SMART WIRES

Optimizing Transmission Grids with Advanced Power Flow Control (APFC)

Ted Bloch-Rubin



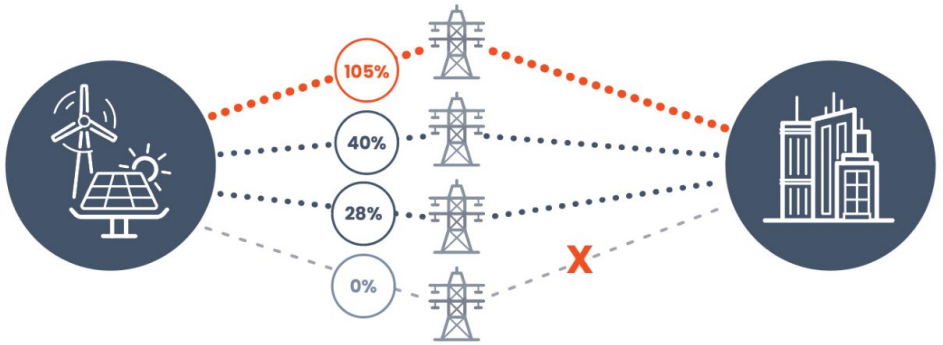




Advanced power flow control (APFC) overview

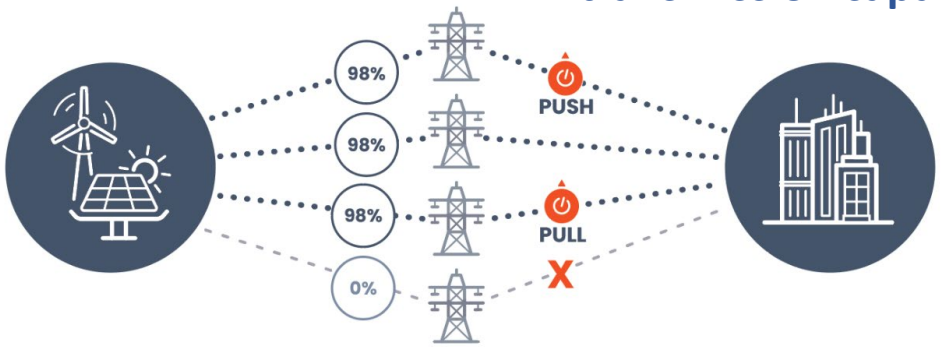
SmartValve™
Modular SSSC

- Transformerless, series-connected FACTS device that employs Voltage Source Converter technology
- Capable of controlling line reactance in real-time
- Modular design for flexible and scalable installations
- Voltage agnostic and redeployable
- Quick to deliver and deploy
- Integrated fast-acting bypass
- High reliability and redundancy



