Applications of High-Voltage Direct Current Transmission Technologies

Panel: US Project Case Studies
Anbaric Transmission

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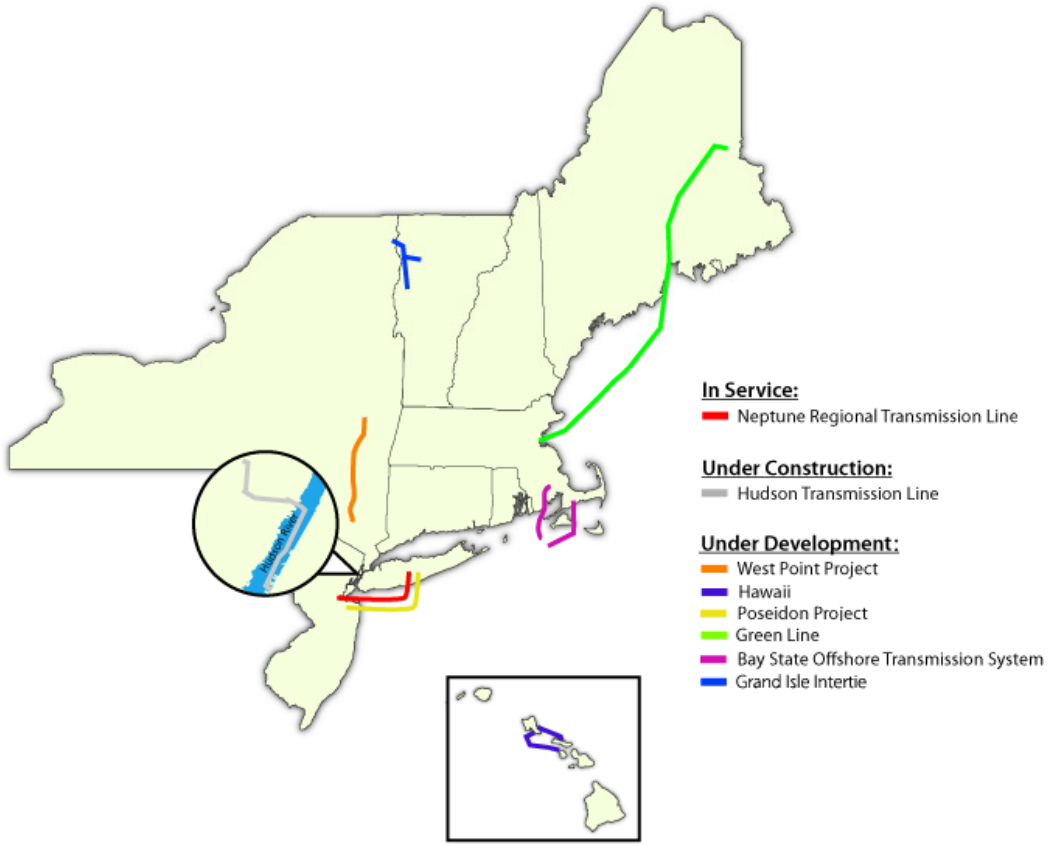
About Anbaric

- Anbaric Transmission – Independent developer of electric transmission lines in U.S. with German subsidiary (GOTIC) positioned to compete for the development of offshore transmission in Germany
- Anbaric Microgrids – specialize in early stage development small, medium and large scale microgrid projects
- Anbaric Transmission in the U.S.
  - Active in 6 to 8 transmission projects in the U.S.
  - Work with a variety of partners and associated project developers – most notably PowerBridge.

