.5 kV system.

Assumptions:

The following assumptions were made in order to conduct this Feasibility Study for IPP 275 Groton Wind:

1. The study is based on the projected 2011 peak and minimum load conditions.

2. The study is based on the proposed Independent Power Producer 387-Hilltop Power, currently ahead of IPP 275-Groton Wind in the ISO queue, along with all associated system upgrades being in-service.

3. The generation facility requires machines with voltage control, remote fault ride-through, and equipment with state-of-the-art control capabilities.

4. The generation is operating at unity power factor.

Options Investigated:

Six options were considered to interconnect IPP 275-Groton Wind. For each option, the maximum allowable generation is specified along with the thermal/voltage criteria that's violated if this generation limit is exceeded.

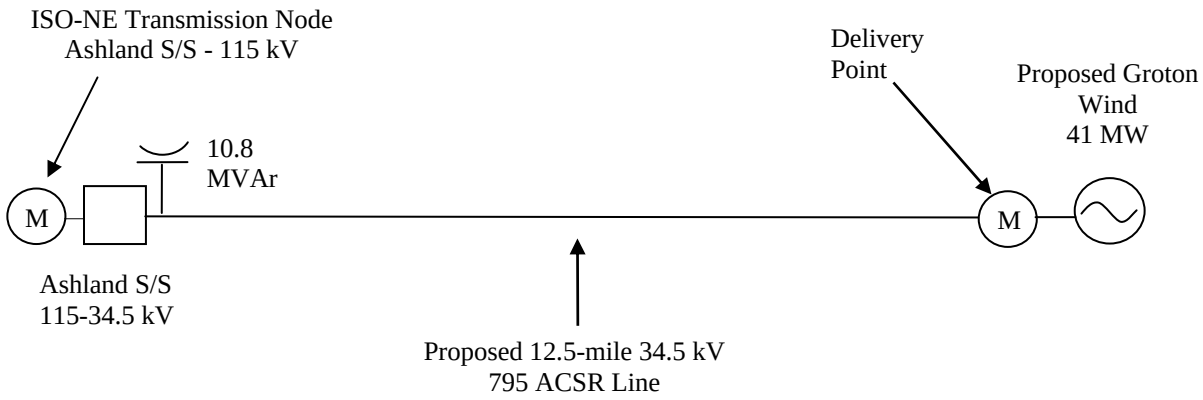
Option 1:

One 34.5 kV line will be constructed from the generation facility to the interconnection point at PSNH's Ashland Substation 34.5 kV bus. The distance of this new 34.5 kV line, which will be constructed by the developer, is approximately 12.5 miles. The new line will be a dedicated line with no customer load, and it will be constructed with conductor size of 795 ACSR. See Figure 1 for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable generation of 41 MW. Under certain conditions, more than 41 MW of generation would overload the existing 115 – 34.5 kV Ashland Substation transformer as a result of excessive power flow into the 115 kV transmission system. Specifically, a contingent loss of the heaviest loaded 34.5 kV distribution line (338 line) served by Ashland Substation during minimum load conditions would cause the thermal limit of the Ashland Substation transformer to be exceeded with a generation output of more than 41 MW.

At a generation output of 41 MW, this interconnection requires 10.8 MVAr of capacitance at Ashland Substation. This capacitance, which will be installed by the developer, is needed to compensate for the reactive losses along the 34.5 kV 795 ACSR line from Ashland Substation to the generating facility as a direct result of this generation.

