From: Hantz Presume
Sent: Monday, June 5, 2017 4:35 PM
To: Doug Smith
Cc: Josh Castonguay; Cole, Chris; Kerrick Johnson; Ancel, Charlotte
Subject: RE: GMP follow-up questions on Potential SHEI Interface Solutions

Good afternoon, Doug.

Please see our responses below in blue.
I hope you find them helpful.

Thank you.

Hantz.

From: Doug Smith
Sent: Friday, May 26, 2017 5:59 PM
To: Hantz Presume
Cc: Josh Castonguay; Cole, Chris; Kerrick Johnson; Ancel, Charlotte
Subject: GMP follow-up questions on Potential SHEI Interface Solutions

Hello Hantz,

GMP appreciates the helpful letter that you sent to Josh Castonguay on May 18th, regarding potential T&D solutions to SHEI export constraints. This type of specific context is needed to support the benefit/cost evaluation of potential solutions, and will help us make progress on that evaluation.

In the meantime, my GMP teammates and I have developed a few follow-up questions related to evaluating potential solutions. The questions below focus mostly on understanding some key points in your letter, and exploring a couple of potential implications that are not directly spelled out in the letter, but could have significant effects on the benefits of the potential solutions. We've grouped them by major themes.

I trust that these questions are helpful, and hope that they are reasonably clear in spite of the fact that I am not a transmission planner! After you have a chance to review them, please let us know if you have any questions. We would also be glad to discuss them with you next week, if that would be helpful.

Thanks again, and wishing you a good weekend,

Douglas C. Smith
Director, Power Supply
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GMP Follow-up Questions Related to Potential Solutions to SHEI Export Constraint

Impacts of Potential Solutions Implemented Together

The May 18th letter contains a table showing ranges of estimated wind generation increases that would be associated with the implementation of each of three potential solutions, and the narrative below notes that the export limit improvements from two or more of the potential solutions would not necessarily be cumulative/additive to each other. It appears to GMP that more than one solution could potentially be warranted in order to cost-effectively address the congestion in this area. In order to support GMP's anticipated benefit/cost screening of combinations of solutions, could VELCO please provide an estimate of the total wind generation increases that would be associated with two combinations of solutions:

*** Upgrading the B20 line is akin to utilizing a lever, which increases the benefit of other system changes to the point where thermal concerns can emerge on the transmission system. These thermal concerns undercut the total voltage benefit that would have been accomplished by the combination of system changes. As I have noted before, improving the voltage performance helps the system during system outages and in other ways that I cannot quantify. For example, thermal limits allow more flexibility in real-time operations. System outages that currently have a minor impact on the limit may become totally irrelevant, which would simplify system operations.

- Voltage regulation at Sheffield, combined with reconductoring of the B-20 line;

  Between 0 and 20 MW.

- Trip of Sheffield, combined with reconductoring of the B-20 line.

  Between 0 and 20 MW.

Baseline Conditions

Relative to what baseline configuration of the transmission system are the estimates of wind generation increase being compared?

- For example, GMP is aware that significant work was recently performed on the Essex Statcom facility. To what extent will the improvements at the Essex Statcom affect the SHEI interface limit, relative to the prior (pre-outage) configuration?

The analysis was conducted before the Essex STATCOM refurbishment. We estimate that the STATCOM refurbishment will increase wind generation by no more than 5 MW.

- If the Essex Statcom improvements will have the effect of increasing or decreasing the SHEI limit and the allowed wind generation in the area, then should GMP consider that change to be additive to the estimated effects of the solutions presented in your letter?

We estimate that the effect of the STATCOM refurbishment will be additive to the other effects, but if multiple changes are implemented as described above, thermal concerns will limit this additional benefit, resulting in a generation increase between 0 and 20 MW. As noted above, while the benefits are not entirely additive, the system will be more robust and more flexible.

How Wind Generation Affects Reported Flow Over The SHEI Interface

Based on GMP's review of 2016 interface flow data as reported by ISO-NE, it appears that in the determination of actual hourly "flow" over the interface, generation from the KCW and Sheffield wind plants has been counted roughly twice (or, equivalently, that generation from these sources was added to the observed physical flows over the interface).

- Is that a valid observation? If not, we'd like to discuss that with you to help us understand what we're seeing in the data.

This is a reasonable interpretation of the data.

- Assuming yes, could you please refresh us: what is the concept behind that? For example, is it that additional generation at the KCW and Sheffield locations tends to be approximately twice as "aggravating" to the grid's post-contingency voltage performance, relative to generation at some of the other locations (e.g., Highgate)?

I think ISO-NE would be the best source for this explanation. My understanding is that ISO-NE has structured the interface in a way that predicts system impacts very well. Due to the complexities of the system, the interface structure goes beyond simple mathematics. The complexities are associated with the location of resources relative to the location of the system concern, whether the resources provide support to the grid or whether the resources lean on the grid, the expected behavior of the resources during system disturbances, and so on. Again, your interpretation of system effects is reasonable.

Looking forward, should we expect that this factor/multiplier for the wind generation will change, if any of the three potential solutions (B-20 reconductor, Sheffield trip, Sheffield voltage regulation) discussed in the VELCO letter were implemented? If yes, what would the direction and approximate magnitude of those changes be?

- For context, this factor as it is presently applied to wind generation appears to be a very important driver of the observed duration and depth of congestion of the SHEI interface. It would therefore be helpful to hear the high-level reasoning on why it would be expected to change (or not).