Before SmartValve™

+75% in firm transmission capacity



After SmartValve™

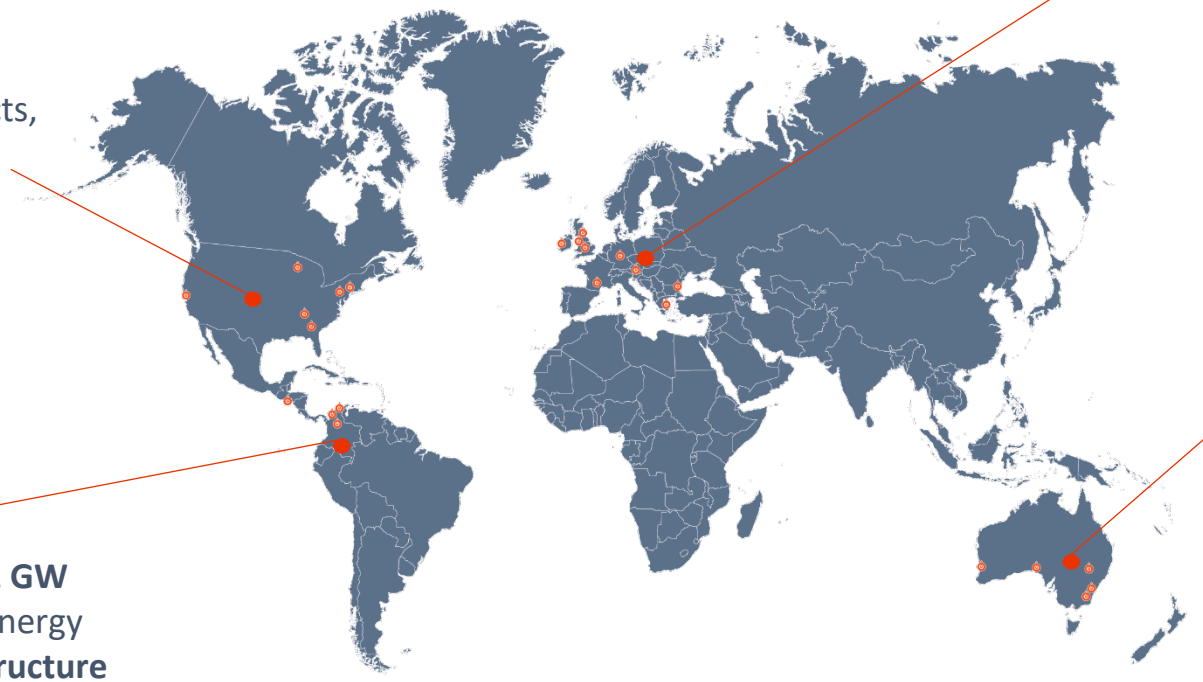
Long-term planning solutions delivering value globally

North America

Multiple projects using previous and current generation technology to **accelerate interconnection** of renewables. In just one of the projects, **over 185 MW capacity** is unlocked.

UK & Europe

Multiple projects, unlocking **over 2 GW capacity** to enable greater power flows across the grid and avoid curtailment of renewables.