Anbaric Transmission Projects



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Projects for Today's Discussion

- Neptune Regional Transmission System
  - Anbaric is an original development partner, in association with the Atlantic Energy Partners… project managed, constructed, and operated by PowerBridge
- Hudson Transmission Project
  - Developed by Hudson Transmission Partners, a partnership of Anbaric, PowerBridge and Trident Partners.
- Green Line
  - Project by Anbaric, PowerBridge and The Cianbro Companies

Case Study Discussion Items

A. Transmission challenge that led to the proposed HVdc solution
B. Basic configuration and technology choice
C. Reasoning behind the decision
D. Key challenges encountered
E. Lessons learned

Neptune Regional Transmission

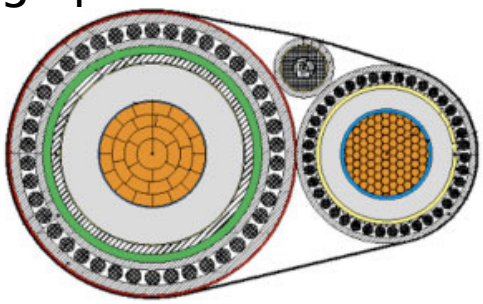
- Challenges
  - Highly congested area
  - Visually sensitive areas
  - Narrow terrestrial right of way
  - Limited/expensive sites
  - Regulatory treatment between two control areas – PJM/NYISO

Neptune Regional Transmission

- Technology and Configuration
  - Siemens conventional HVDC system
  - Prysmian 500kV mass-impregnated cable
  - 660MW transfer capability between direct current converter stations in Sayreville, NJ and North Hempstead, NY
  - 65 mile cable: 50 miles submarine – 15 miles underground

Prysmian Cable

- 500kV mass-impregnated cable paper wrapped
  - Consists of 3 cables:
    - 1) high-voltage ~ 5" diameter – 500kV carries up to 660MW;
    - 2) medium voltage "return" cable; and
    - 3) fiber-optic for system controls
  - In ocean bed – cables bundled and buried 4-6'
  - On land – cables in separate conduits and buried 3-4'



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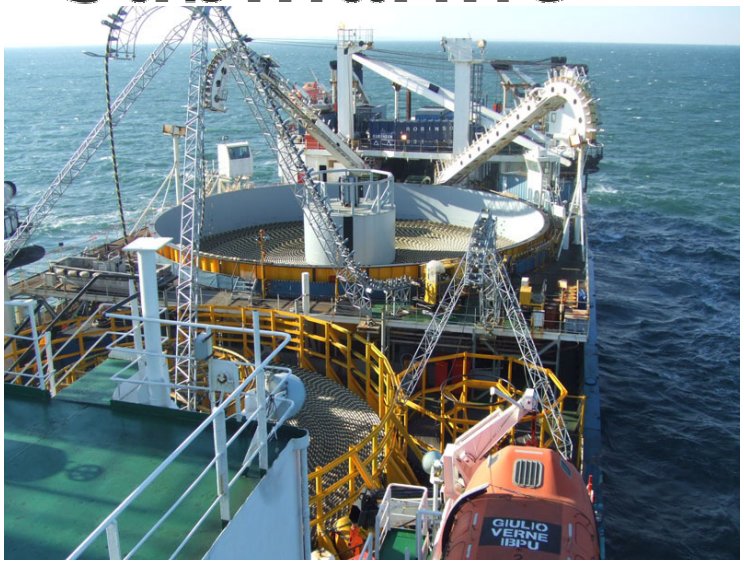
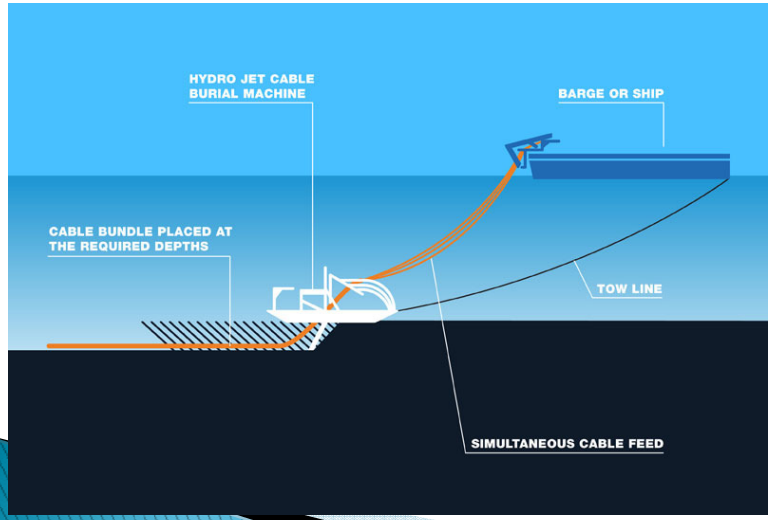
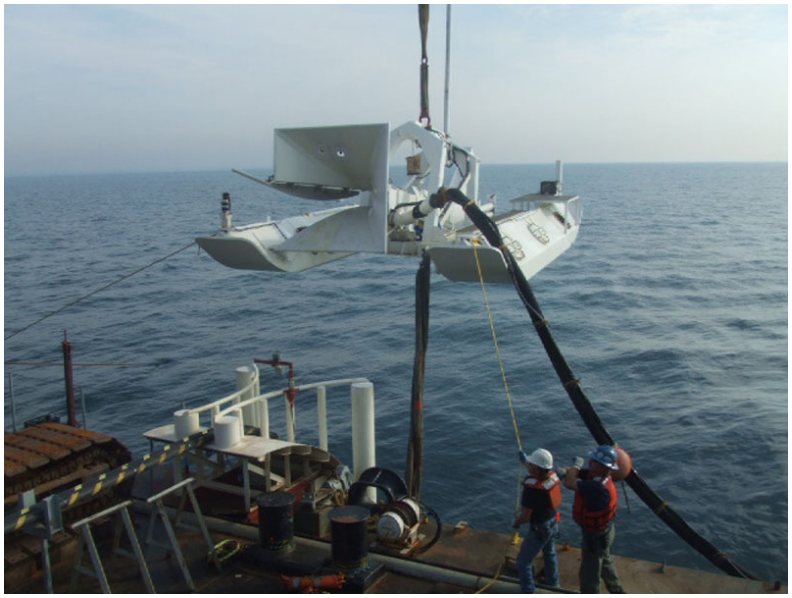
Cable Installation – Submarine