My estimates of benefits assumed that ISO-NE would retain the same interface structure, but your questions raise a possibility that the interface structure itself would change, and this has a relatively good chance of happening under all-lines-in conditions if the binding constraint is based on thermal concerns instead of voltage or stability concerns. I say so because any MW should have relatively the same thermal impact regardless of its location and the amount of grid support it can provide. If the interface structure does change, I believe it would be an improvement, as it would remove or reduce some of the dependencies on system conditions and dispatch. ISO-NE should be able to confirm this assumption.

- If the wind factor can be expected to change, then do the range estimates for wind generation increases presented in your May 18th letter already incorporate such a change, or would it be additive to the estimated effects of the solutions presented in your letter?

No, my estimates of benefits assumed that ISO-NE would retain the same interface structure. Nonetheless, I would assume that ISO-NE would reevaluate wind generation effects following the proposed system changes, and it is possible that these effects would change, particularly if several

changes are implemented. If the "wind factor" does change, my assumption is that it will be a positive outcome for wind generation.

B-20 Flows

If the B-20 line is reconductored, and if observed flows out of the SHEI area via the B-20 line increase as a result, how (if at all) will the amount of allowed wind generation within the SHEI area be affected? For example, can reconductoring the B-20 line be expected to increase the interface limit? Reduce the observed flows over the interface? Or both? If both effects are expected, then we are wondering if the estimated wind generation increases that you've shared capture both effects.

Reconductoring the B20 line has a minimal effect on the flows over the observed interface, but the upgrade does have a positive effect on system performance, which is seen as an increase in the interface limit and the resulting increase in wind generation noted in the May 18th letter to GMP.

Impact of Potential Solutions During Alternative Conditions

Your letter notes that the estimates of additional wind generation that could be enabled by the three potential solutions were estimated under all-lines-in conditions, and that the benefits of the tested solutions could be reduced or eliminated under certain outage conditions and other operating conditions. This appears to be an important observation, because substantial portions of the lost generation and lost financial value that GMP has experienced during the past year as a result of the SHEI export limits have occurred during times when the SHEI interface limit was lower than normal (we expect this was often due to outages of certain transmission system elements). We expect that there are numerous potential outage conditions and operating conditions that may occur, and that it would likely be impractical to test them all. Still, it would be very helpful if VELCO could provide an indication (even directional, rough magnitudes) of whether the potential solutions are likely to increase the potential volumes of wind generation during the types of outage conditions that are most likely to be experienced, because this could be a significant factor in the benefit/cost evaluation of potential solutions.

You are correct in that we could not test all of the possible system outages that could affect the interface negatively. The solution contemplated will allow more wind generation to run under certain but not all outages. As an example, if the B20 line is out of service or an element in series with the B20 line is out service, the B20 benefit will be entirely removed. Certain transmission outages near or inside the SHEI area can have a significant negative impact on the interface. The proposed solutions will reduce these impacts, but the combination of the B20 reconductoring and the Sheffield voltage regulation is very promising in terms of mitigating the negative impacts of system outages.

The previous year was an unusual year because of the amount of hydro energy, both local and HQ through Highgate, and the outage associated with the Essex STATCOM refurbishment, which should not occur again until 25 years from now. Many of the other transmission outages that occurred this spring were necessary to conduct equipment repairs, and this will continue to occur with the same regularity, although better outage coordination can minimize negative effects and VELCO may be able to perform some of the line work energized when warranted. And of course, unplanned outages are always possible, but for the sake of this evaluation, I would recommend we not take into account days of unplanned outages.

As I am thinking through these issues, it may be sufficient to change the interface limit from a voltage limit to a thermal limit, as opposed to trying to accommodate all generation resources under most system conditions.

1. There is some amount of generation diversity in the SHEI area. The gas units only run a few hours a year. The total amount of distributed solar PV is not large enough to be a factor at this time or in the near future. Utility scale solar PV may be a concern depending on their location, the amount of grid support they can provide, and the types of system upgrades associated with their interconnection.
2. Curtailments are severe only during the spring period when hydro generation is the highest. Although system outages are usually scheduled during the spring season to minimize impacts on system load, there may be ways to better coordinate transmission and generation outages to minimize impacts on generation as well.
3. Thermal export limits allow operating approaches that would not be acceptable under voltage or stability limits. Further, thermal ratings are higher during six months starting in October, which would increase the thermal export limit.

   The proposed changes move the export limit towards a thermal limit.
   - The B20 line upgrade – while this is a thermal upgrade, its effect is to improve voltage performance significantly.
   - Sheffield voltage regulation – this reduces the negative impact of the Sheffield plant, and is a very good solution when paired with the B20 upgrade

   Increased capability of existing equipment also help.
   - The Jay synchronous condenser – consider an ISO-NE audit that will bring some certainty to the unit's intrinsic additional capacity. Perhaps VELCO can coordinate with GMP to develop a test protocol that may include switching off 115 kV cap banks to force the Jay SC to inject a large amount of reactive power into the system for an hour at a time when voltages tend to be lower.
   - Essex STATCOM refurbishment – the rating is the same, but the STATCOM controls should provide a little bit of additional support that would increase the system operator's comfort

   There are also other options that might be considered.
   - Add voltage control at the two largest Sheldon Springs hydro generators; or add a 15 MVAr synchronous condenser at Highgate or Sheffield; or add a utility scale battery system with voltage regulation on the order of 15 MVA at Highgate, Jay or Sheffield.