SMART WIRES

REIMAGINE THE GRID

Improving Transfer Capability while Avoiding Series Compensation Challenges

November 2022, Kaveh Aflaki

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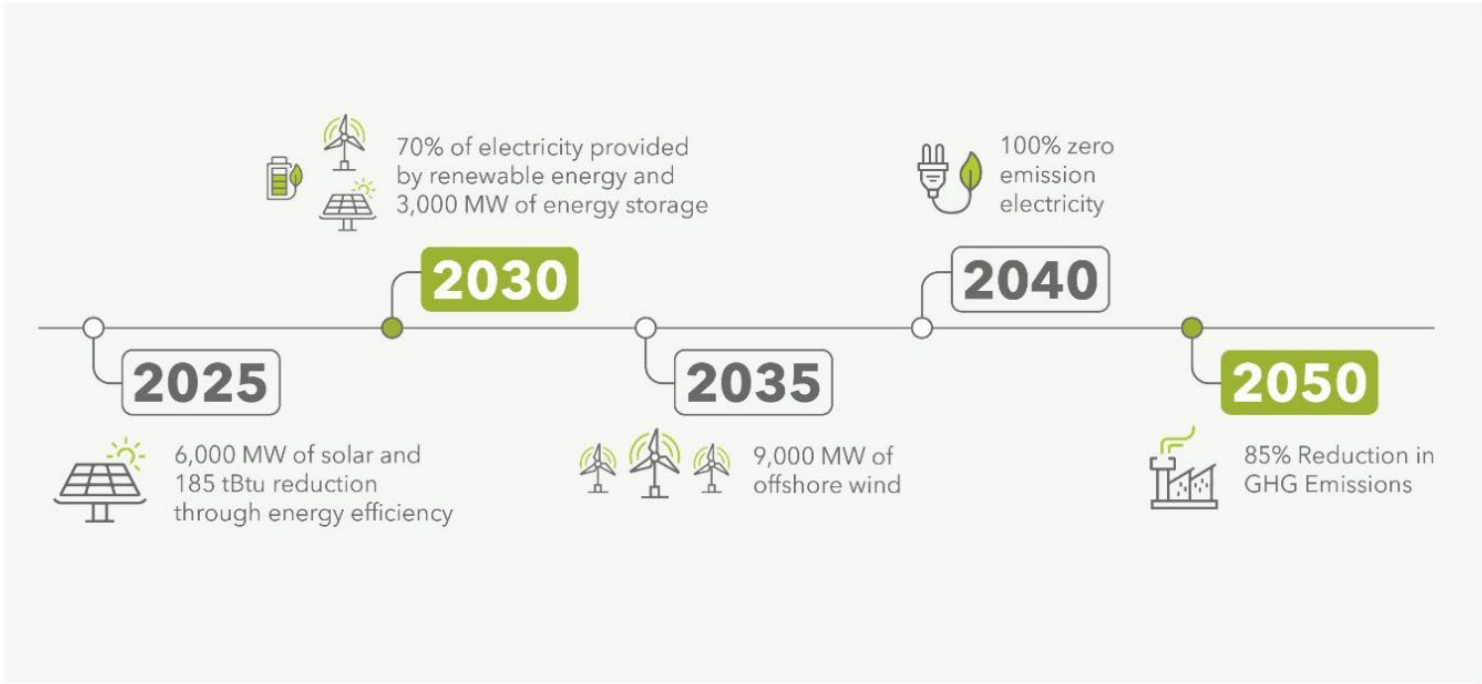
Introduction

