HVDC in the US

Historical, Current, and Future Projects

Geoff Love

12th June 2024

Who Are We?

EPRI Europe

Is a subsidiary of EPRI International Inc., which is in turn a subsidiary of EPRI.

2019

Founded in Ireland as a non-profit organization.

Objectivity and Independence

Conducts objective and independent energy and environmental research, development and demonstration projects in Europe, for the benefit of the public.

+ 40 leading experts

Supporting collaborative projects organized through EPRI.

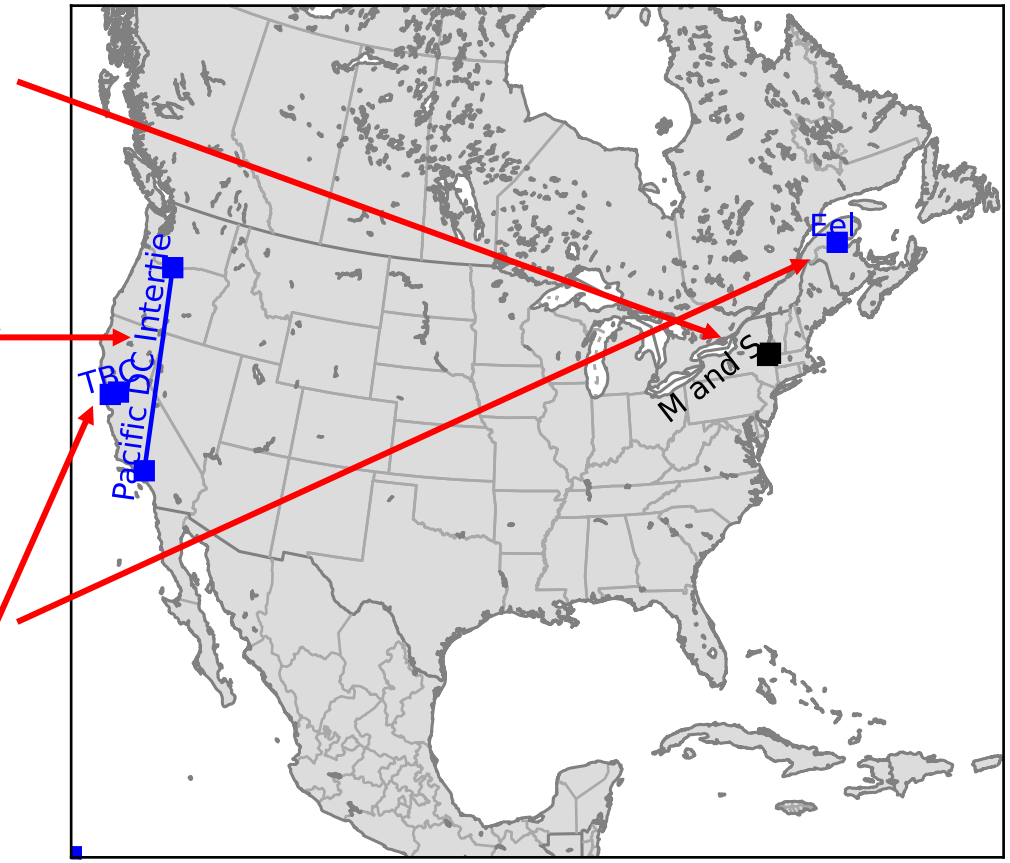
Leading and participating in European regional projects and collaboratives.

Who is EPRI?
Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe.

