SmartValve Project

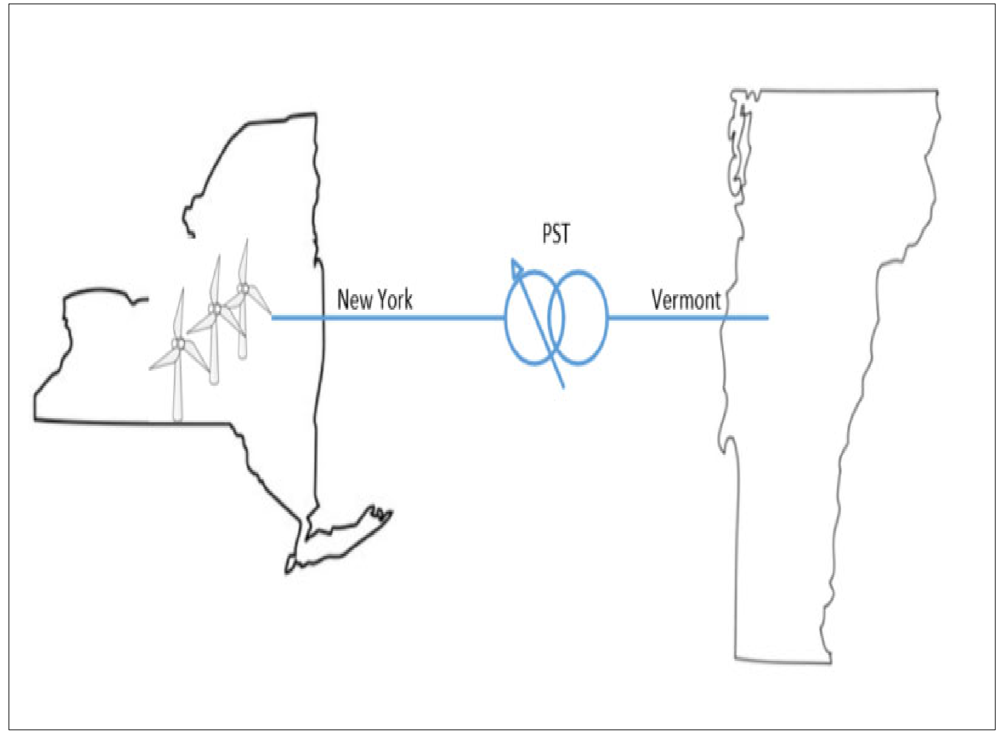
vermont electric power company

Planning Advisory Committee

GETs Day

June 18, 2025

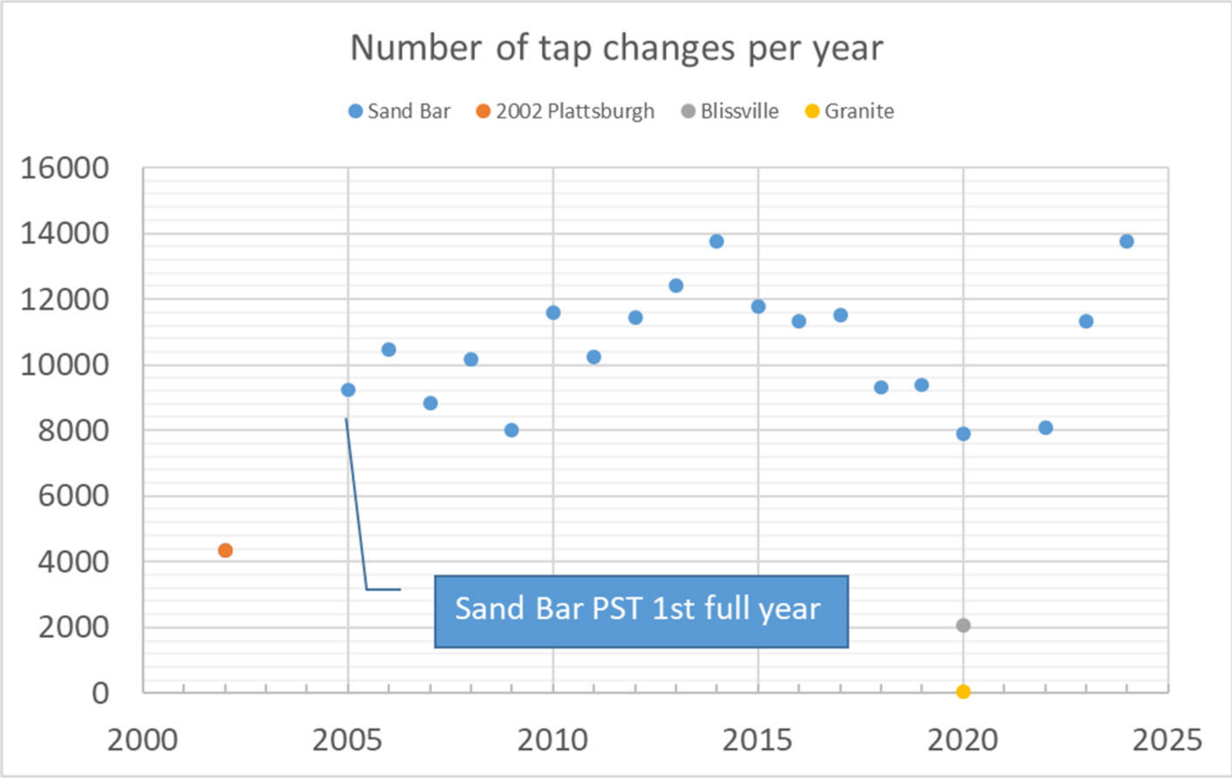
SmartValve project location one-line



- NYISO – ISO-NE tie : tight power flow control operating parameters, not free flowing
- Growing NY Wind influencing increased variability, require constant control/regulation

A history of PV20 phase shifter failures

- Plattsburgh PAR failures after repairs
  - 2002, 2003, and 2007
- Sand Bar PST failure in 2021
  - Likely caused by excessive tap changes
  - Costly repair and transportation
  - Expect similar or increased tap changes in future



Comparison of Alternatives

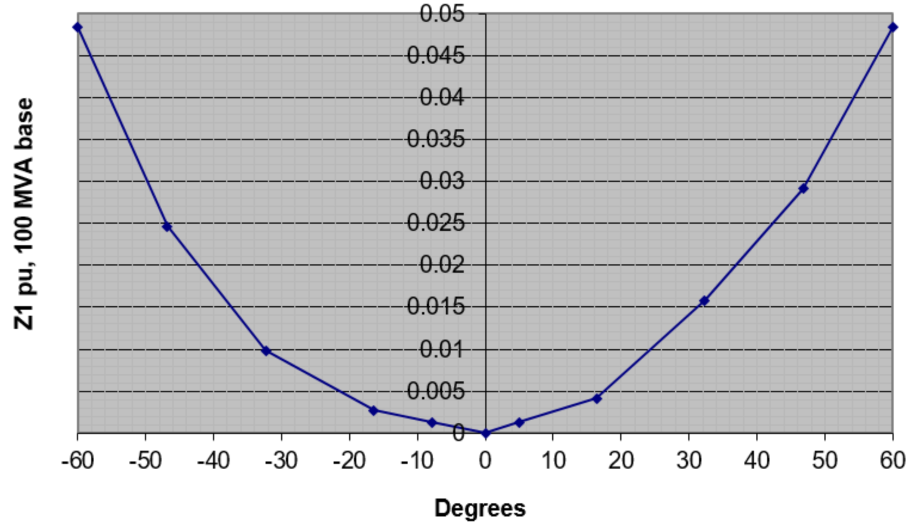
	Alternative #1: Series PST	Alternative #2A: Full PST replacement SmartValve	Alternative #2B: PST augmentation SmartValve (Preferred)
PST life extension	Yes, but not nearly as much as the smart valve options	Yes	Yes
Recovery following PST failure	Restore current imprecise control	Retains fast, precise and full control (+/-64 deg)	Retains fast, precise and half control (+/-32 deg)
Longevity	Portable, but difficult Cannot be used at 230 kV	Easily portable Usable at 230 kV	Easily portable Usable at 230 kV
Delivery timing	4 to 5 years	1 to 2 years	1 to 2 years
Estimated In Service date	Q1 2029	Q4 2026	Q4 2026
Cost estimate with	$56.2M PTF	$66.3M PTF	$47.7M* PTF
Grid-enhancing Technology	No	Yes	Yes
Expected DOE funding support	No	No	Yes – *$13.8M which drops cost to $33.9M