New York Energy Transition

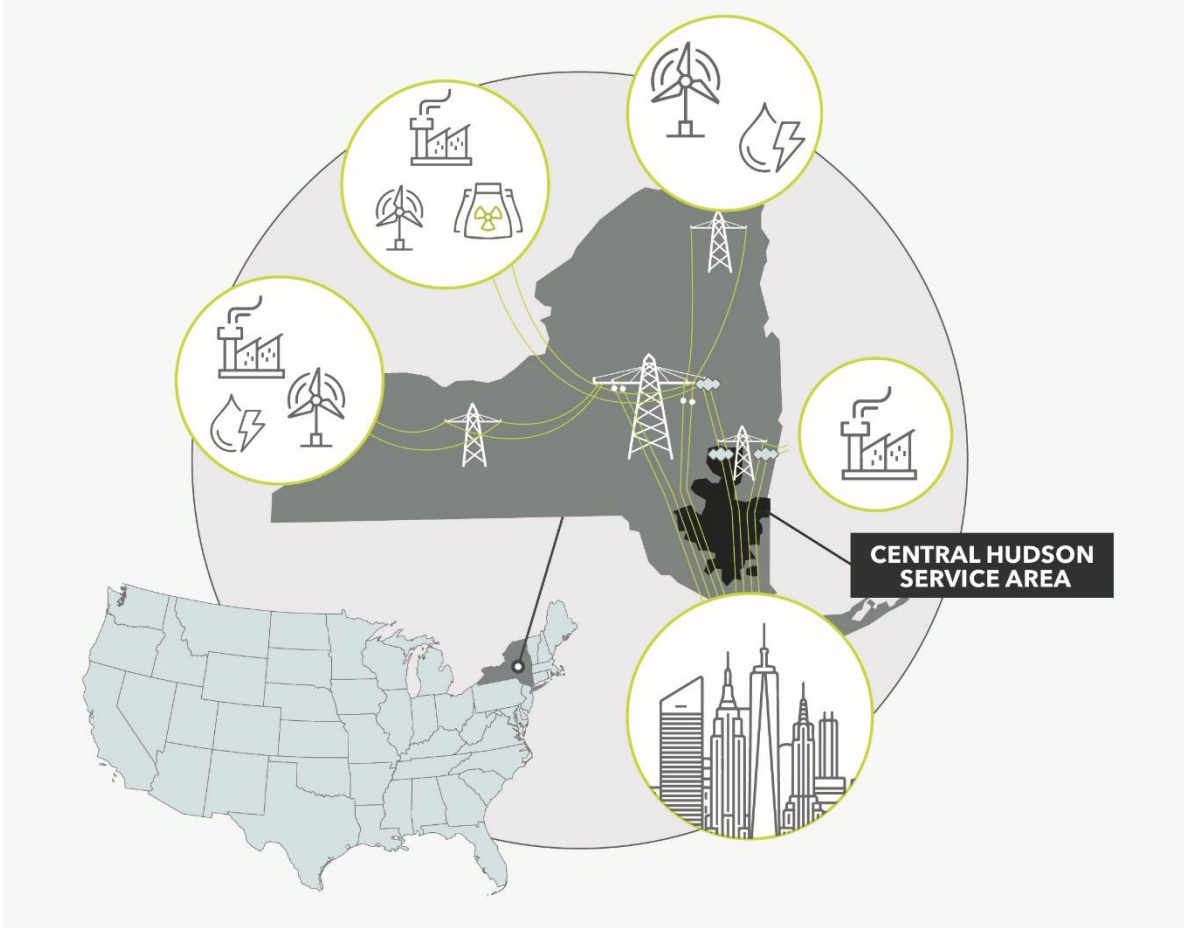
Climate Leadership and Community Protection Act (CLCPA) of 2019



New York Electric Transmission Grid

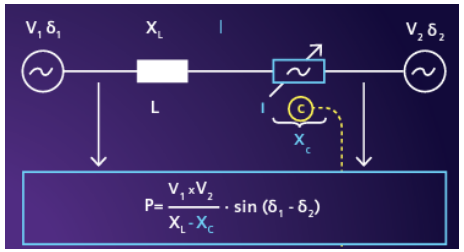
Central Hudson Service Area & Upstate – Southeast NY interconnection constrained

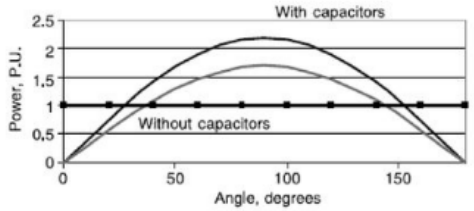
- Central Hudson Gas & Electric
  - Established in 1911
  - Electric service for nearly 300,000 customer.
- Renewables fed from northern border to NYC.
- Upstate – Southeast NY interconnection constrained
- 185 MW uprating needed to integrate new generation.
  - 21% series compensation @ 345kV Leeds – Hurley Avenue