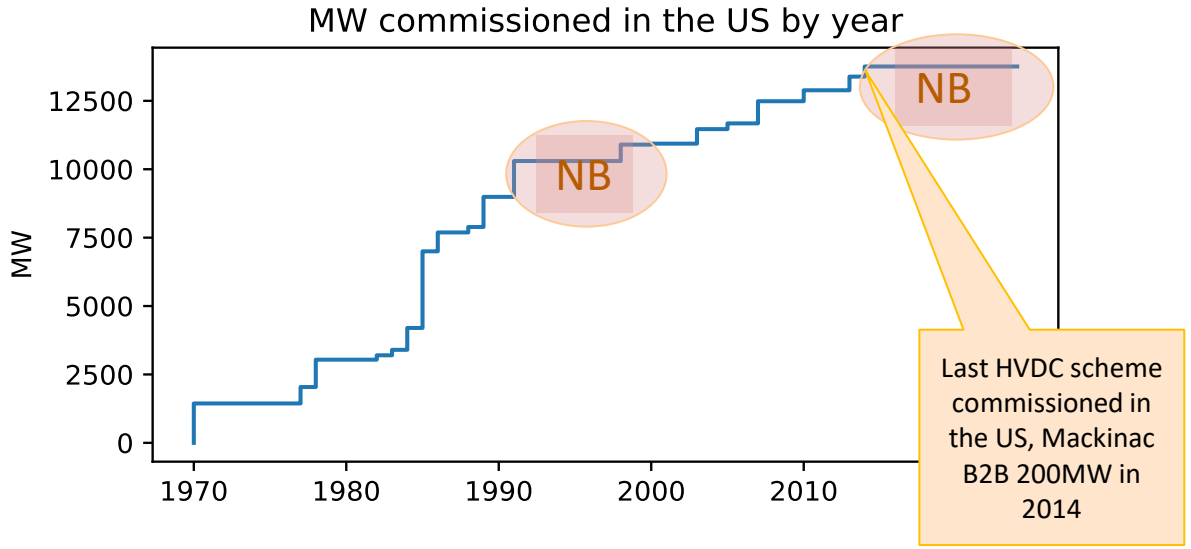
US HVDC Past and Present

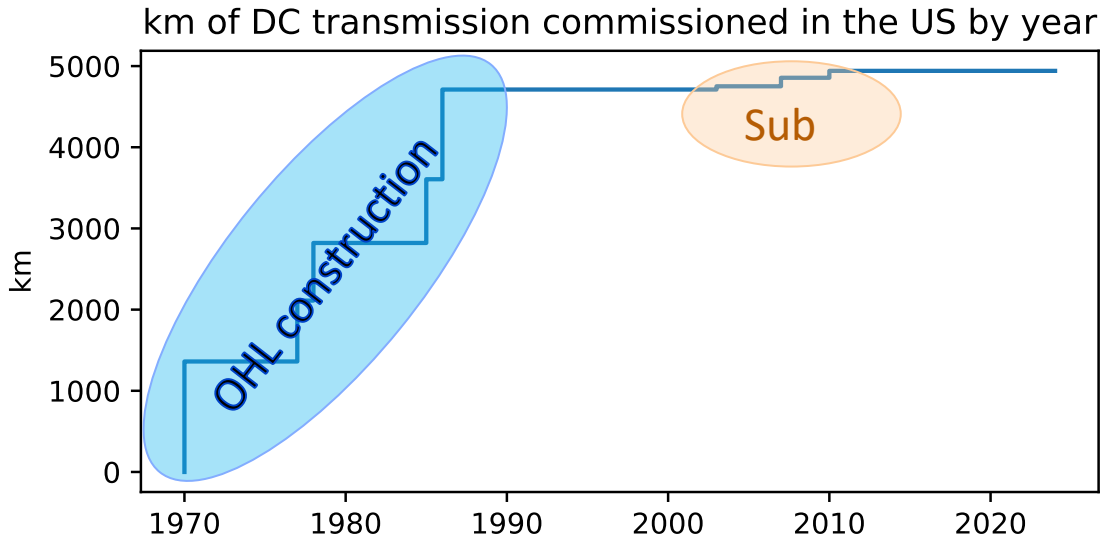
HVDC milestone in the United States

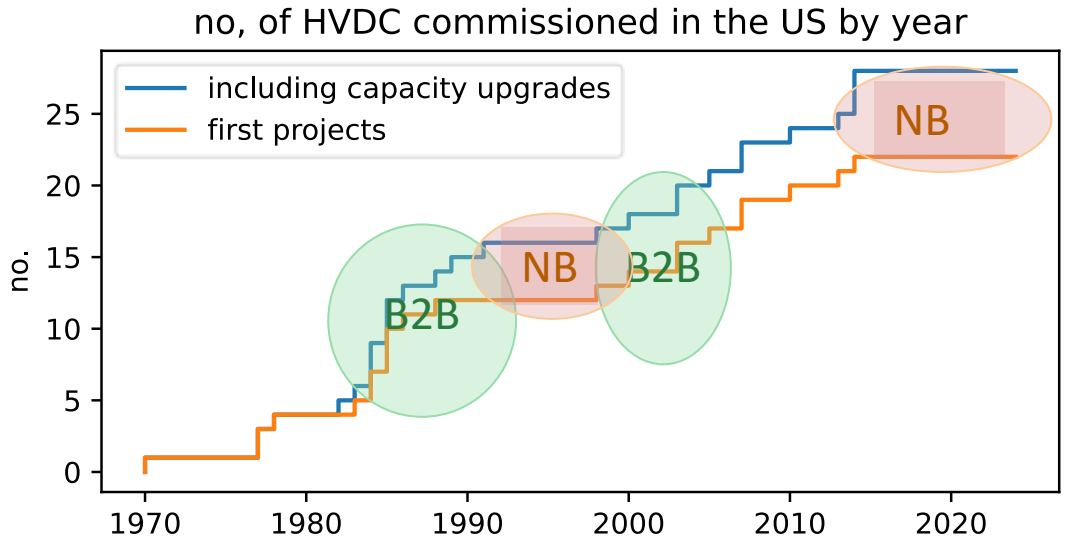
- First experimental HVDC scheme; Mechanicville and Schenectady New York; GE, 1932, 12kV, 5MW, 37km OHL, Mercury Arc Valves (rectifier end), DC motors (load end). Dismantled after WW2. *(1929 Uno Lamm patent, 1944 ASEA built 2MW 60kV converter)*
- 1970 First commercial US project, Pacific DC Intertie, GE/ASEA joint project, Oregon->California (LA); ±400kV, 1440MW, 1362km OHL, Mercury Arc (now ±500kV, 3100MW, Thyristor)
- 1972 Eel River (320MW, B2B) (in Canada! but built by GE (Schenectady)). First fully thyristor HVDC system. (previously ASEA had operated Gotland with a thyristor valve).
- 2010 Trans Bay Cable (San Francisco, OHL, ±200kV, 400MW 85km cable, VSC), world first commercial MMC HVDC converter.