Figure 1: System Configuration for Option 1



Option 1(a):

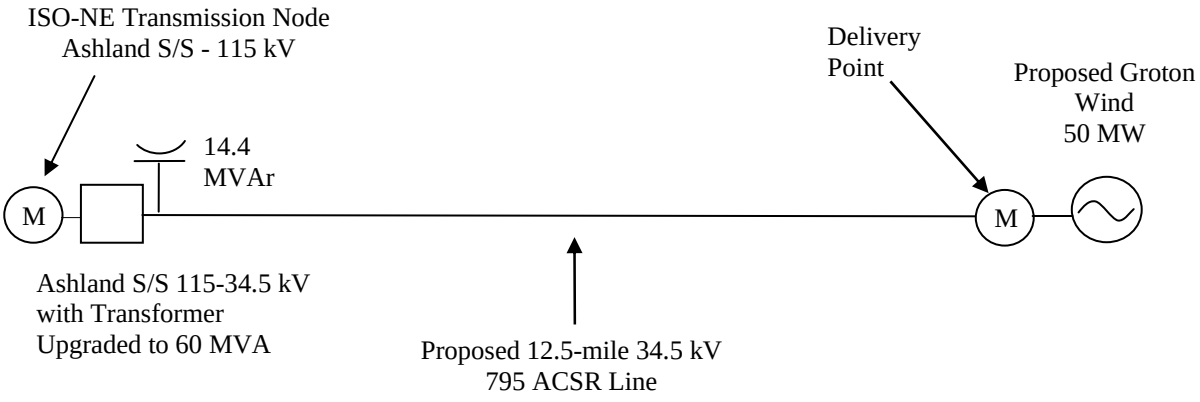
In addition to the line construction described in Option 1, the existing 115 – 34.5 kV transformer at Ashland Substation will be upgraded from 44.8 MVA to 60 MVA. See Figure 1(a) for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable generation of 50 MW. Looking at all realistic scenarios, 50 MW of generation would result in no thermal or voltage criteria violations under steady state conditions.

At a generation output of 50 MW, this interconnection requires 14.4 MVAr of capacitance at Ashland Substation. This capacitance, which will be installed by the developer, is needed to compensate for the reactive losses along the 34.5 kV 795 ACSR line from Ashland Substation to the generating facility as a direct result of this generation.

In order to generate the full 50 MW output, the 14.4 MVAr of capacitance at Ashland Substation specified above needs to trip off-line via transfer trip upon contingent loss of generation or loss of the dedicated line from the generation facility to Ashland Substation. This condition must be satisfied in order to prevent unacceptable voltage rise on PSNH's 34.5 kV distribution system. Given that this stipulation is met, 50 MW of generation would result in no voltage flicker violations.

Figure 1(a): System Configuration for Option 1(a)



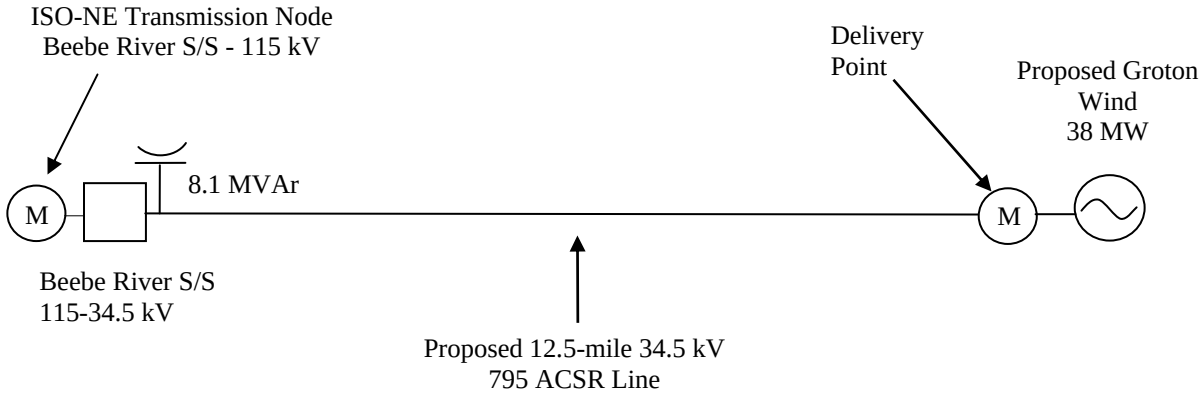
Option 2:

