SHEI: CONTEXT & SOLUTION EVALUATION

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January 24, 2018

Discussion Themes

When is SHEI typically congested, and what does that mean?

Implications for GMP customers

Initial thinking on evaluation of solutions

When is SHEI Congested?

SHEI is an export-constrained area

Congestion happens when generation in SHEI area is high

- Wind (Kingdom Community Wind, Sheffield) and hydro
- Deliveries over Highgate Converter
- This typically means winter & spring months

Also, any time of year - if particular transmission system maintenance/outages occur

During most hours of the year, SHEI is not congested

- Typically ~20% of the time on average, but big fluctuations (monthly, Day Ahead vs. Real Time markets)
- Can vary greatly by day/hour, and even within hours

But typically, congestion occurs when a lot of power can be produced >> significant generation value at stake

- This is overwhelmingly value for Vermont customers

What Happens When SHEI is Congested?

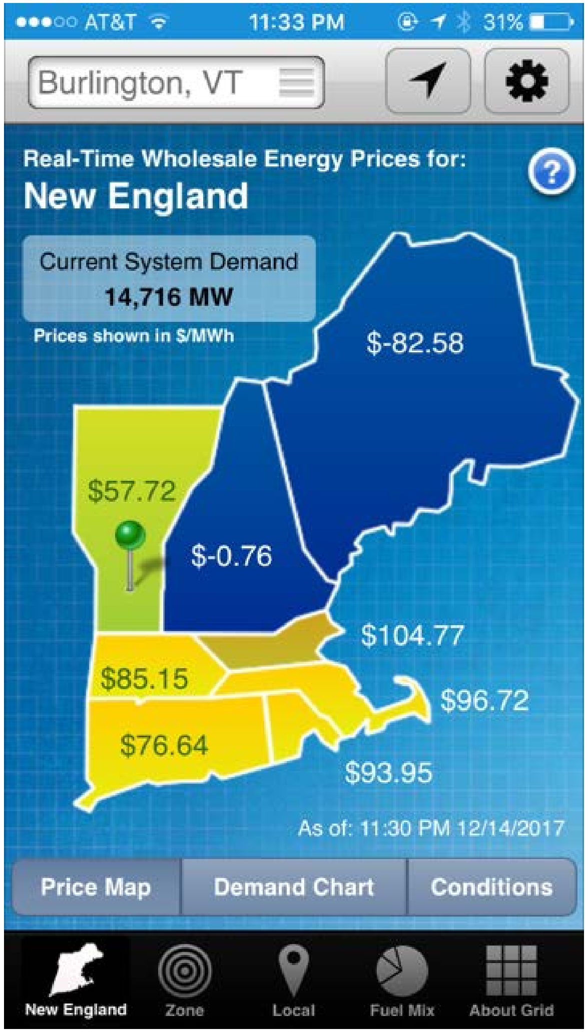
When SHEI is constrained, total potential generation within SHEI area exceeds the interface limit

- ISO-NE monitors interface flows
- If interface would be exceeded, some source(s) need to limit their output

Framework governing dispatch of larger generators is known as “DNE” (Do Not Exceed)

- Intermittent generators (like Sheffield, KCW, Sheldon Springs) are included (started late May, 2016) >> they submit price offers for energy output
- Transmission constraints are now resolved based on offer prices of resources (and other factors)
- Market prices (LMP) can diverge much more strongly across interfaces
  - A significant change for the regional market (not only VT/SHEI)

Congestion in ISO-NE: One Extreme Example



When a transmission interface becomes congested, LMPs across the interface diverge
In this case, the constraint was from northern NE to southern NE
When SHEI becomes congested, LMPs in the area typically fall below rest of ISO-NE

Increased Net Costs for GMP Customers

When SHEI is congested, three primary mechanisms:

- Reduced generation output (e.g., at KCW)
  - Lose value of energy, Renewable Energy Certificates, Production Tax Credit
  - Almost all power generated/delivered in SHEI is renewable
- Lower LMP payments to generation in SHEI
  - Affects all sources in the area, not just the one(s) being reduced
- Offsetting: lower cost to purchase load requirements

Estimated net impact for GMP: several $million of net cost increase, over 18 months

- Key reason why: in the SHEI area, much more generation than load
- True for VT in total, although there are exceptions

Enough to justify meaningful effort on finding solutions

- To cost-effectively increase interface capacity >> reduce frequency & magnitude of interface congestion
- And to exercise caution re: addition of new generation in the area

Evaluation of Potential Solutions

A complex evaluation

- Electrical engineering; wholesale power markets
- Range of operating conditions
- Two forms of limits (thermal and voltage) that could constrain SHEI
- Some potential solutions would bring unique benefits/revenues

VELCO/EIG study (Q4 2017) was a big step

- How much would potential solutions increase SHEI limits?
- Under different system conditions?