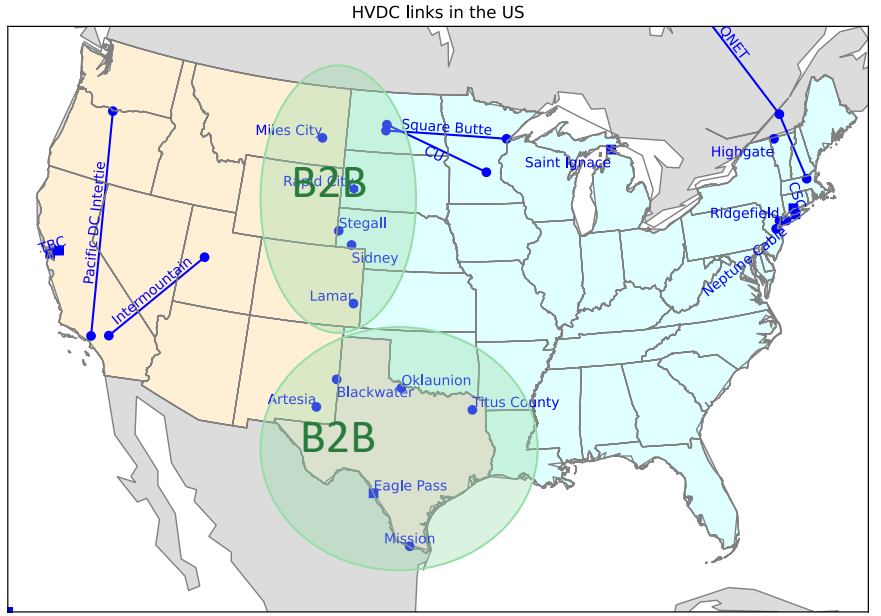


Current US HVDC Interconnectors

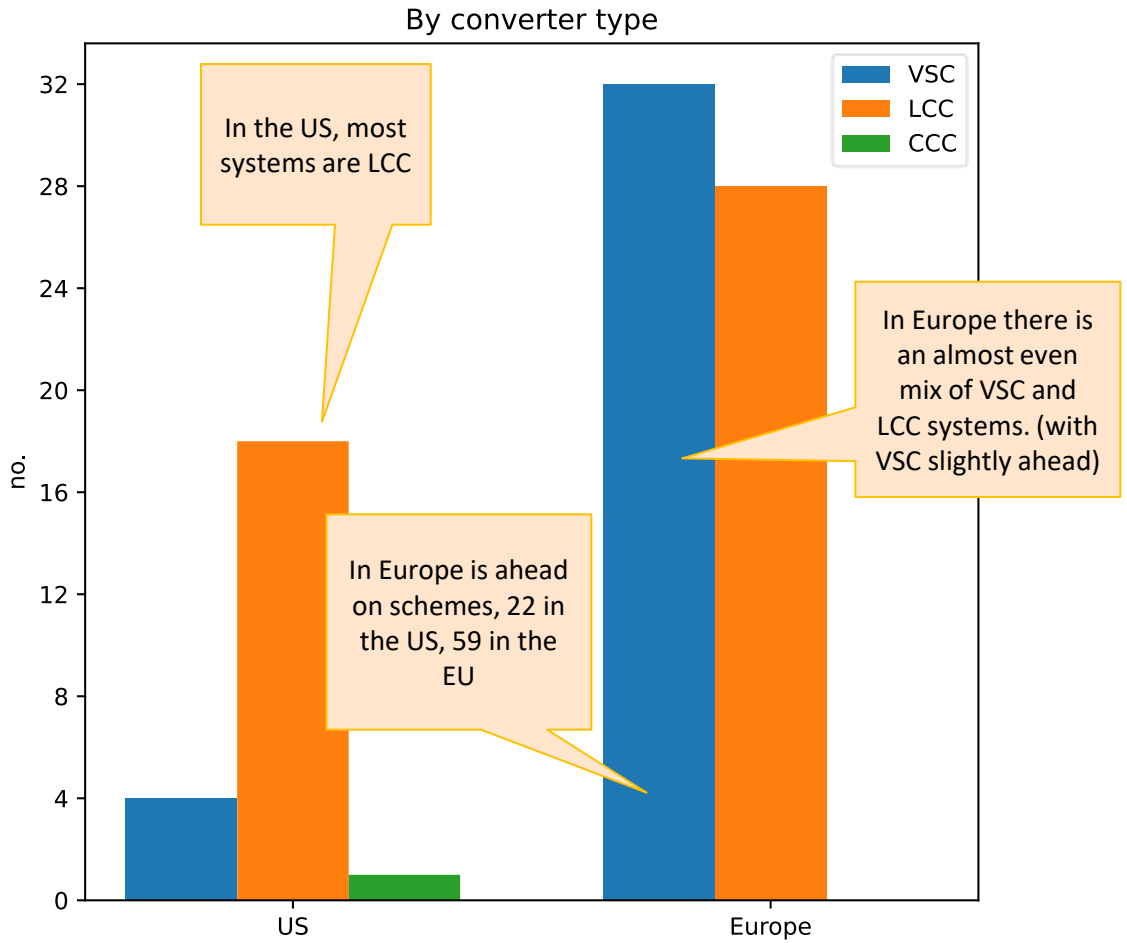