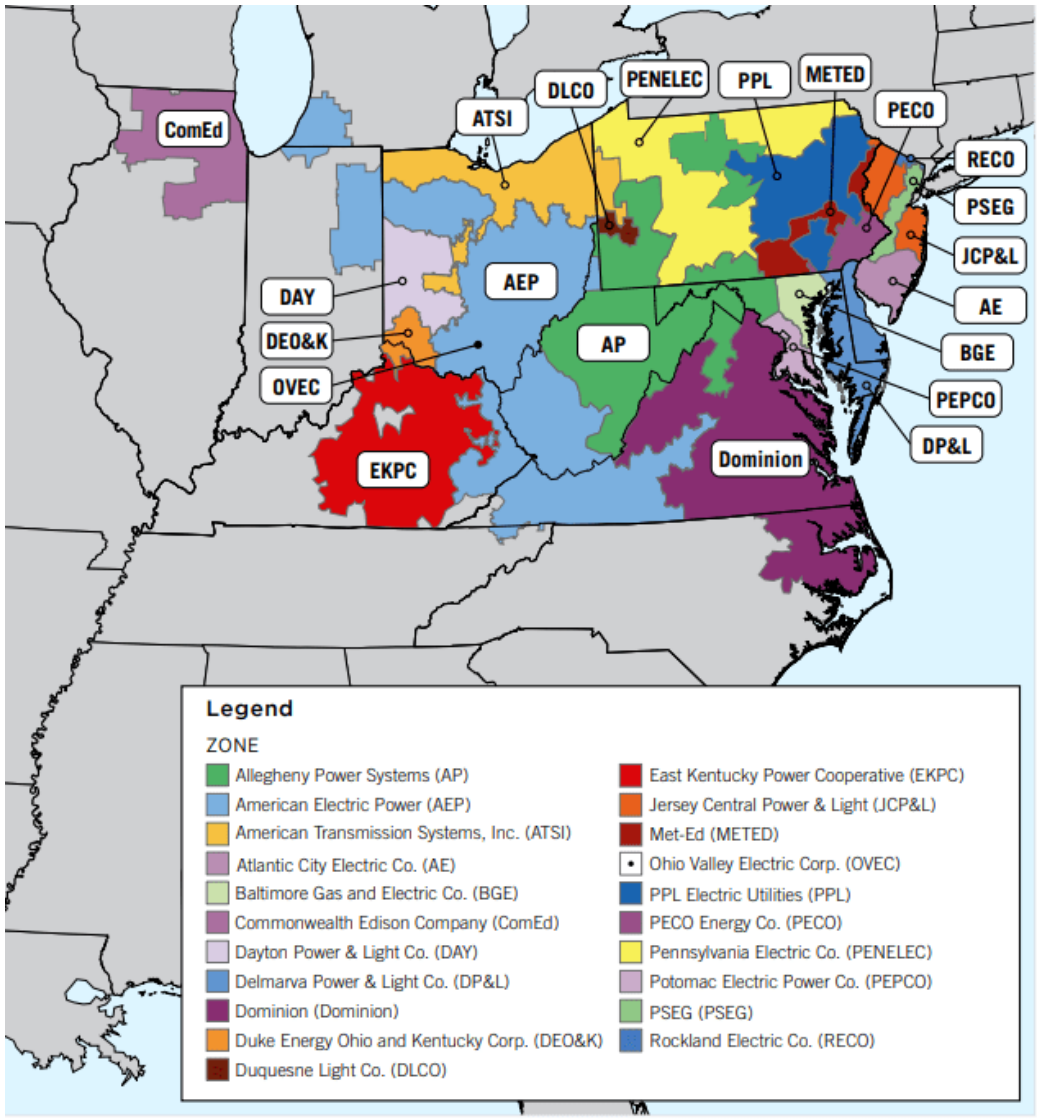
Latin America

Multiple projects, unlocking over **1.2 GW capacity** to support the renewable energy transition, **reducing need for infrastructure** in urban areas and **lowering consumer costs.**

Australia