Traditional Solution with Series Compensation

Fixed Series Compensation





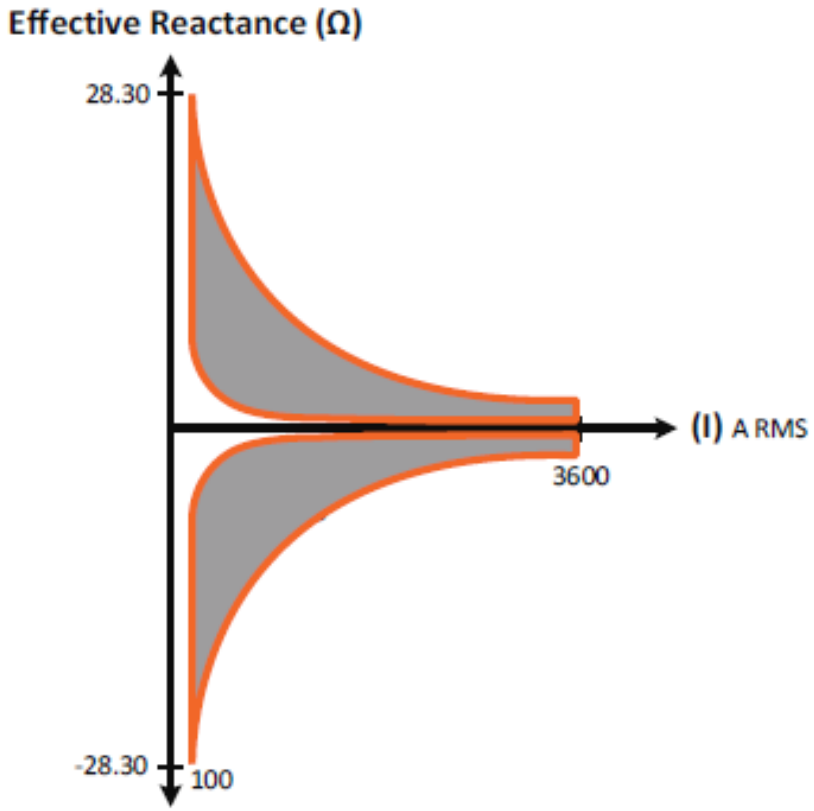
- Applied since 1980's, especially for long transmission systems, to increase system stability and power transfer over long distances.
- Fixed reactance, that will virtually approximate two nodes.
- Tailor made solution. Difficult to up or down-grade.
- Single point of failure risks reduces availability.
- SSR (subsynchronous resonance) risks:
  - Interaction between fixed C and generator shaft.
  - Demanding studies to avoid SSR risk for actual grid
  - Future Grid topology & generation modification will always modify the studies
  - New schemes to incorporate SSR detection / protection.

Alternative Solution with Modular SSSC

SmartValve™ - Key attributes of modular power flow control

- **The SmartValve:** is a modular Static Synchronous Series Compensator (M-SSSC)
- **Power Electronics Technology:** that injects a controllable voltage (leading or lagging) in to a circuit, either manually or automated controls.
- **Main Application:** dynamic power flow control
- **Flexible Electrical Deployment:** Same unit can be used at any voltage in network; scaled or rescaled to meet the need
- **Flexible Physical Deployment:** Substations, in the existing right-of-way, or on mobile platforms, light and compact
- **Wider Use Cases:** solve small near-term and large long-term problems at any voltage level
- **Fast deployment:** 1 Year deployment possible from order to installation
- **High Security:** Combined capability offers naturally high reliability and redundancy
- **Lifetime:** 40 year plus

SmartValve operating range



The SmartValve **injects a voltage in quadrature with the line current such that it is capacitive (-Ωs) or inductive (+ Ωs)**. However, unlike physical capacitors or inductors, the injected voltage is **independent of the line current**.

The curve shows the range of injected reactance as a function of the line current. The outer orange boundary is when the SmartValve is injecting the full output voltage, in this case ± 2830 V RMS.

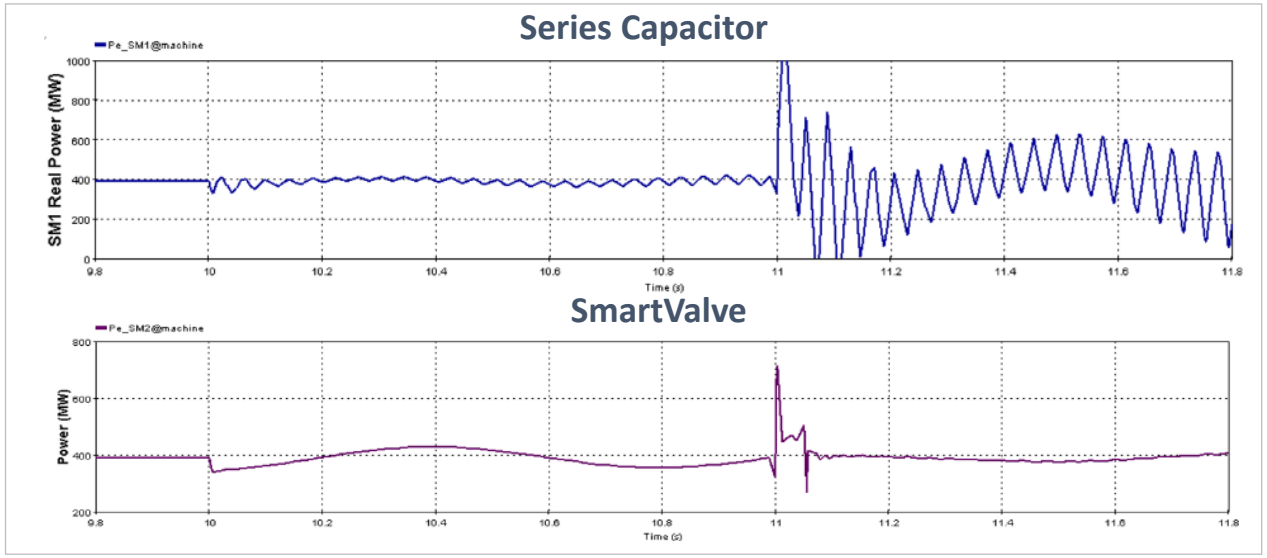
SmartValve control modes

The operator does not need to control individual devices, but can program a desired value for the fleet as follows

- **The voltage injection is continuously variable and can be changed without decreasing product life or increasing maintenance requirements**. This makes SmartValve the best power flow control technology in the market suitable for dynamic power flow applications.