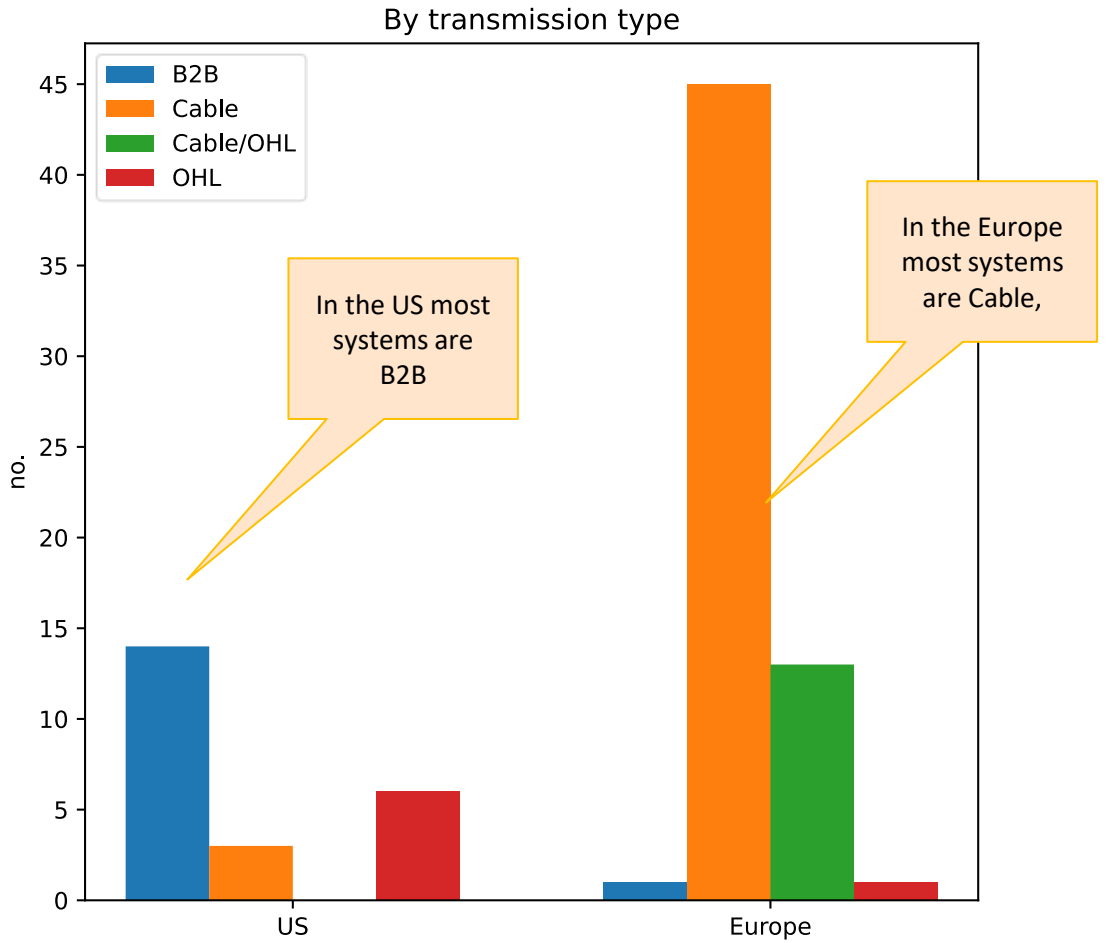






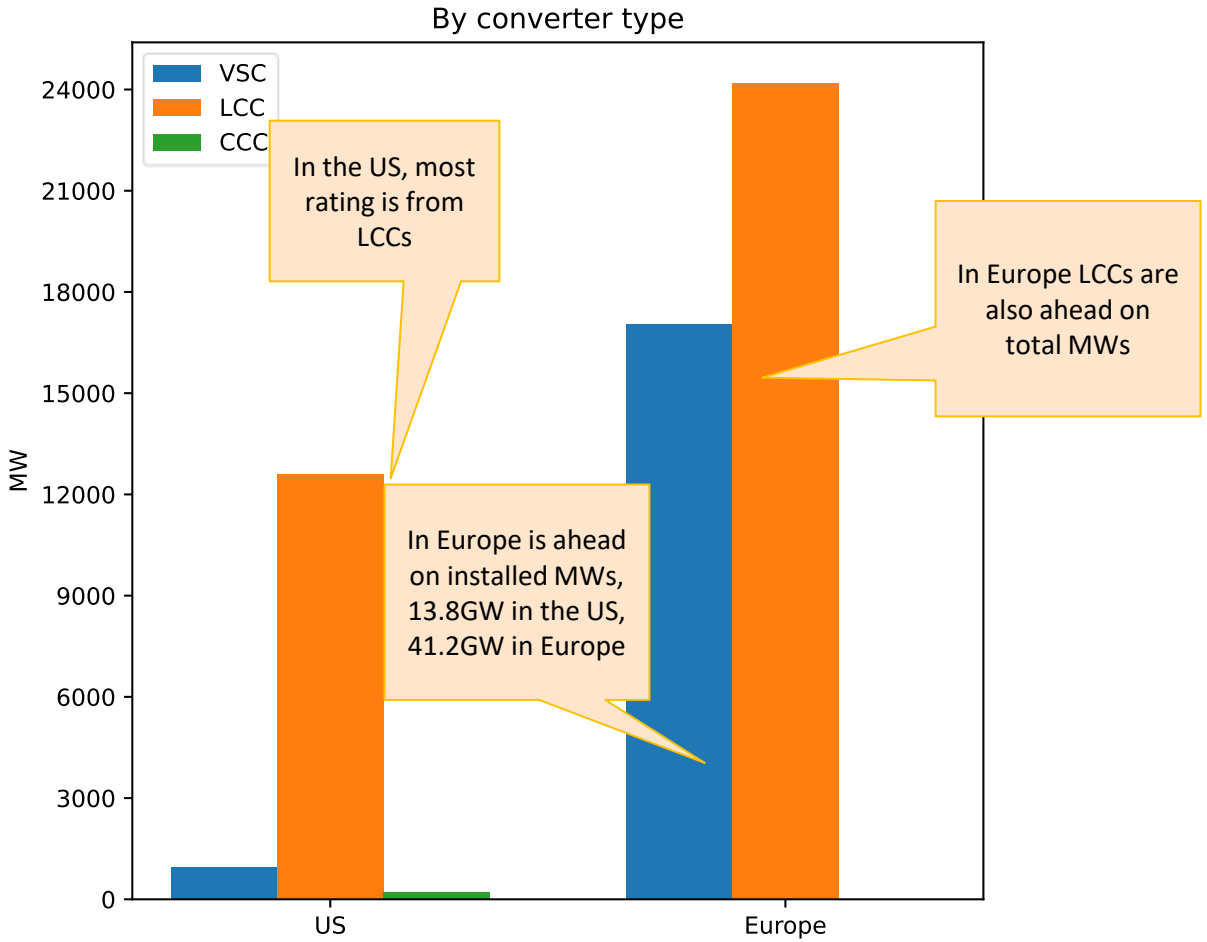
Comparison with the EU – number of HVDC systems (today)