Multiple projects delivered and in progress, unlocking **over 185 MW capacity** and improving transfer of electricity between states.

APFC solution development in PJM footprint to-date



Source: PCI Energy Solutions

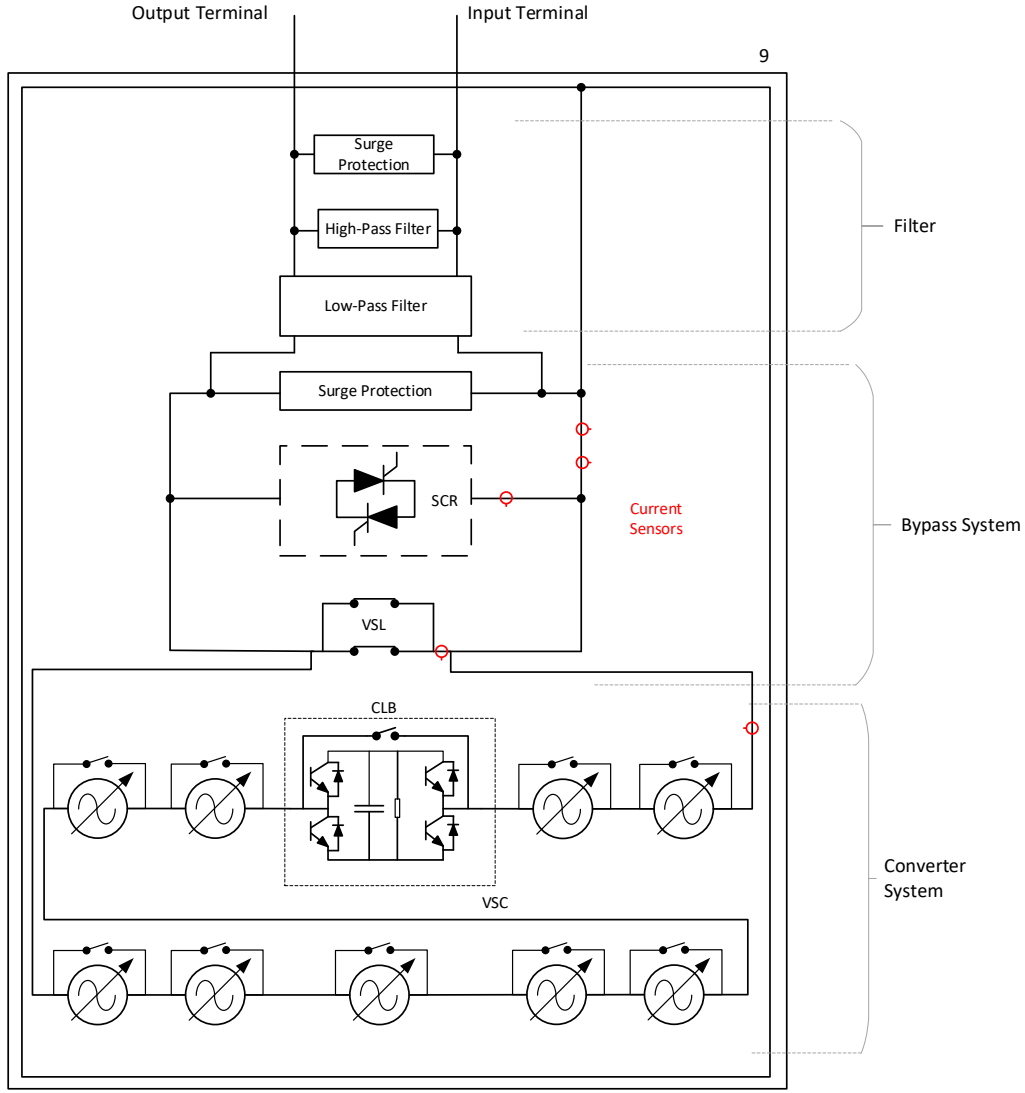
IL – Generation interconnection, thermal and voltage stability applications