Impedance of the three flow control devices

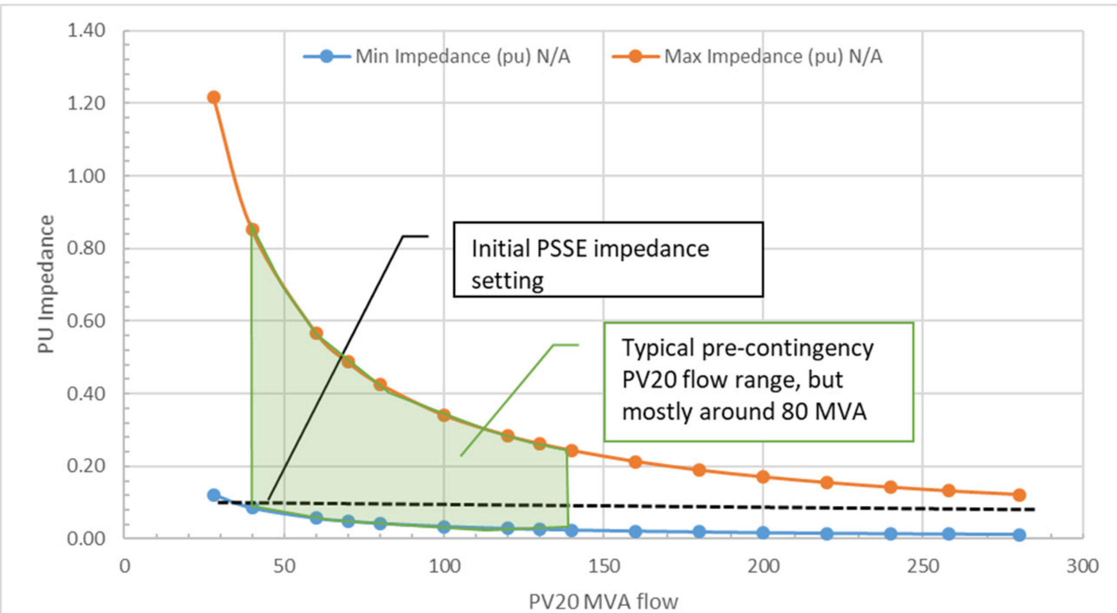
Series reactor (OMS)

- Bypassed = 0.0001 pu
- Inserted = 0.227 pu

Phase shifter (PST)



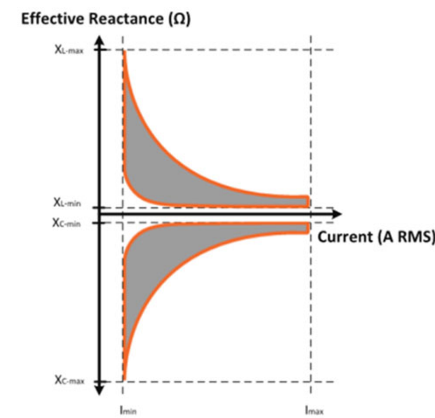
Smart Valve (SV)



$$X_{effective} = \frac{V_{injected}^{max}}{I_{line}}$$

Vmax Inj=+/-56.6V RMS
Vmin Inj=+/-5660V RMS

Per module per phase



Proposed Control Coordination Settings

	Phase Shifter (PST)	SmartValve
Typical target flow (MW)	80	
Flow bandwidth (MW)	+/-25	+/-5
Initial change timer (sec)	420	300
Tap-tap delay (sec)	10	N/A
Ramp rate (pu/sec)	N/A	0.005 - 0.01 pu/sec
Flow change to disable control (MW)	40	
Time delay to disable control (sec)	10	