One 34.5 kV line will be constructed from the generation facility to the interconnection point at PSNH's Beebe River Substation 34.5 kV bus. The distance of this new 34.5 kV line, which will be constructed by the developer, is approximately 12.5 miles. The new line will be a dedicated line with no customer load, and it will be constructed with conductor size of 795 ACSR. See Figure 2 for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable generation of 38 MW. Under minimum load conditions, more than 38 MW of generation would cause unacceptable voltage flicker on PSNH's 34.5 kV system upon contingent loss of the generation.

At a generation output of 38 MW, this interconnection requires 8.1 MVAr of capacitance at Beebe River Substation. This capacitance, which will be installed by the developer, is needed to compensate for the reactive losses along the 34.5 kV 795 ACSR line from Beebe River Substation to the generating facility as a direct result of this generation.

Figure 2: System Configuration for Option 2



Option 3:

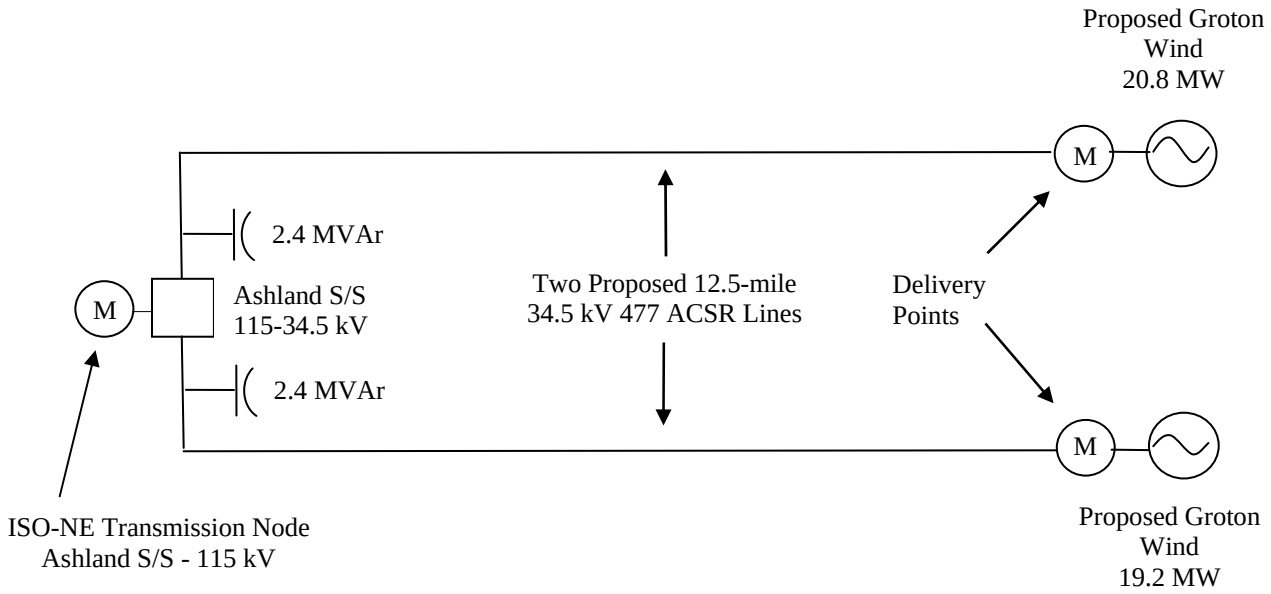
Two 34.5 kV lines on separate polelines will be constructed from the generation facility to the interconnection point at PSNH's Ashland Substation 34.5 kV bus. One line will support 13 of the 25 total wind turbine generators while the other line will support the remaining 12 generators. The distance of each of these new 34.5 kV lines, which will be constructed by the developer, is approximately 12.5 miles. The two new lines will be dedicated lines with no customer load, and they will both be constructed with conductor size of 477 ACSR. See Figure 3 for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable cumulative generation of 40 MW. Under certain conditions, more than 40 MW of total generation would overload the existing 115 – 34.5 kV Ashland Substation transformer as a result of excessive power flow into the 115 kV transmission system. Specifically, a contingent loss of the heaviest loaded 34.5 kV distribution line (338 line) served by Ashland Substation during minimum load conditions would cause the thermal limit of the Ashland Substation transformer to be exceeded with a total generation output of more than 40 MW.