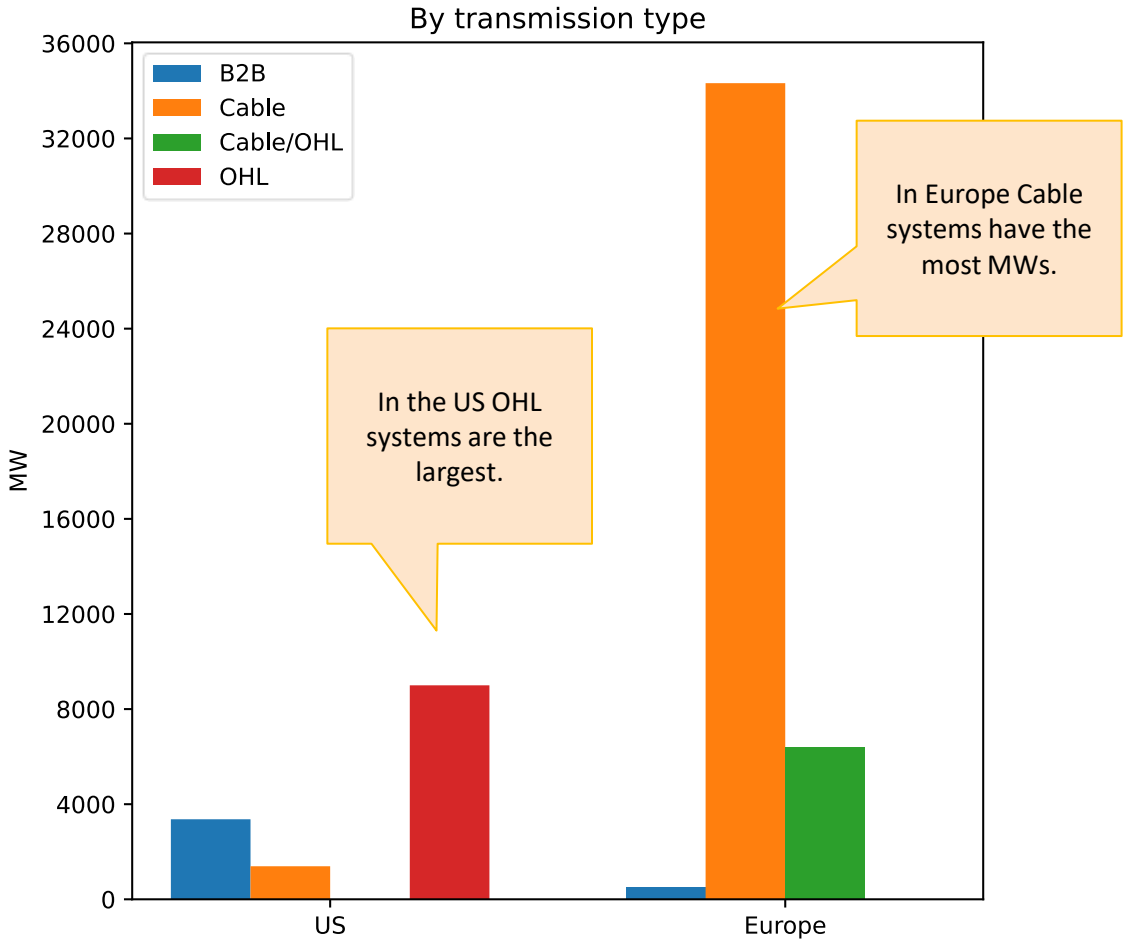




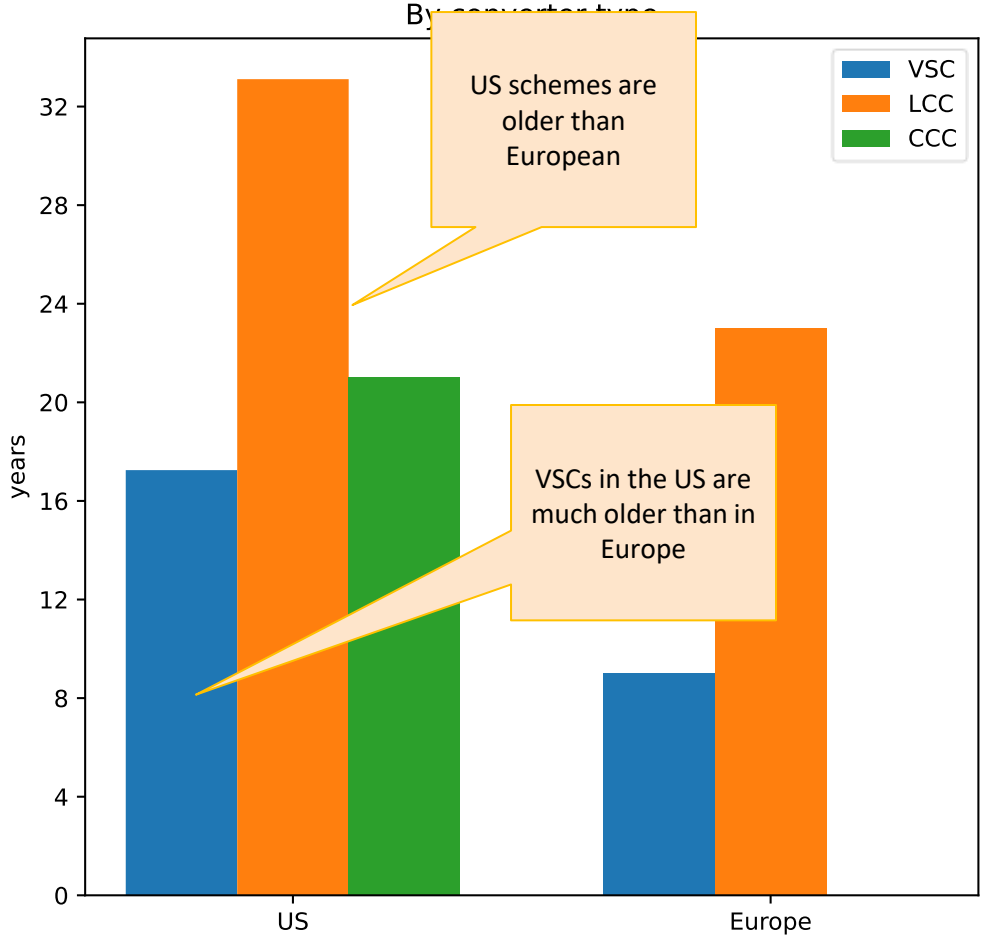
***HVDC systems/schemes (not stations, converters etc)**

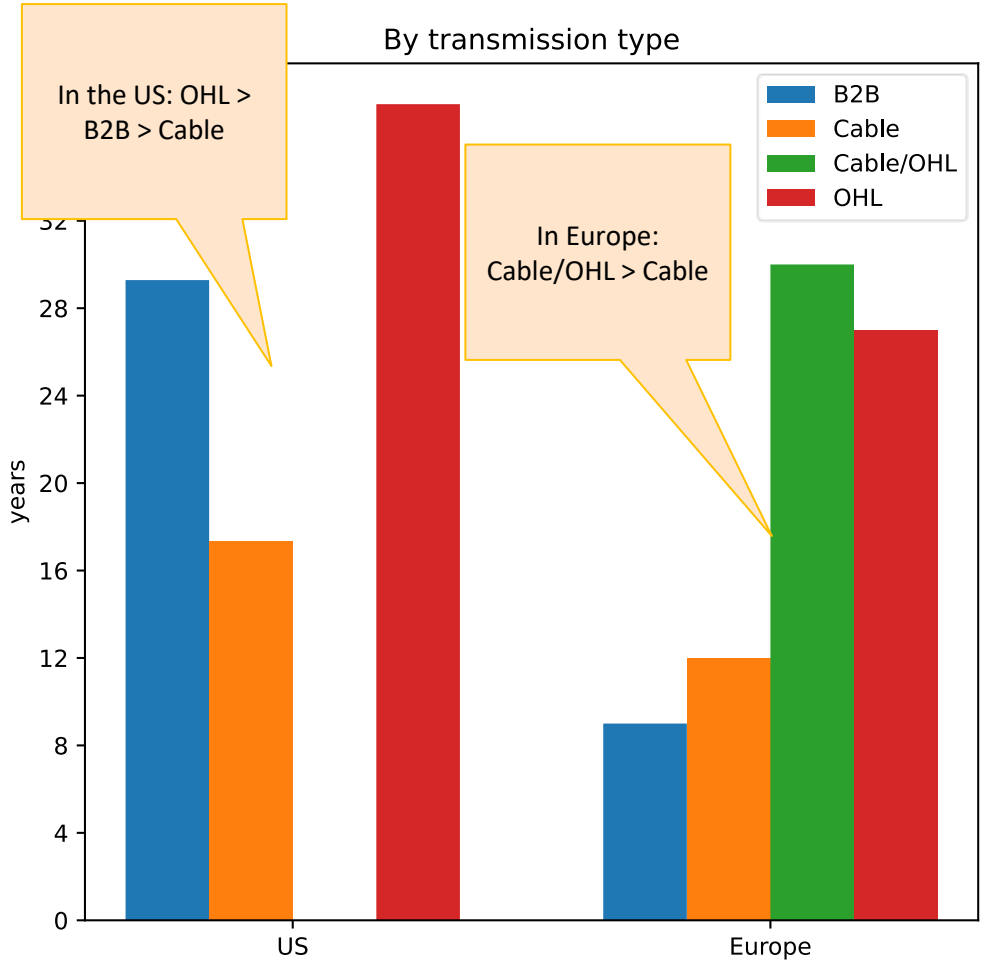
Comparison with the Europe – MW of HVDC systems (today)