Application Design Challenges

- Nameplate limitations
  - Line current is the SV auxiliary power source. Minimum current injection required --> impedance can go to zero
  - Maximum voltage injection --> Impedance can decrease post contingency
- Modeling in PSSE, TARA, EMS
  - ISO-NE Planning and Operation Powerflow software tools currently lack commercially available SV models. Being developed with the project
  - Siemens expected standalone model in PSSE v37 (Steady State)

Project Milestones

- Study Complete
  - Powerflow, Dynamic, EMT
- Report submitted on 5-22-2025
- RC presentation – July 16
- ISO-NE approval letter – August 15
- Expected in-service date: Sep 2027

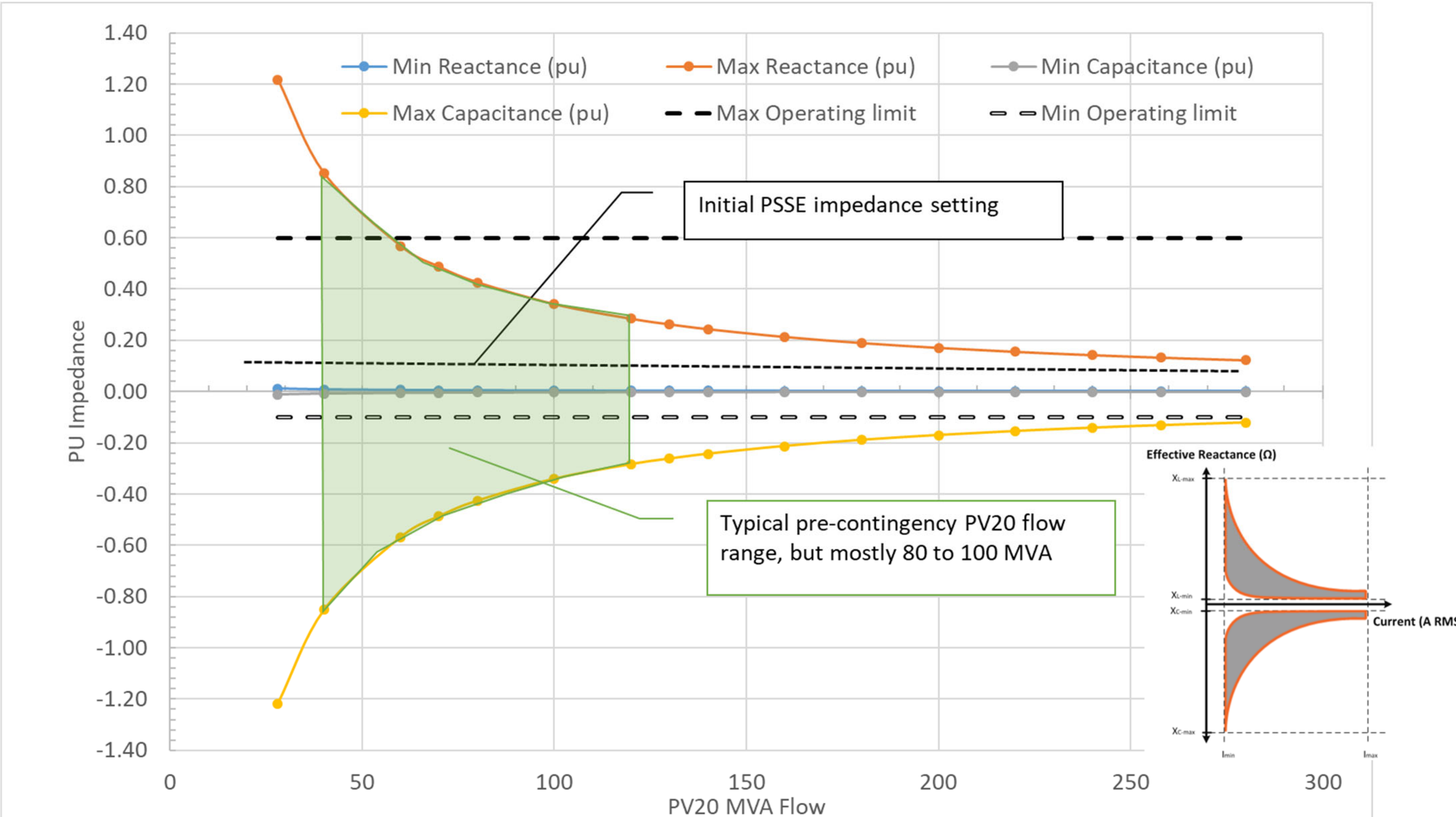
Thank you!

