# Sand Bar Phase Shifting Transformer Asset Condition

vermont electric power company

VELCO

Planning Advisory Committee

February 28, 2024

# Previous PAC presentations

- Sand Bar substation asset condition project, August 2019

https://smd.iso-ne.com/operations-services/ceii/pac/2019/08/a4_velco_sandbar_asset_conditions_presentation.pptx

# 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

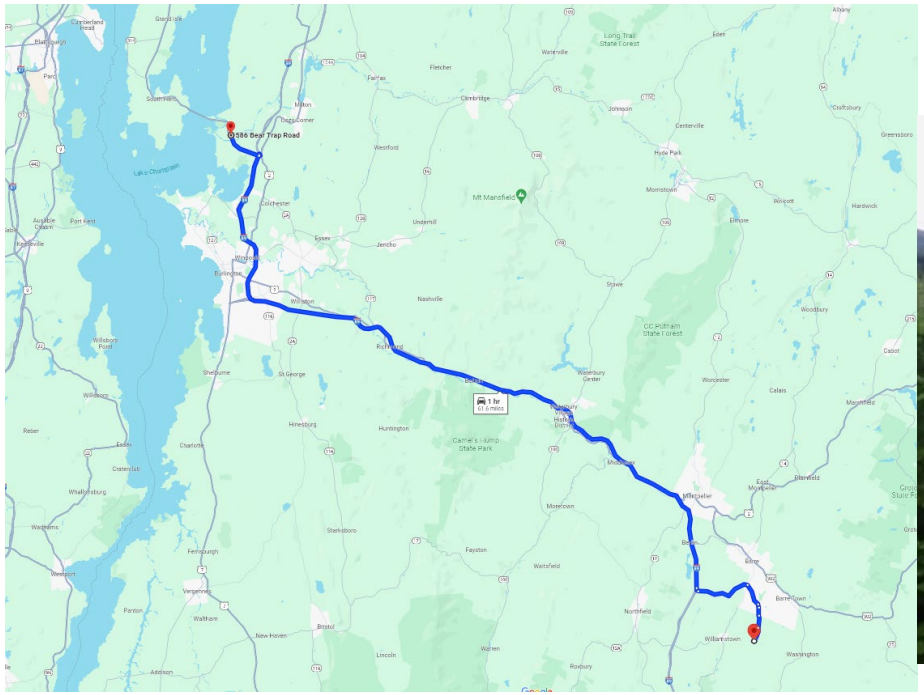
# Sand Bar PST failure

- 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