Comparison with the EU – commissioning date of HVDC system



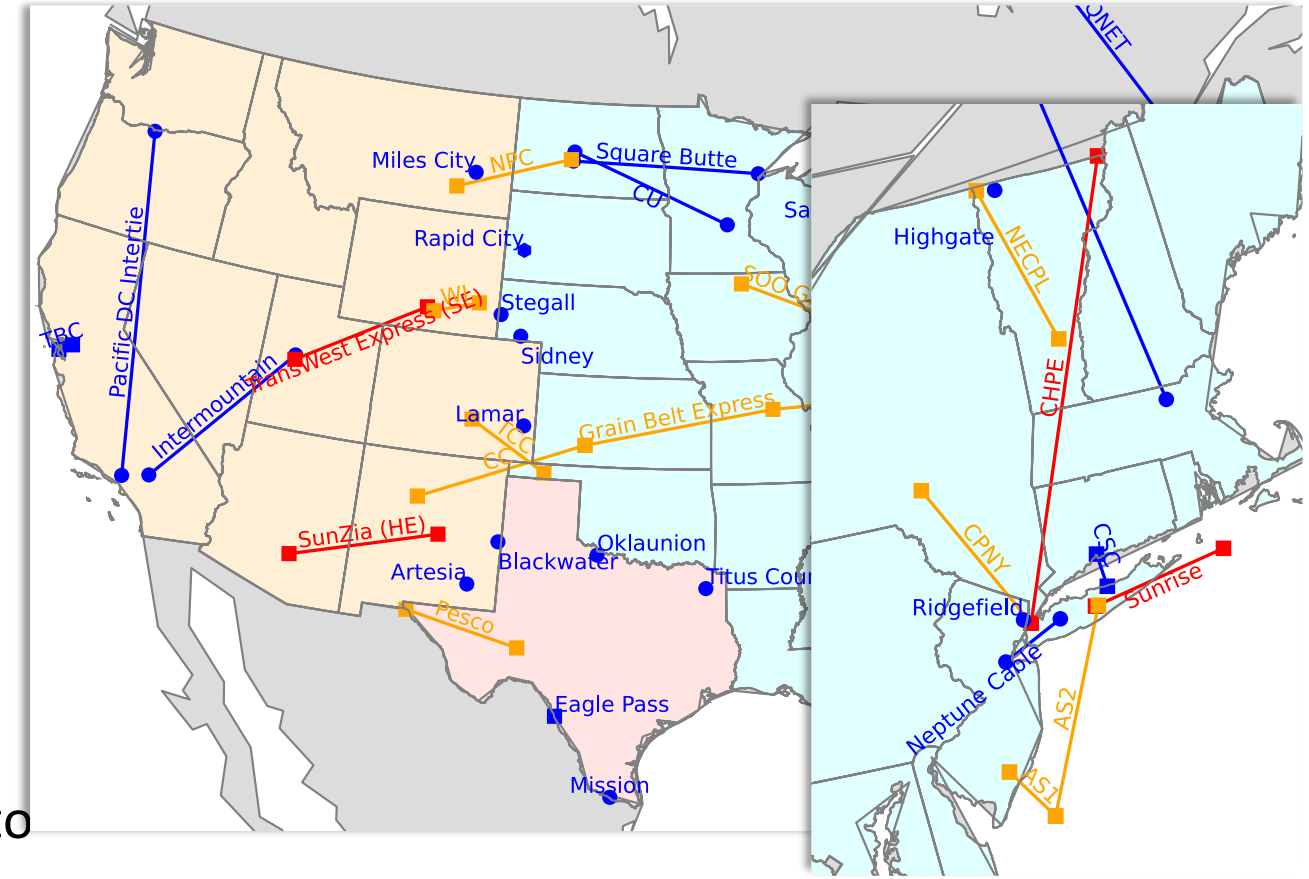


***initial date, not including upgrades**

US HVDC the future

Current US HVDC schemes

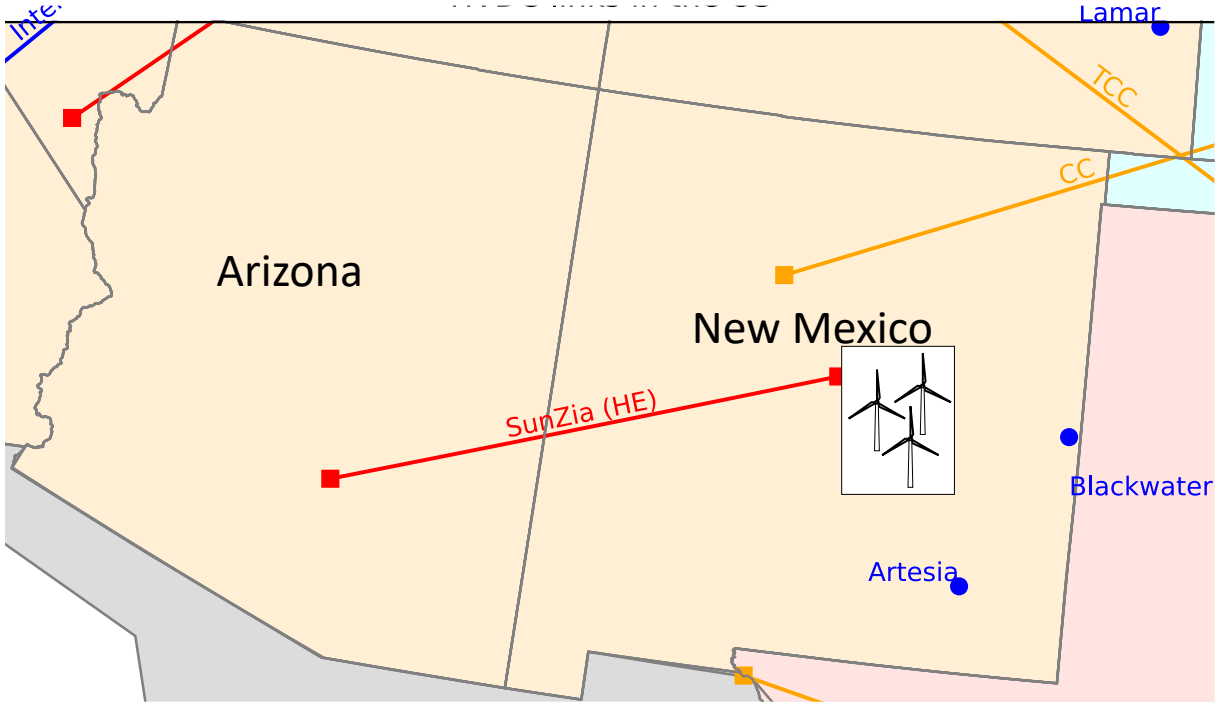
- Only one new HVDC scheme commissioned in the US in the last 10years (not including upgrades)
- Americans for a Clean Energy Grid* Have identified “4” under construction:
  - SunZia, HE Arizona/ New Mexico
  - TransWest SE Wyoming/Utah
  - Champlain Hudson Power Express CHPE HE Canada/New York
  - Sunrise SE NY/offshore
- One more CPNY NY/NY has announced a cable vendor (but no HVDC vendor), cable contract conditional on project approvals.
- Americans for Clean Energy ten are “ready to go” (approved or near approval, getting to financial closure).