https://www.smartwires.com/
https://www.sgb-smit.com/products/large-power-transformers/phase-shifting-transformers

SmartValve Benefits

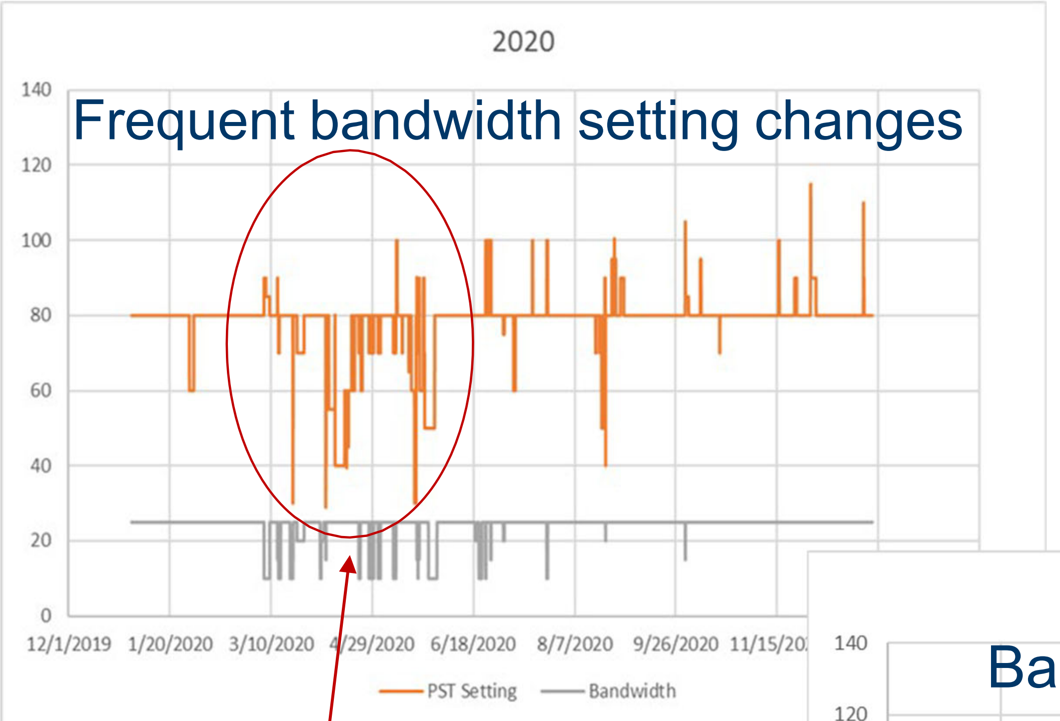
- Reduces number of tap changes by nearly 60%
- Other benefits
  - Partial redundancy, if PST fails keeps PV20 line closed and flow controlled
  - Widens the flow control operating range with PST 60 angle + SV injection
  - More precise control
  - Modular, expandable
  - SmartValve modules can be reapplied at 230 kV