# Sand Bar PST failure

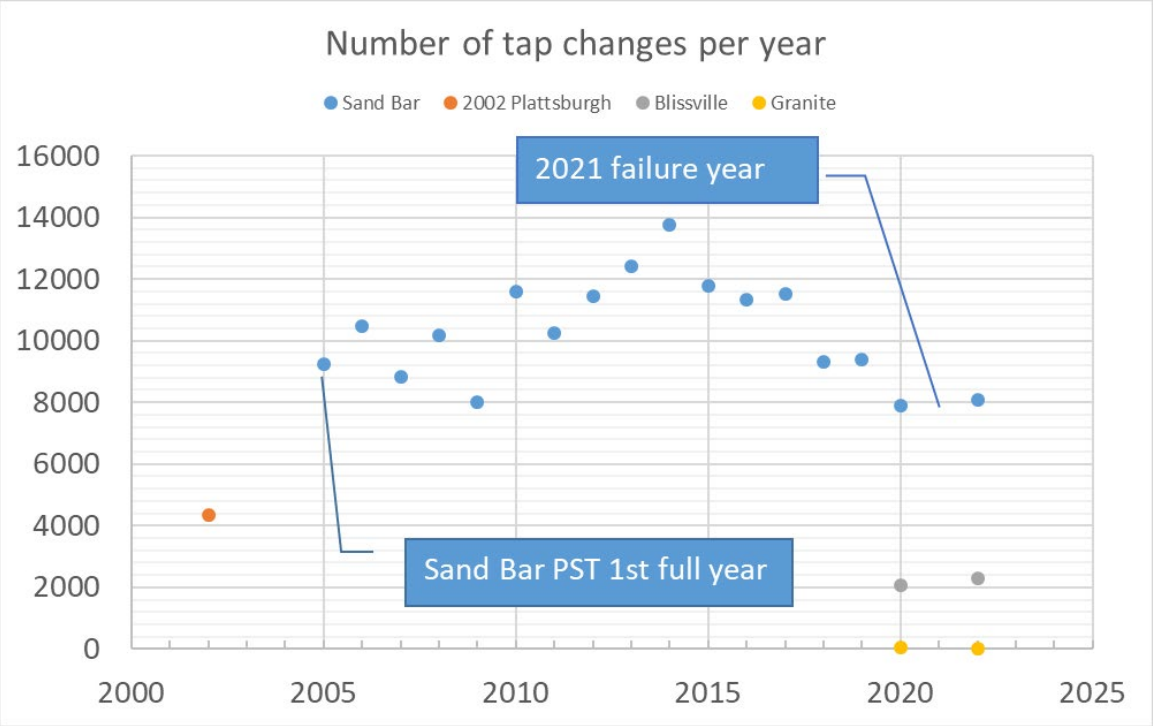
# PST move from Granite to Sand Bar



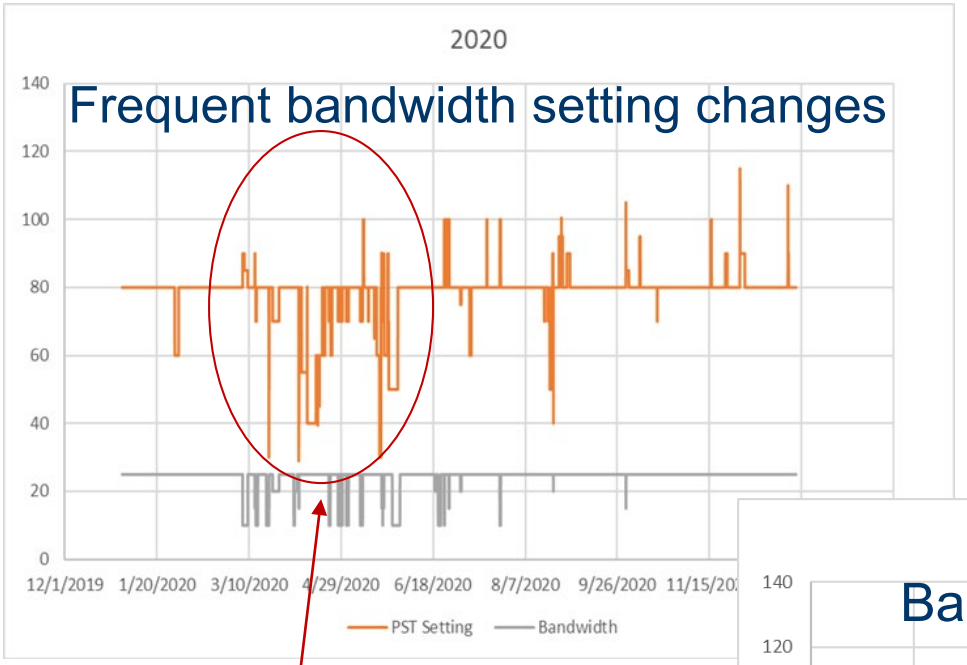



# A history of PV20 phase shifter failures

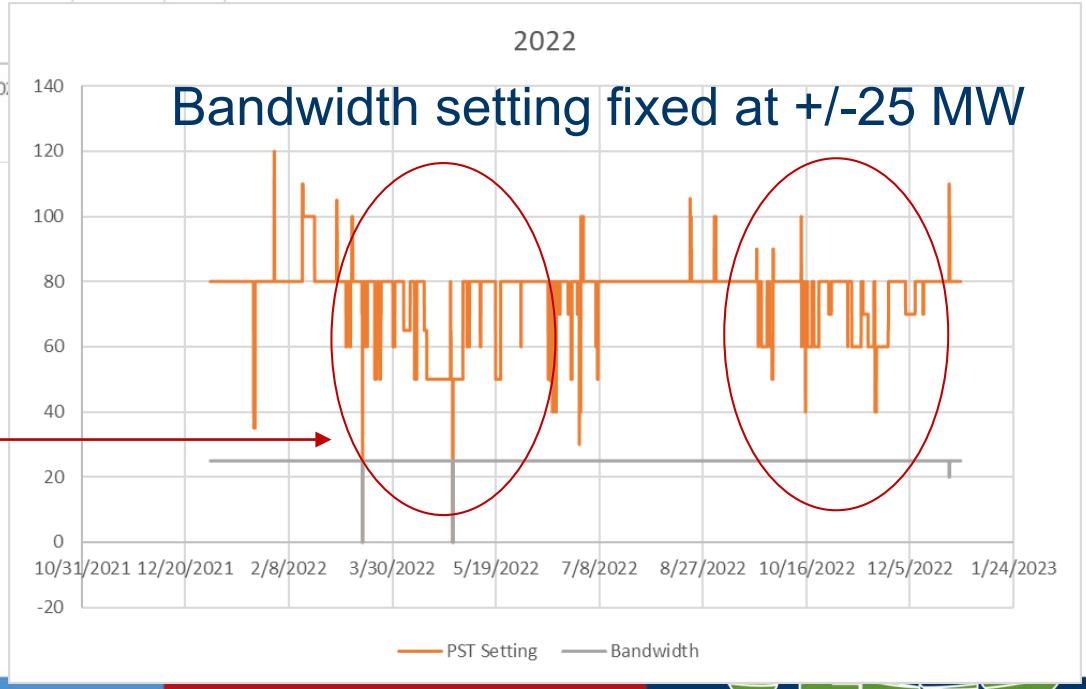
- Plattsburgh PAR failures after repairs
  - 2002, 2003, and 2007
- Sand Bar PST failure in 2021
  - Likely caused by excessive tap changes
  - Expect similar or increased tap changes due to future NY wind gens and recently observed Highgate cycling



# 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

# Need to extend PST asset life

- Excessive tap changes even with recent operating change
  - From frequent bandwidth changes to a constant bandwidth of +/-25 MW
- **Alternative 1 –** install a second PST in series
  - Reduces number of tap changes by a half (4000 or less)
  - Other benefits
    - Full redundancy – keeps PV20 line closed and flow controlled after a PST failure
    - Doubles the control range with both PSTs in service