Other important ingredients are needed

- Capital cost of the potential solutions
- Breadth/depth of lost generation and congestion to date
  - Scale of solutions needed?
- How representative was the recent history?
  - Particularly re: transmission outages that reduced SHEI limits

Solution Evaluation – Cases Studied

Table 2: Studied Case Combinations Matrix

			Cases																						
Option	Upgrade elements	Abbrev	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Reconductor B20 Lowell-Johnson 34.5 kV line and upgrade the Lowell 46/34.5 kV transformer	B20		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X
2	Enable the Sheffield AVR	Shef			X			X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	
3	Recognize Jay synch condenser 1.15 service factor	JaySC				X		X		X	X	X	X	X	X	X	X	X	X	X	X				
4	Enable the Sheldon Springs AVR	ShSpr					X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
5	Install a 15 MVAr synchronous condenser at Highgate 115 kV	HSC										X								X					
6	Reconductor K42 Highgate-St Albans 115 kV line	K42-2											X								X				
7	Install a 2nd K39 Sheffield-Lyndonville 115 kV line	K39P												X											
8	20 MVA (16 MW / 12 MVAR) Battery Storage at Highgate 115 kV	HBESS													X										
9	Reconductor K41 Highgate-Jay 115 kV line	K41														X									
10	Install a new Irasburg to Stowe 115 kV line	IraStowe															X								
11	Install a new Irasburg to East Fairfax 115 kV line	IraEF																X							
12	Close the normally open Lowell C53 switch	LowC53																							X
13	Close the normally open Ritchford 14W switch and reconductor from Richford to Highgate 46 kV	Ritchf14W																							
14	20 MVA (16 MW / 12 MVAR) Battery Storage at Sheffield 115 kV	SheffBESS																							
15	Install a 2nd 115 kV line alongside the K42 line	ParallelK42																							
16	Upgrade 1.7 miles of B22 line for 39 MVA LTE rating	B22																							
17	Open B20 line at Johnson	OpenB20																							

			Cases																						
Option	Upgrade elements	Abbrev	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1	Reconductor B20 Lowell-Johnson 34.5 kV line and upgrade the Lowell 46/34.5 kV transformer	B20	X	X			X	X				X				X		X	X				X		X
2	Enable the Sheffield AVR	Shef	X	X			X		X							X		X	X	X		X			
3	Recognize Jay synch condenser 1.15 service factor	JaySC					X									X			X						
4	Enable the Sheldon Springs AVR	ShSpr	X	X			X			X						X		X	X	X		X			
5	Install a 15 MVAr synchronous condenser at Highgate 115 kV	HSC									X	X					X							X	
6	Reconductor K42 Highgate-St Albans 115 kV line	K42-2						X	X	X	X	X	X	X	X				X			X			
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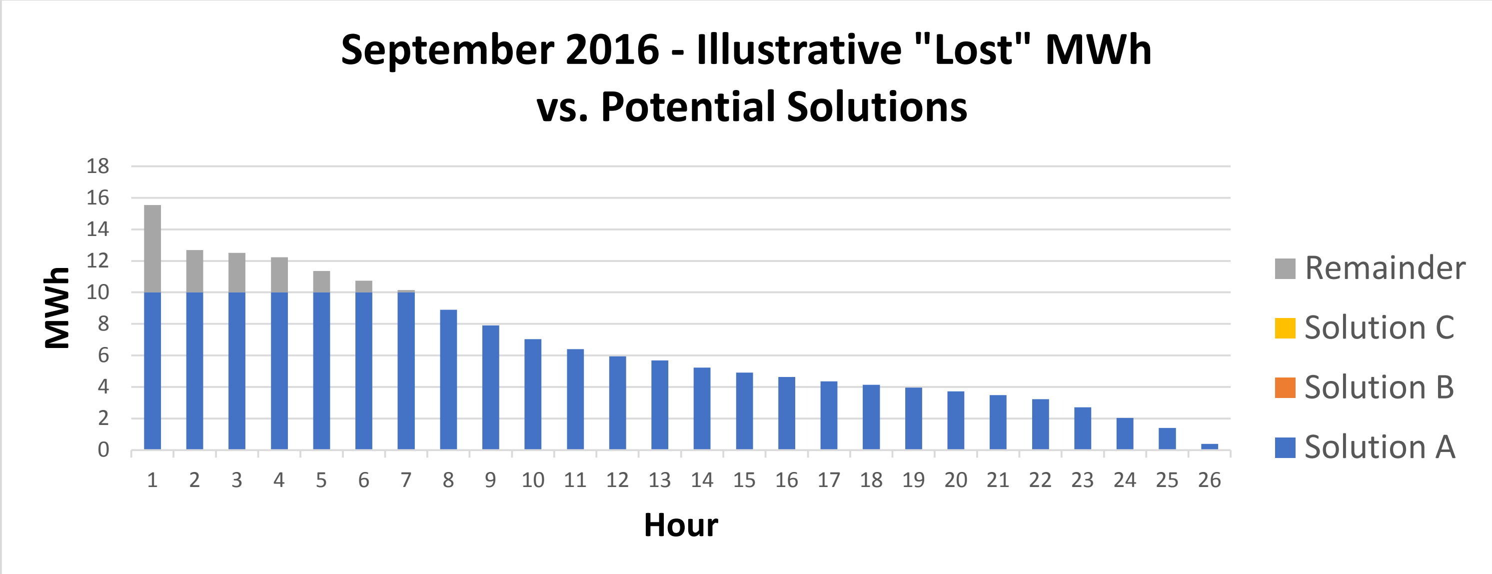
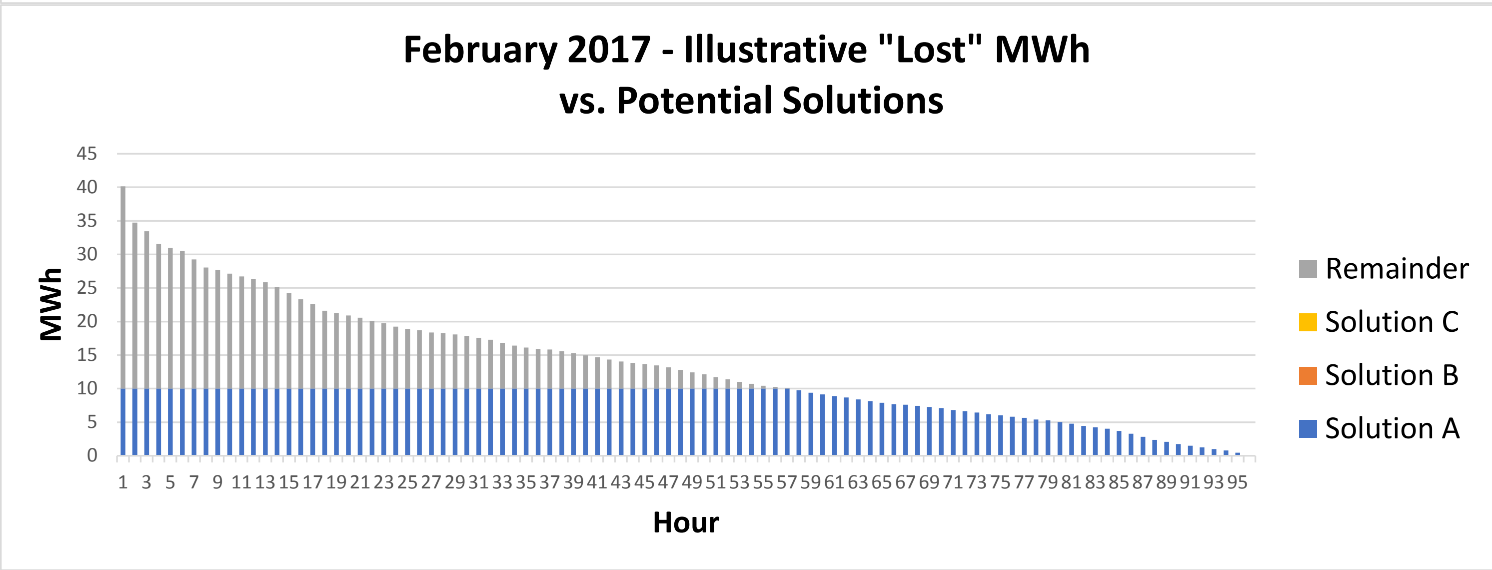
17	Open B20 line at Johnson	OpenB20																		X		X			