Impedance characteristics of the Sand Bar smart valve

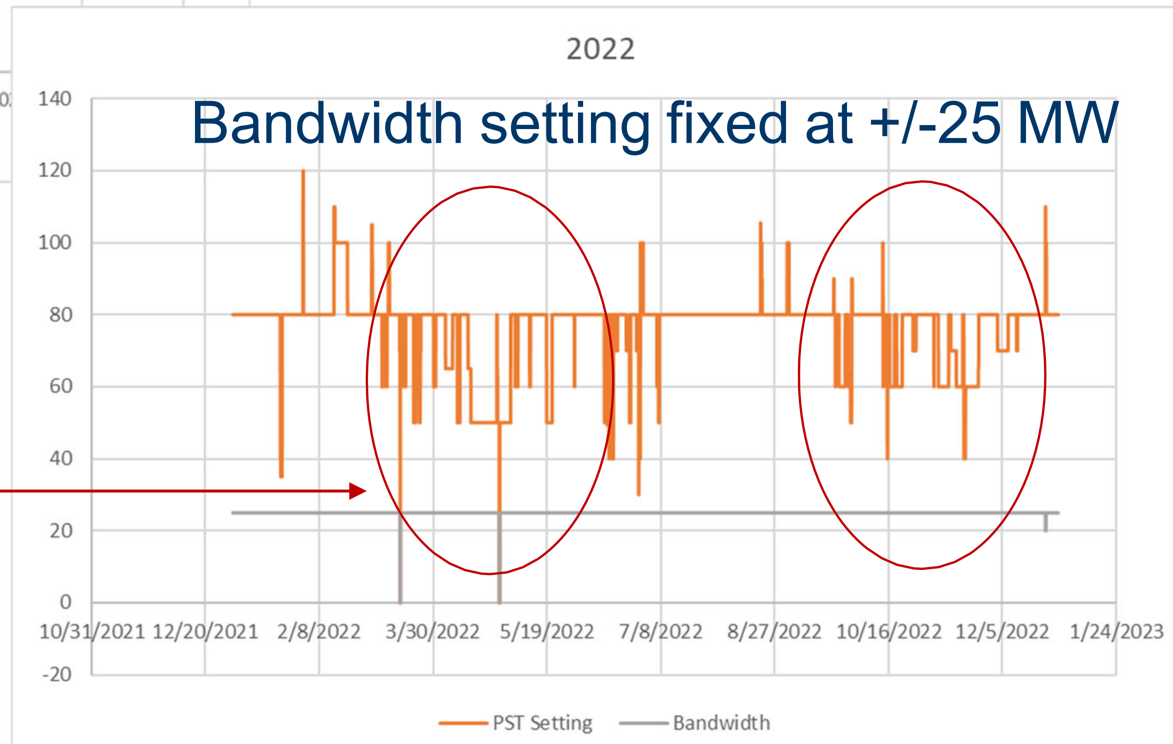


Based on min-max injection voltage +/-56.6 to +/-5660V RMS per module per phase, times 4 modules

Constant bandwidth after restoration



- Flow setting normally 80 MW
- Bandwidth setting
  - Normally +/-25 MW
- Tighter bandwidth when a different flow is needed
  - Frequently +/-10 MW



Variability appears to align with spring and fall low load/high renewables periods

History

- Prior to 2005
  - Needed to protect against large-source contingencies
  - Series reactor installed at Sand Bar OMS
  - Phase-angle regulator (PAR) at Plattsburgh NY
    - Normal rating 180 MVA, +/-20 degrees, 20-deg fixed tap
  - Interphase Power Controller (IPC*) coil placed in parallel with the PAR
    - Increased PAR/IPC rating to 228 MVA
- 2005
  - Sand Bar phase shifting transformer (PST) installed
    - Normal rating 380 MVA, +/-60 degrees
  - IPC removed
- After 2007
  - Plattsburgh PAR removed
  - Need to throttle PV20 line flow in response to NY wind growth
  - Protect against large-source contingencies