# Need to extend PST asset life

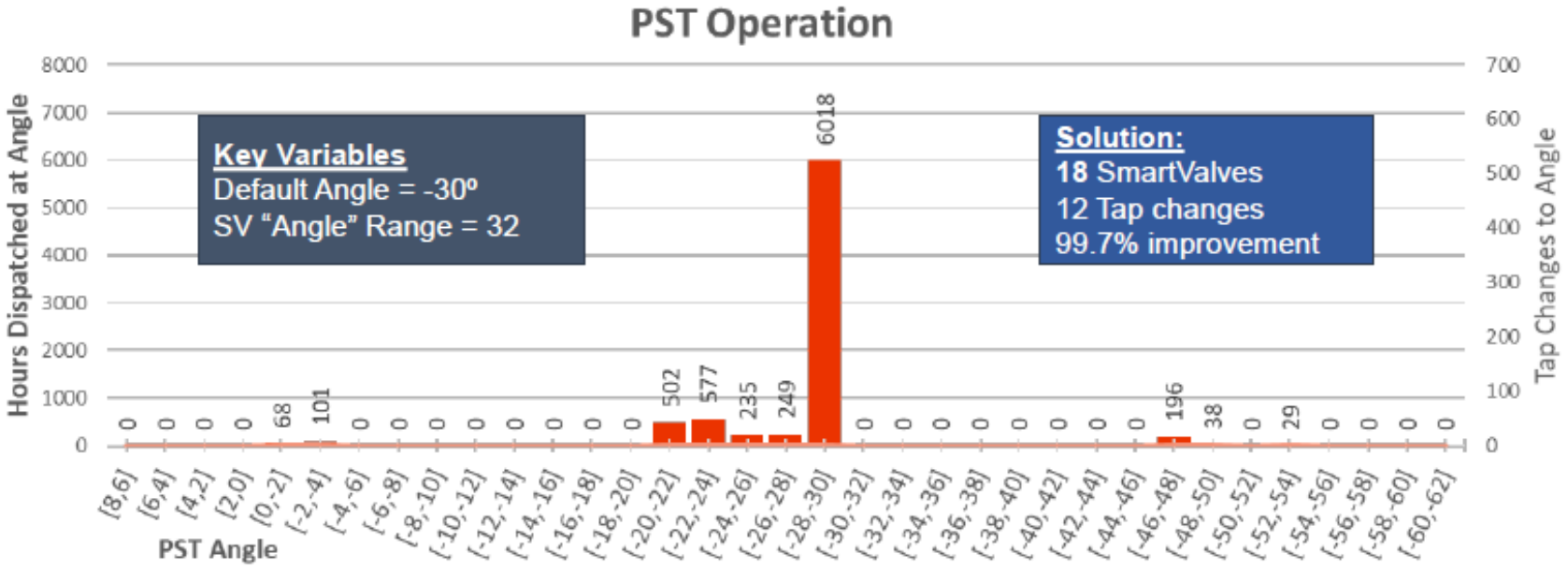
- Alternative 2A: Install full replacement SMARTVALVE™ in series
  - High-level description
    - 12 valves per phase, VSC technology
    - Footprint 179’ x 65’
  - Reduces number of tap changes to nearly 0
  - Other benefits
    - Full redundancy – keeps PV20 line closed and flow controlled after a PST failure
    - Doubles the control range with the PST in service
    - More precise control → More renewable generation delivery
    - Technology diversity – modular, expandable, faster failure recovery
    - SMARTVALVE™ modules can be reapplied at 230 kV
    - Two-year materials delivery time

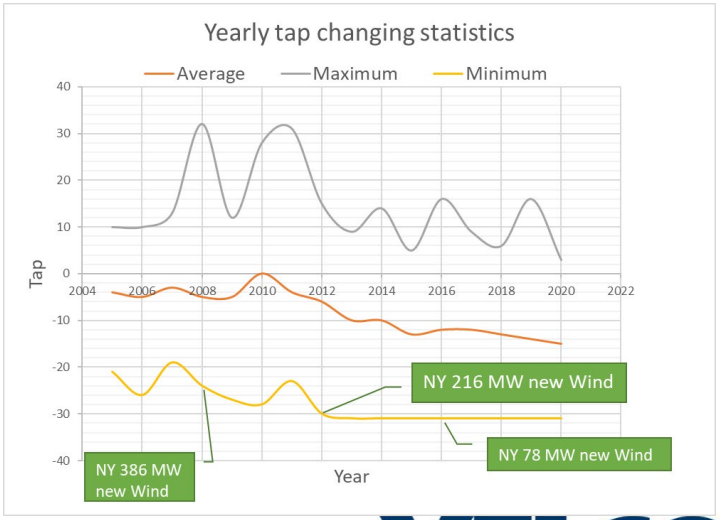

-SV02-1R
-SV02-2R

# Need to extend PST asset life

- Alternative 2B Install a half replacement SMARTVALVE™ in series (preferred)
  - High-level description
    - 6 valves per phase, VSC technology
    - Footprint 82’ x 65’
  - Reduces number of tap changes to nearly 0
  - Other benefits
    - 50% redundancy – keeps line closed and flow controlled after a PST failure
    - Increases the control range by 50% with the PST in service
    - More precise control → More renewable generation delivery
    - Technology diversity – modular, expandable, faster failure recovery
    - SMARTVALVE™ modules can be reapplied at 230 kV
    - Two-year materials delivery time