*** Z.Zimmerman et al Ready to Go Transmission Projects 2023, Americans for a clean energy grid**

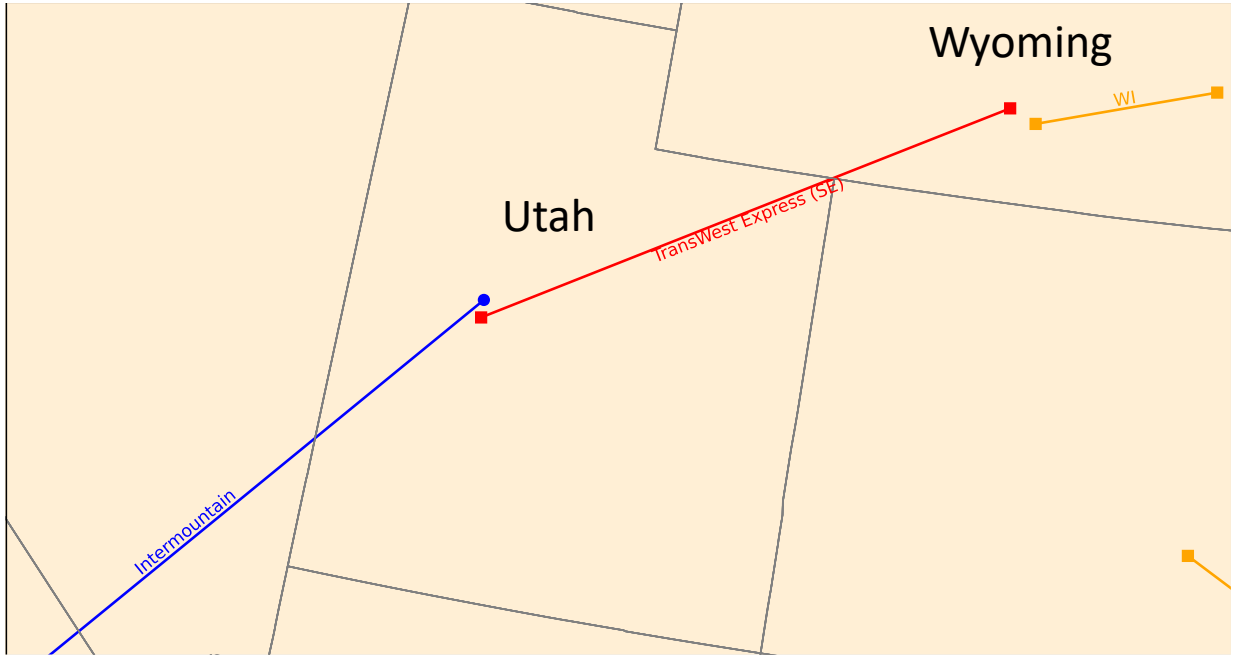
SunZia New Mexico to Arizona

- Developer is Pattern Energy, the converter supplier is Hitachi Energy
- Commissioning year 2025/2026 (Hitachi website (may 2024 press release), Recent Pattern submissions)
- NM (near Albuquerque)->AZ flow(Near Phoenix)
- 3000MW, ±525kV VSC, Bipole,
- 885km OHL, two triplex bluebird conductor bundles (525kV), two Lapwing return wires (85kV)
- Return wires can act as a DMR
- 3500MW SunZia wind project in New Mexico Two 1500MW AC chopper in NM for fault ride-through (DC and AC faults)(2s rating?)



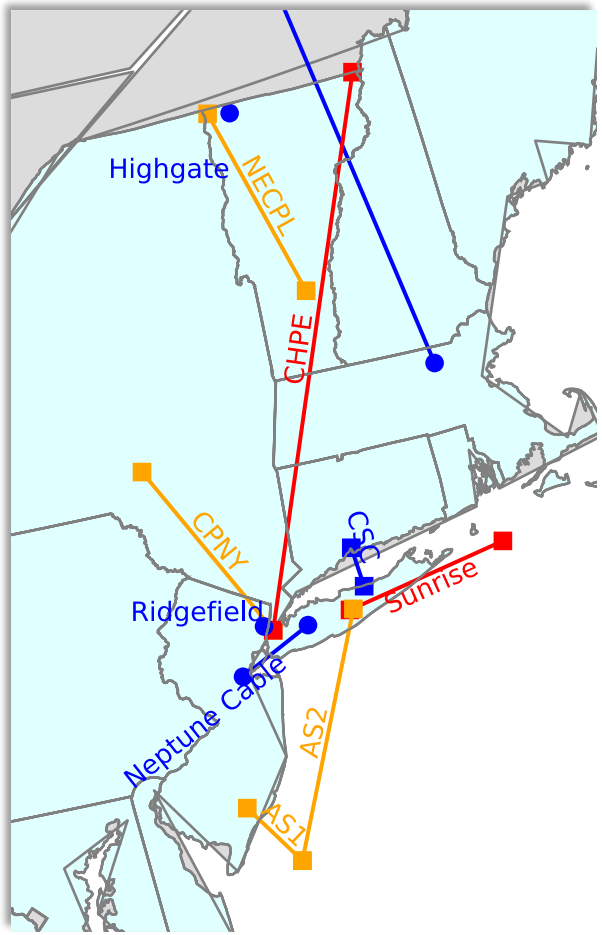
Trans West Express Wyoming to Utah (AC to Nevada)