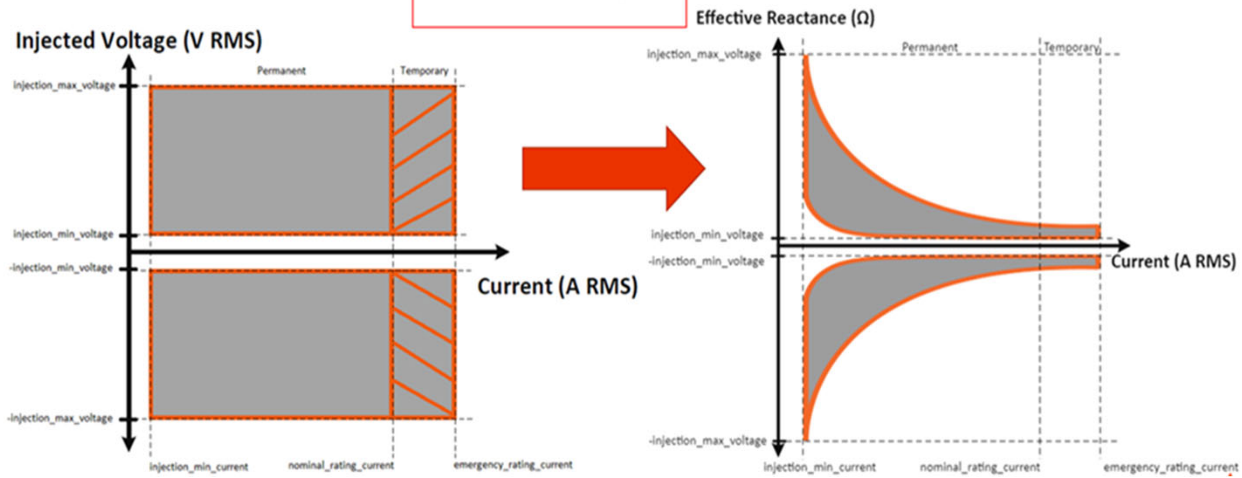
* https://ieeexplore.ieee.org/document/756127

Sand Bar PST failure

- Internal fault on Feb 22, 2021
- PV20 line remained open until restoration
  - Found fault location
    - Effected on-site fix in lieu of shipping to Europe
  - Moved one Granite PST to Sand Bar in May 2021
    - 62 miles on dirt road, highway, and city streets – 12 hours
    - Limited VT roads meant significant transportation impacts (seasonal limitations, permitting, dirt roads)
  - PST placed in service at Sand Bar in July 2021
  - Repaired PST returned to Granite in Nov 2023
- Cost of repair and transportation
  - $3.5M

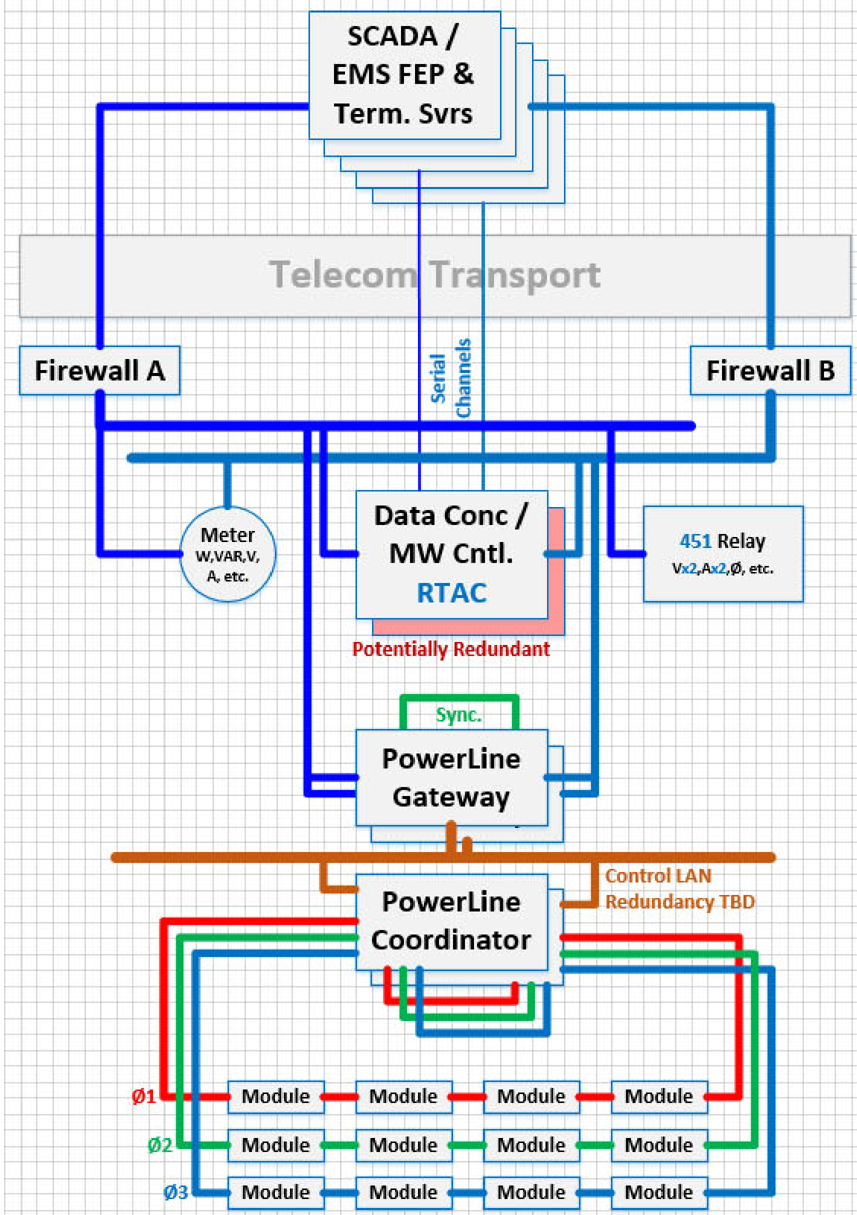
The V-I characteristic can be ‘translated’ into a X-I one