# PST tap changes reduced with Alt 2B




- The PST stays at -30 degrees (at -15 tap step)
- The smart valve moves +/-32 degrees on either side of the PST setting
- The PST is adjusted only when the smart valve is at max or min angle

# More variability expected

| Project Name | Date of IR | SP (MW) | Type/ Fuel | County | Zone | Status | Last Updated Date | Availability of Studies | Proposed COD |
|---|---|---|---|---|---|---|---|---|---|
| Bull Run II Wind | 12/15/2015 | 449 | W | Clinton | D | 10 | 11/30/2022 | FES, SRIS, FS | 12-2026 |
| North Side Solar | 3/27/2017 | 180 | S | St. Lawrence | D | 11 | 9/30/2022 | FES, SRIS, FS | 12-2024 |
| Bull Run Solar Energy Center | 1/26/2018 | 125 | S | Clinton | D | 9 | 5/31/2023 | SRIS | 06-2027 |
| North Country Wind | 6/3/2019 | 298.2 | W | Franklin | D | 9 | 4/30/2023 | FES, SRIS | 12-2026 |
| Brookside Solar | 6/10/2019 | 100.0 | S | Franklin | D | 9 | 4/30/2023 | SRIS | 07-2026 |
| Bangor Solar | 10/26/2020 | 106.9 | S | Franklin | D | P | 12/31/2023 | FES | 12-2026 |
| Northline Energy Center | 5/20/2021 | 200 | ES | Clinton | D | 5P | 12/31/2023 | | 12-2028 |
| NY125A - Fort Covington Solar | 5/20/2021 | 250 | S | Franklin | D | 9 | 4/30/2023 | SRIS | 12-2026 |
| NY125B - Two Rivers Solar | 5/20/2021 | 200 | S | St-Lawrence | D | 9 | 4/30/2023 | SRIS | 12-2025 |
| Roosevelt Solar LLC | 6/25/2021 | 19.9 | CR | St. Lawrence | D | 9 | 3/31/2023 | SIS | 12-2025 |
| North Foothills | 9/13/2022 | 100 | S | FRANKLIN | D | P | 12/31/2023 | | 12-2026 |
| Golden Knight Solar | 6/13/2023 | 140 | S | St. Lawrence | D | P | 12/31/2023 | | 09-2028 |
| Jericho Solar | 9/11/2023 | 100 | S | Franklin | D | 1 | 11/30/2023 | | 10-2027 |
| Lake City Storage | 10/25/2023 | 120 | ES | Clinton | D | 1 | 11/30/2023 | | 12-2027 |
| Marble River Storage | 10/25/2023 | 160 | ES | Clinton | D | 1 | 11/30/2023 | | 12-2027 |
| North Farm Solar LLC | 11/14/2023 | 19.9 | S | Clinton | D | 1 | 12/31/2023 | | 03-2025 |
| Malone Energy Storage | 11/15/2023 | 80 | ES | Franklin | D | 1 | 11/30/2023 | | 12-2027 |

- Future/proposed Generation projects in NYISO queue
  - Wind: 750 MW; Solar PV: 1,300 MW; Storage: 560 MW
- Should cause taps to be more variable and more negative on average (pushing more against NY-VT flows)

# 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) |
| **Recovery following smart valve failure** | N/A | Restore current imprecise control | Restore current imprecise control |
| **Longevity** | Portable, but difficult<br>Cannot be used at 230 kV | Easily portable<br>Usable at 230 kV | Easily portable<br>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 50% contingency** | $56.2M PTF<br>(+50%/-25% accuracy) | $66.3M PTF<br>(+50%/-25% accuracy) | $47.7M* PTF<br>(+50%/-25% accuracy) |
| **Grid-enhancing Technology** | No | Yes | Yes |
| **Expected DOE funding support** | No | No | Yes – *$13.8M which drops cost to $33.9M |

# Thank you!

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