OH – Load interconnection

MD/DE – Offshore wind interconnection network upgrades

VA – Load interconnection, congestion mitigation

SmartValve single line diagram



SmartValve 10-1800 Single-Line Diagram

SmartValve harvests all power from the line to operate the control and communication circuits and senses line current for control and fault-protection purposes.

Filter Capabilities

- The high-pass filter allows the passage of high frequency transients.
- The low-pass filters allow the power line frequency to enter the SmartValve.

Bypass Capabilities

- The vacuum switch links (VSLs) primarily conduct current during steady-state conditions.
- The silicon-controlled rectifiers (SCRs) primarily conduct current during grid faults (e.g. a fault on the line connected to the SmartValve).

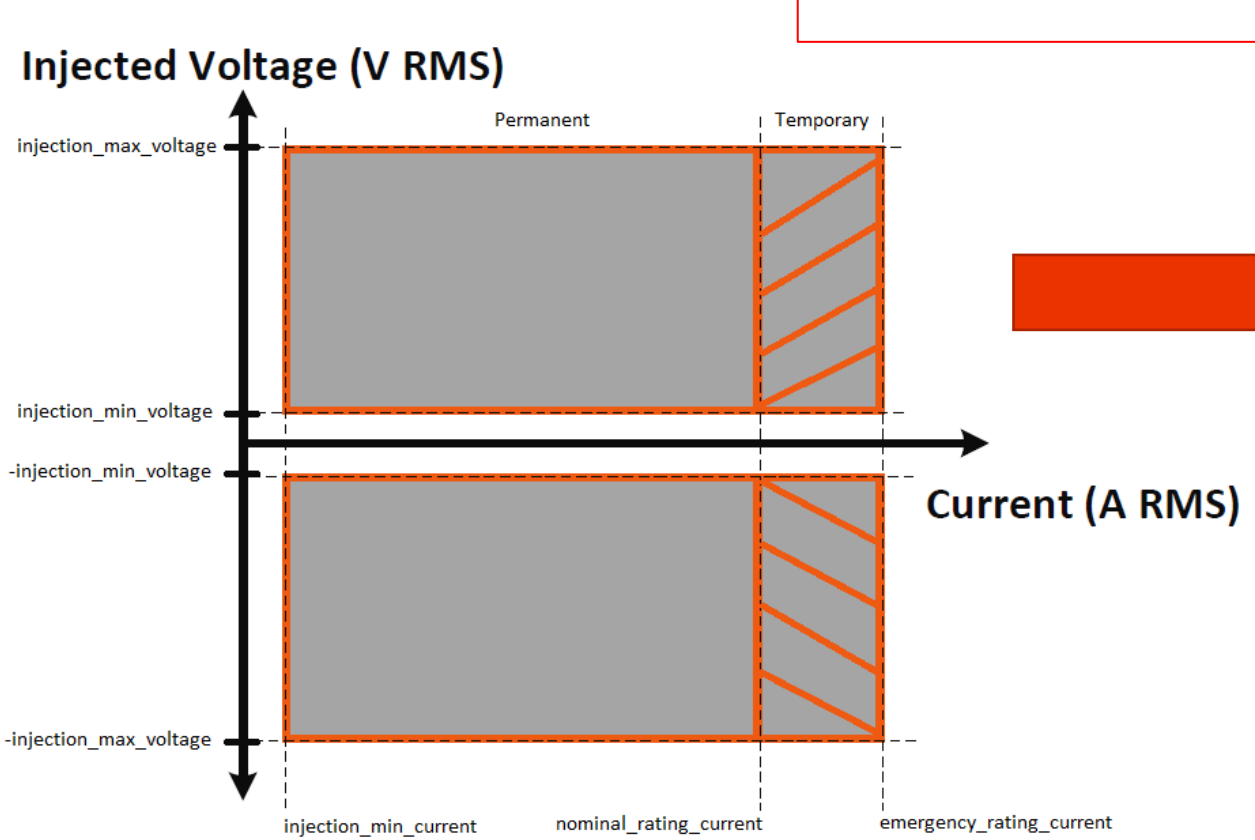
Converter Capabilities

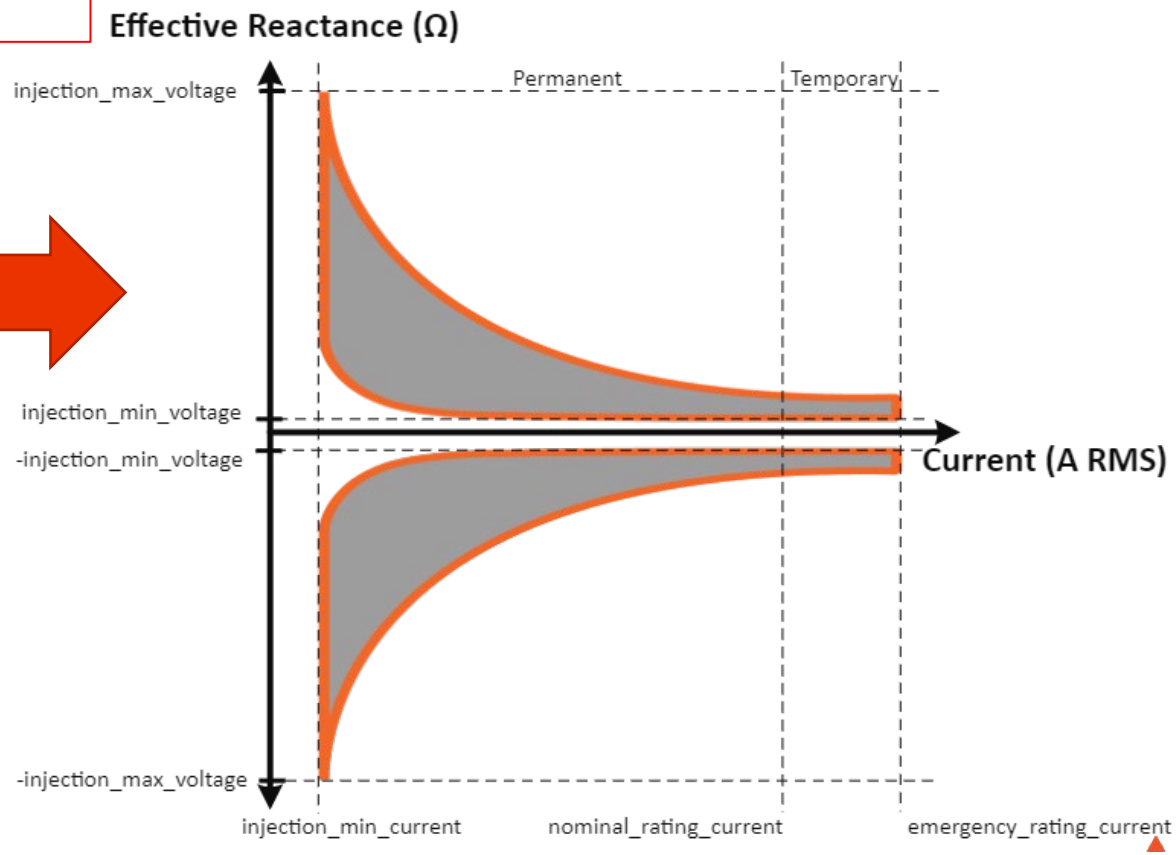
- The core components of each Voltage-Sourced Converter (VSC) are four semiconductor switches and the DC Link capacitor.