At a generation output of 40 MW, this interconnection requires two 2.4 MVAr capacitor banks at Ashland Substation, one on each of the new 34.5 kV lines. These capacitor banks, which will be installed by the developer, are needed to compensate for the reactive losses along each 34.5 kV 477 ACSR line from Ashland Substation to the generating facility as a direct result of this generation.

It should be noted that while acceptable voltage levels on PSNH's 34.5 kV distribution system is maintained, a voltage as high as 106.3% of nominal voltage can be expected at the generation terminals if this option is implemented.

Figure 3: System Configuration for Option 3



Option 4:

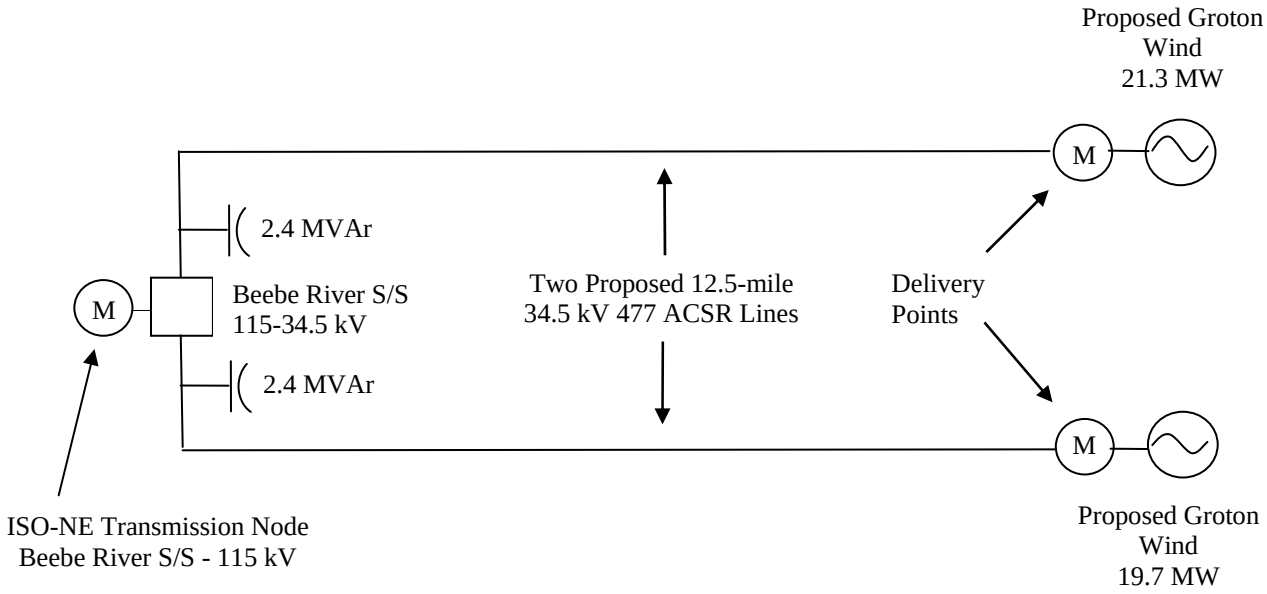
Two 34.5 kV lines on separate polelines will be constructed from the generation facility to the interconnection point at PSNH's Beebe River Substation 34.5 kV bus. One line will support 13 of the 25 total wind turbine generators while the other line will support the remaining 12 generators. The distance of each of these new 34.5 kV lines, which will be constructed by the developer, is approximately 12.5 miles. The two new lines will be dedicated lines with no customer load, and they will both be constructed with conductor size of 477 ACSR. See Figure 4 for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable cumulative generation of 41 MW. Under certain conditions, more than 41 MW of total generation would overload the existing 115 – 34.5 kV Beebe River Substation transformer as a result of excessive power flow into the 115 kV transmission system. Specifically, a contingent loss of the heaviest loaded 34.5 kV distribution line (342B line) served by Beebe River Substation during minimum load conditions would cause the thermal limit of the Beebe River Substation transformer to be exceeded with a total generation output of more than 41 MW.