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Cable Installation – Terrestrial

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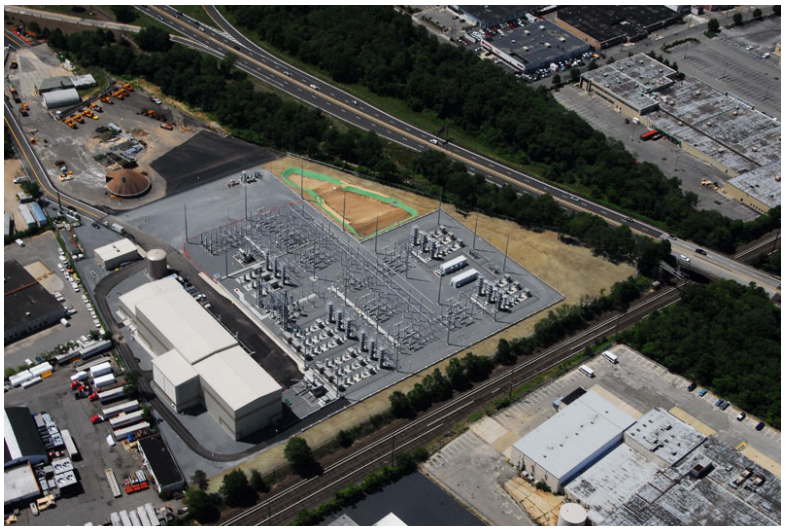
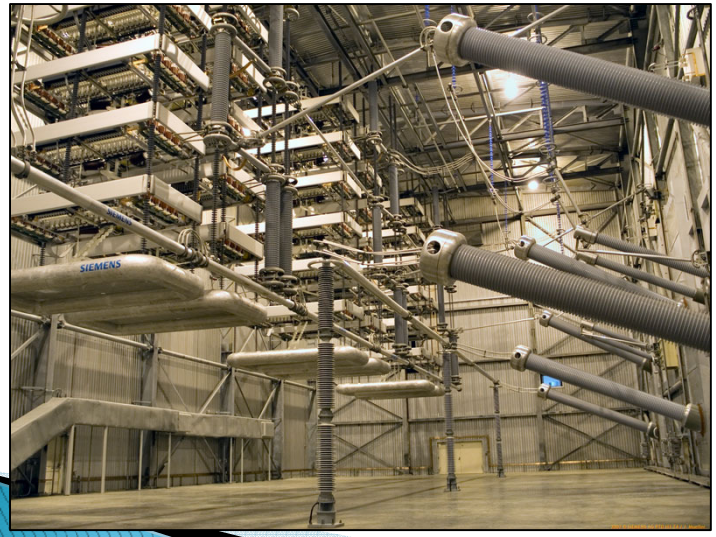
Converter Stations