Not practical to study all potential combinations of solutions, but it is helpful that VELCO/EIG studied a fairly wide menu.

Solution Evaluation: How Deep?





Amount & type of solutions needed to de-congest SHEI will depend in part on how often the interface may be congested, and how deeply. These examples show illustrative data only.

Components of Benefit/Cost Screening

Significant range of potential solutions

- Type, scale, complexity, permitting/time required

Estimation of capital costs

- For some, also operating revenues/expenses

Effectiveness of solutions in different system conditions

- How much would potential solutions increase SHEI limits?
- Under different system conditions?

Ideally, an initial screening step

- Solution feasibility, scale, benefit/cost, timing
- Narrow the focus to a subset of options, to evaluate more deeply

Potential Solutions – Initial Themes

Can a mix of small/mid-size options cost-effectively address today's SHEI congestion?

Are there any solutions that should be deployed ASAP?

- Initial GMP view: AVR at Sheldon Springs Hydro could be one
- Low cost/strong payback; relatively quick to deploy; a partial option

Are there additional solutions that should be explored in parallel?

- Ex: Modify line ratings? Reduce deliveries over Highgate? Encourage additional load in the SHEI area?

Process for broad solution evaluation = TBD

- Technical/financial analysis suitable to small groups – particularly needing data from VELCO and VDUs
- But need to involve other parties/stakeholders
- Working group, with periodic briefings to VSPC and PUC?

Future Generation in SHEI Area

Key first step: evaluation options to cost-effectively de-congest the current system?

- Current generation sources and loads

If additional generation is then added in SHEI, gains could be eroded

An ongoing dialogue will likely be needed re: proposed future generation in the area

- Likely impacts (MWh, $$) on existing sources in the area (which are almost all renewables)
- Benefits of the proposed generation to Vermont customers
- Options to mitigate future congestion, and who should pay