At a generation output of 41 MW, this interconnection requires two 2.4 MVAr capacitor banks at Beebe River Substation, one on each of the new 34.5 kV lines. These capacitor banks, which will be installed by the developer, are needed to compensate for the reactive losses along each 34.5 kV 477 ACSR line from Beebe River Substation to the generating facility as a direct result of this generation.

It should be noted that while acceptable voltage levels on PSNH's 34.5 kV distribution system is maintained, a voltage as high as 106.3% of nominal voltage can be expected at the generation terminals if this option is implemented.

Figure 4: System Configuration for Option 4



Option 5:

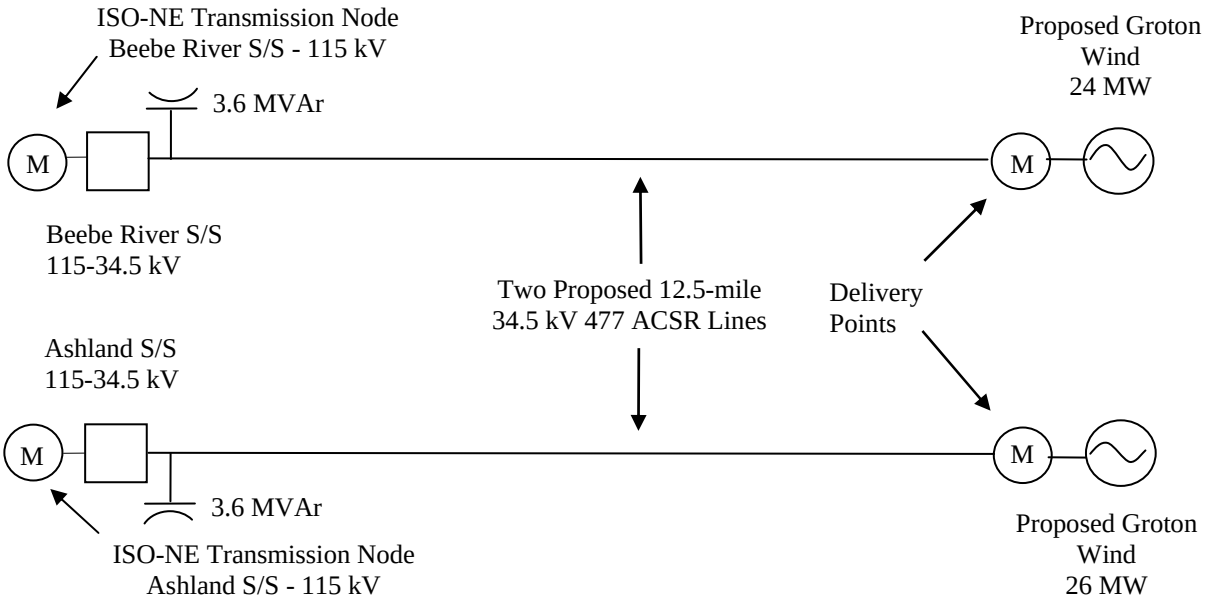
One 34.5 kV line will be constructed from the generation facility to the interconnection point at PSNH's Ashland Substation 34.5 kV bus, and another separate 34.5 kV line will be constructed from the generation facility to the interconnection point at PSNH's Beebe River Substation 34.5 kV bus. The line to Ashland Substation will support 13 of the 25 total wind turbine generators while the line to Beebe River Substation will support the remaining 12 generators. The distance of each of these new 34.5 kV lines, which will be constructed by the developer, is approximately 12.5 miles. The two new lines will be dedicated lines with no customer load, and they will both be constructed with conductor size of 477 ACSR. See Figure 5 for system configuration with generator interconnection under this scenario.