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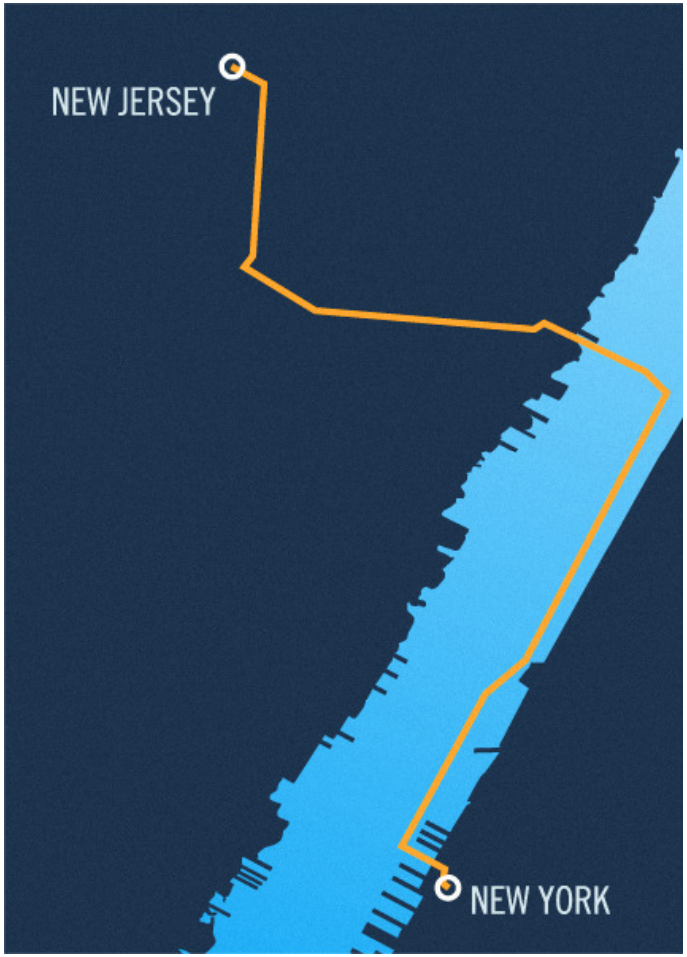
Hudson Transmission Project

- Summary
  - 660MW link between PSE&G substation in Ridgefield, NJ and ConEd substation at W.49th St. NYC PJM
  - NYPA customer
  - Transmission lines entirely underground (via railroad right of way) and underwater (under Hudson River ~ 3miles)
  - Construction start May 2011
  - Commercial operation mid-2013
  - Includes upgrades to the NJ transmission system



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Hudson Transmission Project

- Technology and Configuration
  - 230 kV cable from PSE&G substation to
  - Back-to-back (AC-DC-AC) converter station
  - 345kV underground cable 3 miles to Hudson River
  - Transition from upland cable to submarine cable
  - Submarine cable buried 10 to 15 feet below Hudson River for 4 miles
  - Transition to upland cable to run along West Side Highway from W52nd St. to W49th St.