- **SmartValve can vary series compensation provided to handle changing load conditions and line contingencies.** The SmartValve can increase power flow when the relevant machines in the system accelerate, and, conversely, force the line current and transmitted power to decrease when the machines decelerate.

- **SmartValve compensation level is not limited by Sub-synchronous resonance (SSR) and Sub-synchronous Control Interaction (SSCI).** Since it is injecting voltage that emulates capacitance, the SmartValve has a negligible risk of initiating SSR/SSCI. The SmartValve is more effective in providing larger amounts of compensation series capacitor, even under dynamic conditions.



Pilot Project experience

Pilot Project Lessons Learned

Phase 1 & 2

- 115kV Ohioville Substation.

Phase 1: 3 x M-SSSC (Injection unit) + 3 x Fast By-Pass units

- Installation within 2 working days.
- Communications via radio frequency antenna.
- Areas of improvement:
  - Travelling waves causing by-pass of the M-SSSC.→ Firmware enhancement. / By-Pass filter sytem.
  - EMS integration and communication.

Phase 2: Phase 1 + improvements implemented.

- Upgrade of phase 1 to include 3 x by-pass filter module
- Installation within 2 working days.
- Successfully in operation, providing confidence for higher voltage levels.

Comparison

Comparison under different evaluation criteria

FSC vs Modular SSSC

Required Feature	Technology	
		FSC: Fixed Series Capacitor
1	**Control**: solution is controllable and flexible for different grid scenarios of generation and load.	Not available. FSC is a fixed solution, which does not give controllability, it is on/off only.
2	**SSR Risk free:** solution does not add any SSR risk to existing or the future grid. Few changes on protection schemes.	Not available. Even if comprehensive grid study is carried out, system will always be at risk in future, in case of changes
3	**Flexibility:** Solution is flexible to different grid topology, since grid will develop in the future scenario (ex: short circuit level, generation mix, line sectioning, etc). Possibility to scale up or down.	Possible at high cost. Overdimensioning the solution can make it flexible for future. Scaling up/down can be done at high cost.
4	**Space:** solution is compact and can be installed in substation areas	Equivalent. Both solutions can be compact, depending on the system requirements.
5	**Availability**: High availability design. Can operate in degraded mode with limited output, if necessary.	Partially available. Installed redundancy, however not possible to work in degraded mode.
6	**References**: Solution has been used in 345kV systems in the past	FSC has many installed references up to 765kV and 1000kV.
		M-SSSC: Modular SSSC
1		Available. Full controllability within equipment capacities, possible to adjust by EMS, SCADA.
2		Available. No Capacitance, instead voltage injection, makes m-SSSC a SSR solution free of risk for now and future topoly.
3		Available. Solution can be scaled up, down or even relocate in case grid changes.
4		Equivalent. Both solutions can be compact, depending on the system requirements.
5		Available. Solution with installed redundancy and enhance availability packages. Degraded mode available.
6		Not available. Solution limited to lower voltage levels. [1]

[1]) – after the assessment in 2019, Smart Wires has delivered and commissioned in 2021, a multiple device-solution for 400kV system to National Grid in UK and is contracting for a 500kV 1200 MVAr solution in Latin America

Conclusion

- Comparable total costs for M-SSSC and FSC.
- M-SSSC is a SSR risk-free solution.
- Lack of references for M-SSSC in 345kV[1], while FSC is a proven solution.
- Significant technical advantages for M-SSSC against FSC.
- Studies showed the possibility to scale the compensation in future, from 30 to 50%. M-SSSC can be scaled easily.

Conclusion 1: M-SSSC is the best technical & economical solution for the compensation required @ 345kV Leeds – Hurley Avenue.

Conclusion 2: Due to lack of operational experience in 345kV[1] systems, Central Hudson ran a pilot project to evaluate the commercial operation of M-SSSC in lower voltage levels, before ordering the 345kV project.

[1]) – after the assessment in 2019, Smart Wires has delivered and commissioned in 2021, a multiple device-solution for 400kV system to National Grid in UK. Image of the installation. SW is also contracting for a 500kV 1200 MVAr solution in Latin America

THANK YOU

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