SmartValve (M-SSSC) Operating Range

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

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





SmartValve: Control Modes – Fleet Management

Monitoring

SmartValve devices are bypassed and can report line current measurements and other telemetry data.

Reactance Mode

Constant reactance setpoint either **inductive** or **capacitive**. Injected voltage will vary depending on the line current variation to obtain the required fixed reactance.

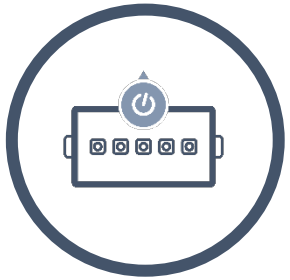
Current Control Mode

This mode **regulates line current** within a tunable operating range. SmartValve device can increase or decrease injection in order to keep line current within the allowed limits.

Modelling SmartValve in power system planning

STUDY SERVICES

- Steady State Studies
- Economic Analysis
- Dynamic Time Domain Studies
- EMT Studies
- Additional Studies
- Customer Defined Analysis

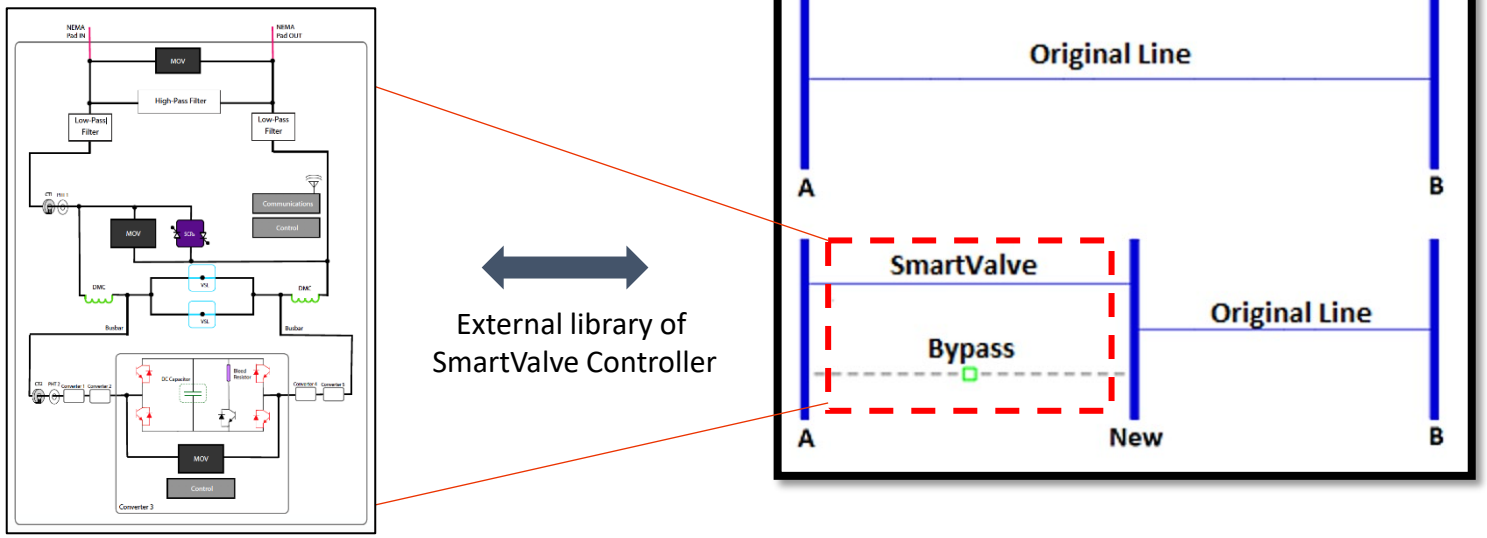


SMARTVALVE™ MODELS

- PowerFactory*
- INTEGRAL*
- Organon*
- ASPEN
- MATLAB® / Simulink®
- PSCAD™/ EMTDC
- PSLF
- PSS®E
- RSCAD/RTDS
- TSAT
- PowerWorld
- NEPLAN

Collaborated with planning software vendors and utilities to co-develop modular SSSC models for PowerFactory, INTEGRAL and Organon, and developed user-defined models for other planning platforms.

PSS/E Steady-State Model



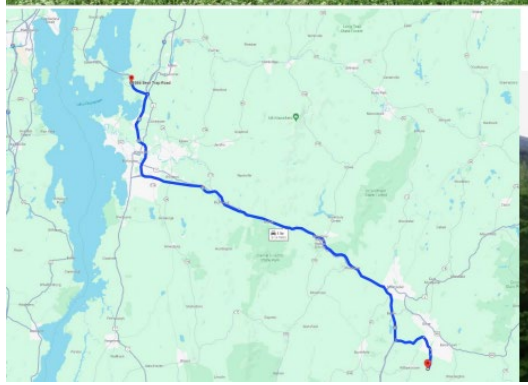
- SmartValve deployment is modeled as two components:
  - Bypass: low-impedance branch (almost equal to 0 Ohms)
  - SmartValve: dedicated branch with reactance dependent on SmartValve injection

- SmartValve deployment and operations parameters are stored in separate files
- SmartValve Control Modes: Current, Voltage, Reactance

Extending the asset life of a PST in Vermont

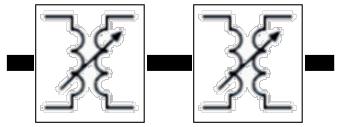
VELCO

PST failure

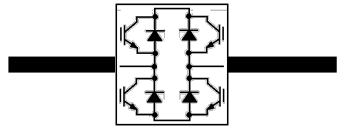


Solution

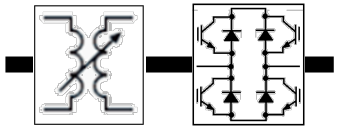
Alternative #1:
Series PST



Alternative #2A:
Full PST replacement with SmartValve



Alternative #2B:
Series SmartValve



Source: https://www.iso-ne.com/static-assets/documents/100008/a04_2024_02_28_pac_sand_bar_pst_asset_condition_presentation.pdf

SmatValve directly support data center connection

US utility

Project due to be contracted in Q4 2024 and commissioned in Q3 2025

Challenge	• New data center connection in urban area **increased power delivery requirement** • New HVDC circuits will be required in the long-term, but the **utility also needs a quick solution** to meet the near-term need
Technology	• SmartValve can push power off the overloaded circuits onto underutilized lines in the neighboring network • The solution addressed the primary constraints by mitigating thermal overloads **up to 34% above the transmission line rating**
Why SmartValve?	• **SmartValve solution can be put in place in 12 – 15 months** while new HVDC circuits are being permitted and constructed • This modular solution can be **easily expanded** to meet further growth in the area ahead of HVDC completion

SMART WIRES