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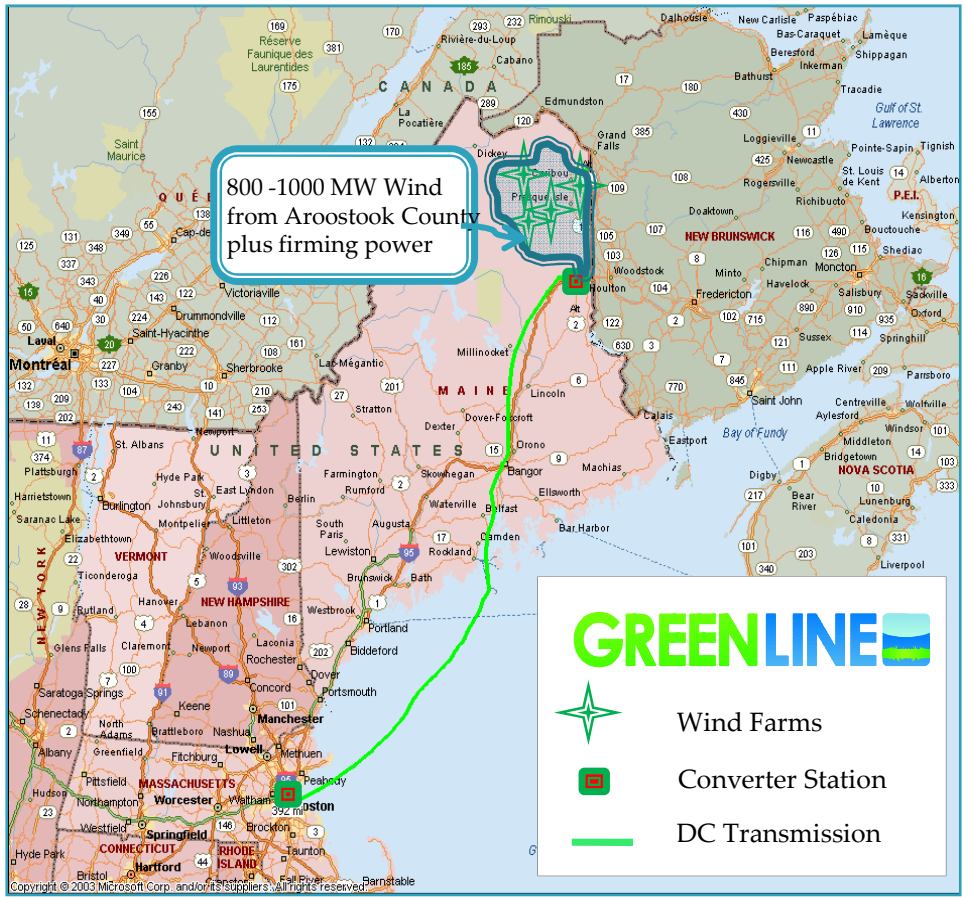
Hudson Transmission Project

- Challenges
  - No room for converter station in NYC
  - Narrow terrestrial right of way
  - Limited/expensive sites
  - Regulatory treatment between two control areas – PJM/NYISO

Green Line

- HVDC transmission system with transfer capability of 800 -1000 MW
- 300+ miles of overhead and submarine conductors between northern Maine and Boston
- 800-1000 MW of wind from northern Maine
- Firming power potential from eastern Canadian resources



Green Line

- Challenges
  - Length of transmission line
  - Combination of OH, UG, and Sub transmission
  - Visually sensitive areas
  - Narrow terrestrial right of way
  - System strength of interconnection locations

Green Line Considerations

- Transfer capability and conductor sizes
- Cost and constructability
- Narrow terrestrial right of way
- Strength of grid interconnection points
- Technological advancement with HVDC systems, i.e. compatibility of VSC technology with overhead conductors and the development of DC breakers
- Submarine cable routing
- Converter station footprint and appearance

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