Implementing this option results in a maximum allowable cumulative generation of 50 MW. Under all realistic conditions, 50 MW of total generation would result in no thermal or voltage criteria violations.

At a generation output of 50 MW, this interconnection requires a 3.6 MVAr capacitor bank at Ashland Substation and a 3.6 MVAr capacitor bank at Beebe River Substation, one on each of the new 34.5 kV lines. These capacitor banks, which will be installed by the developer, are needed to compensate for the reactive losses along each 34.5 kV 477 ACSR line from Ashland and Beebe River Substations to the generating facility as a direct result of this generation.

It should be noted that while acceptable voltage levels on PSNH's 34.5 kV distribution system is maintained, a voltage as high as 106.9% of nominal voltage can be expected at the generation terminals if this option is implemented.

Figure 5: System Configuration for Option 5



Summary:

The chart below summarizes the five options that were considered to interconnect IPP 275-Groton Wind along with their conclusions:

Chart 1: Overview of Options

Option	Project Description	Maximum Allowable Generation	Distribution System Violation if Generation Limit Exceeded
1	Build 12.5 mile 34.5 kV 795 ACSR line to Ashland Substation & install 10.8 MVAr of capacitance.	41 MW	Loss of heaviest loaded 34.5 kV line out of Ashland Substation during minimum load conditions overloads Ashland Substation transformer
1a	Build 12.5 mile 34.5 kV 795 ACSR line to Ashland Substation, install 14.4 MVAr of capacitance along with transfer trip scheme, and upgrade Ashland Substation transformer to 60 MVA.	50 MW	N/A
2	Build 12.5 mile 34.5 kV 795 ACSR line to Beebe River Substation & install 8.1 MVAr of capacitance.	38 MW	Loss of Groton Wind generation during minimum load conditions causes unacceptable voltage flicker on 34.5 kV distribution
3	Build two separate 12.5 mile 34.5 kV 477 ACSR lines to Ashland Substation and install 2-2.4 MVAr capacitor banks.	40 MW	Loss of heaviest loaded 34.5 kV line out of Ashland Substation during minimum load conditions overloads Ashland Substation transformer
4	Build two separate 12.5 mile 34.5 kV 477 ACSR lines to Beebe River Substation and install 2-2.4 MVAr capacitor banks.	41 MW	Loss of heaviest loaded 34.5 kV line out of Beebe River Substation during minimum load conditions overloads Beebe River Substation transformer
5	Build two separate 12.5 mile 34.5 kV 477 ACSR lines (one to Ashland Substation & one to Beebe River Substation) and install 2-3.6 MVAr capacitor banks.	50 MW	N/A

This study was based upon initial data provided by the developer. The results stated above have not been engineered nor designed; therefore, this Feasibility Study shall be used for project feasibility and guidance. A more detailed interconnection study is required by PSNH to identify specific interconnection requirements based upon detailed project data provided by the developer.

Finally, this report is a 34.5 kV feasibility study only. PSNH did not study any transmission issues, as that was not part of the feasibility analysis for a distribution interconnection. A separate transmission study is required to determine the impact of the wind generation on the transmission system. The Groton Wind generation will be exporting to the transmission system at both light and peak loads, and as a result, the developer will need to contact ISO for an impact study on the transmission system.