- The converter supplier is Siemens Energy (2022)
- Site works started in 2024, commissioning year 2029 (final construction year on TWE website)
- Wyoming to Utah, 3000MW, ±600kV (?) VSC (?), Bipole (?) OHL
- Series compensated AC line from Utah to Nevada near Los Vegas)



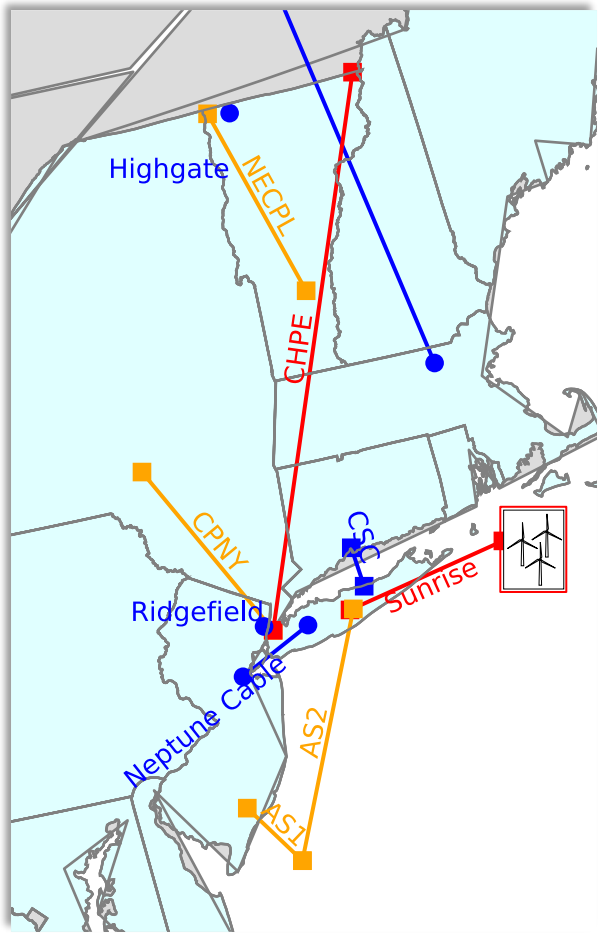
CHPE (Champlain Hudson Express) Quebec : New York

- The converter supplier is Hitachi Energy
- Commissioning year 2026 (Hitachi website)
- Quebec (Hertal) to New York City (Queens)
- 1250MW, ±400kV VSC
- 600km, Underground, including lake, river routes.



Sunrise : Offshore to New York (Long Island)

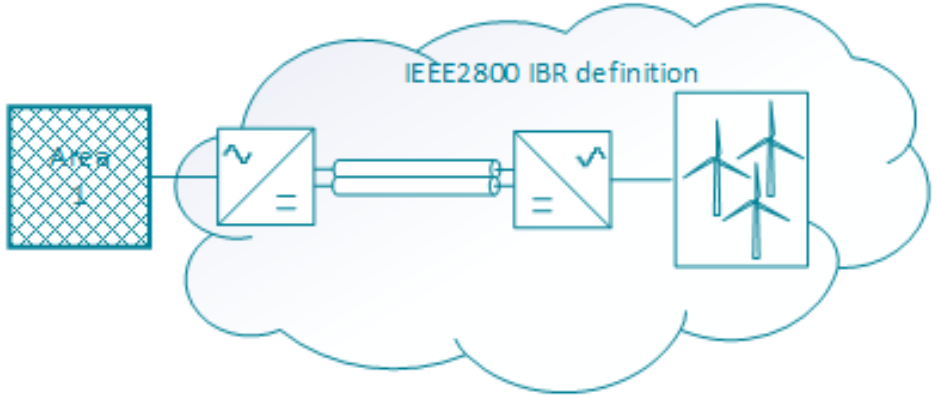
- The converter supplier is Siemens Energy (selected in 2021).
- Developed by Ørsted and Eversource.
- Initial contract with NYSEDA in 2019, 2023 asked for new terms (inflation costs), Orsted/Eversource final financial approval in 2024.
- Interface transformers reported to be delivered to site in 2024 (May)
- Offshore windfarm, to Long Island
- 924MW (windfarm) HVDC system, ±320kV VSC, 150km



US HVDC and standards

HVDC Standards

- There is no US equivalent to the EU HVDC Code.
- IEEE 2800-2022 *Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems*;
  - IEEE2800-2 Test and Verification
- EPRI (sponsored by SPP) *Recommendations for planning criteria, grid code performance, models and simulations tools*
- *DOE Wind Energy Technology Office Projects (awarded Sep 2023)*
  - Enabling HVDC Transmission and Offshore Wind via the Creation of HVDC Standards and Benchmark System Models (DNV)
  - DC Multi-Terminal Simulation (HVDC MultiSim) (GE)
  - Operation of Vendor-Agnostic Multi-Terminal DC-Based Offshore Wind Integration (Oak Ridge)



Project Objective

Step 1:

Review of international HVDC grid codes

3002027099 Planning Criteria and Performance Standards for HVDC: Review of International Codes

Step 2:

Recommendations for grid code requirements for HVDC systems

Grid Code Requirements

Performance Criteria for HVDC systems

Feasibility, Planning and Design Studies

Feasibility/Planning studies for AC performance
Design studies for confirming performance.

Power system data

Models and other information provided by SO.

Models

Preliminary and as built models, RMS and EMT format.

Grid Code Requirements

Performance Criteria for HVDC systems

1. **IEEE 2800-2022**
   Extended to other HVDC topologies
2. **Co-ordination**
   SO requirements will need to be coordinated with other RTO/ISOs
3. **Reactive power and voltage control and capacity**
4. **Active power control**
5. **Frequency**
   Ride through and control
6. **Stability**
   Power frequency, SSO, Converter Driven
7. **DC faults**
   Active power recovery
8. **UVRT**
   Ride through, current injection, active power recovery
9. **TOV**
   Ride through, current injection, active power recovery
10. **Power Quality**
    Harmonics, voltage step, unbalance
11. **EPC**
    Power limits, runbacks/ups
12. **Grid Forming**
    IF required….