$$X_{effective} = \frac{V_{injected}^{max}}{I_{line}}$$



Maximum Voltage Injection at 50 Hz or 60 Hz (2)	± 5660 V RMS	Injection Mode 2-Hour Current Rating (3,4,5)	2160 A RMS
Minimum Injection Voltage at 50 Hz or 60 Hz (6,7)	± 566 V RMS	Maximum Rate of Change of Frequency (RoCoF) Withstand	2 Hz/s for up to 0.5 s and 1 Hz/s for up to 1 s
Max Ramp Time from 0% to 90% of Maximum Injection Voltage (8)	200 ms	Maximum Corona-Free Voltage	550 kV RMS line-to-line
Minimum Current for Monitoring (3)	50 A RMS	Power Source	Powered by line current
Minimum Current for Injection (3)	100 A RMS	Operational Frequency Range	47.00 Hz to 52.00 Hz 57.00 Hz to 62.00 Hz
Injection Mode Continuous Current Rating (3,4)	1800 A RMS	Fault Current Rating (1)	63 kA RMS for 1 second
Monitoring Mode Continuous Current Rating (3,4)	2250 A RMS	Peak Fault Current Rating	164 kA @ 60Hz 158 kA @ 50 Hz

Communications and Controls one-line



- System Operator sets MW Set-point (and potentially bandwidth)
- System Operator: Start/Stop PFC & Enabled/disable MW control
- EMS Auto-disable MW Control (pause) if 40 MW change in 10 seconds

Telecom has redundant IP transport (CES1 & CES2) used by IT Firewalls for Sub LAN A & B connectivity to EMS – legacy serial channels as backup to IP

- MW Controller polls Meter & Relay for MW.
- Compare against MW Set-point & bandwidth.
- Reactance Set-point change is dependent on:
  - MW Control is enabled (vs disabled/paused)
  - Time Delay (~5 min) after MW outside of band
  - Following Time delay uses ramp-rate (~ 0.01 pu/sec)
- Send Reactance Set-point to Powerline Gateway(s)

MW Controller provides Powerline Gateway data as well as Measured MW & Phase angle, feedback of set-points and status of timer (if out of band)

- Powerline Gateway and downstream controls/ hardware take Reactance set-point in Fixed Reactance Mode
- If there is at least 100 Amps…
- Based upon measured current operates converters to build a voltage perpendicular to the current to achieve Reactance target

Powerline Gateway provides status of converters including overall reactance (which should match Reactance set-point if within capabilities) which includes if in injection mode, monitoring mode & modules offline (including if paused due to fault condition)