

ALSTOM Grid HVDC Tres Amigas and VSC Technology

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July 2011

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The Tres Amigas Superstation

Tres Amigas – Overview



TA's transmission capacity creates market opportunities where none exist today

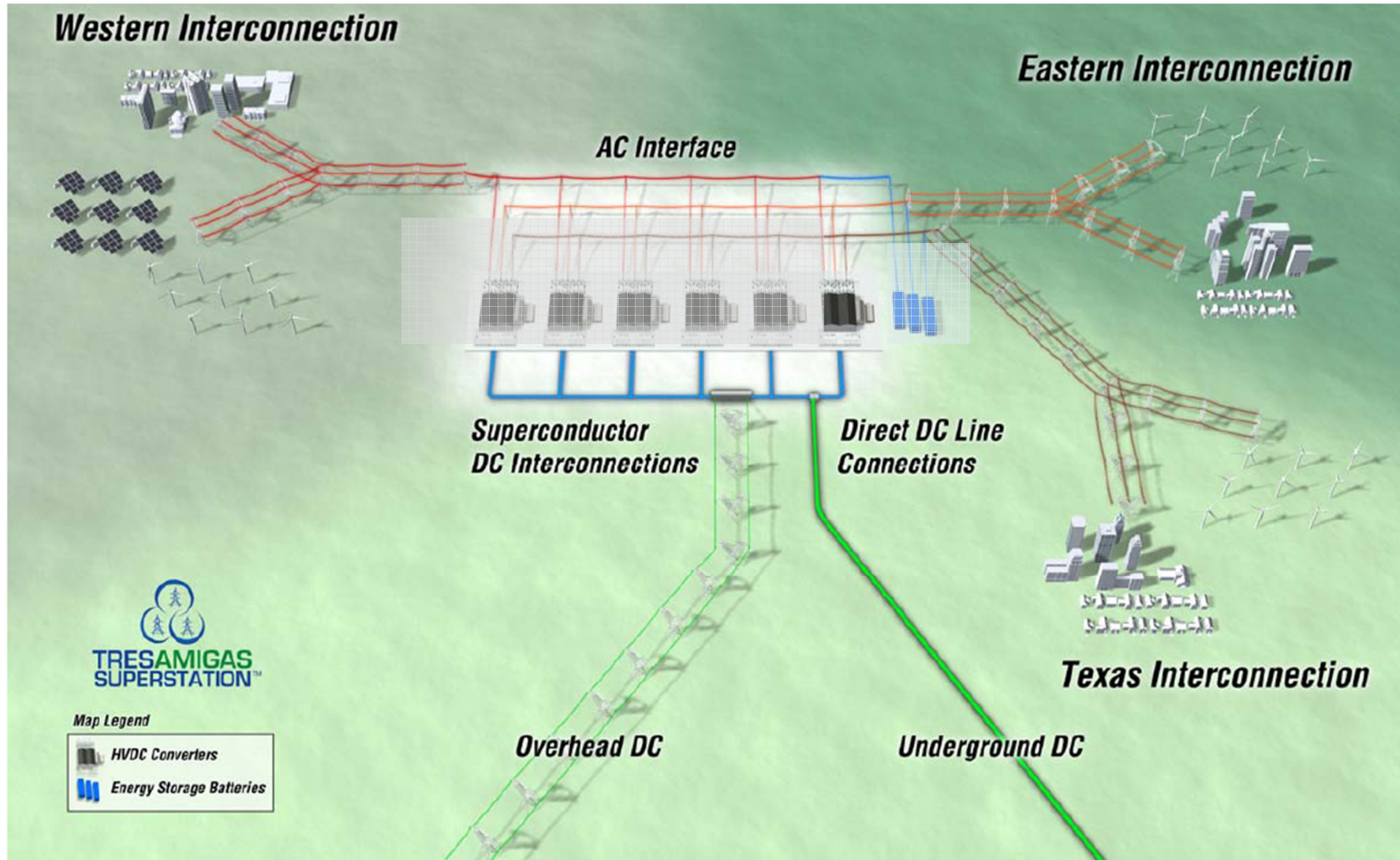
- Tres Amigas (TA) is a three-way AC/ DC merchant transmission project, located in Clovis, New Mexico, interconnecting the Western Electricity Coordinating Council (WECC), the Electric Reliability Council of Texas (ERCOT), and the Eastern Interconnection (through the Southwest Power Pool (SPP))

TA is designed to be expanded as economic and transmission opportunities develop

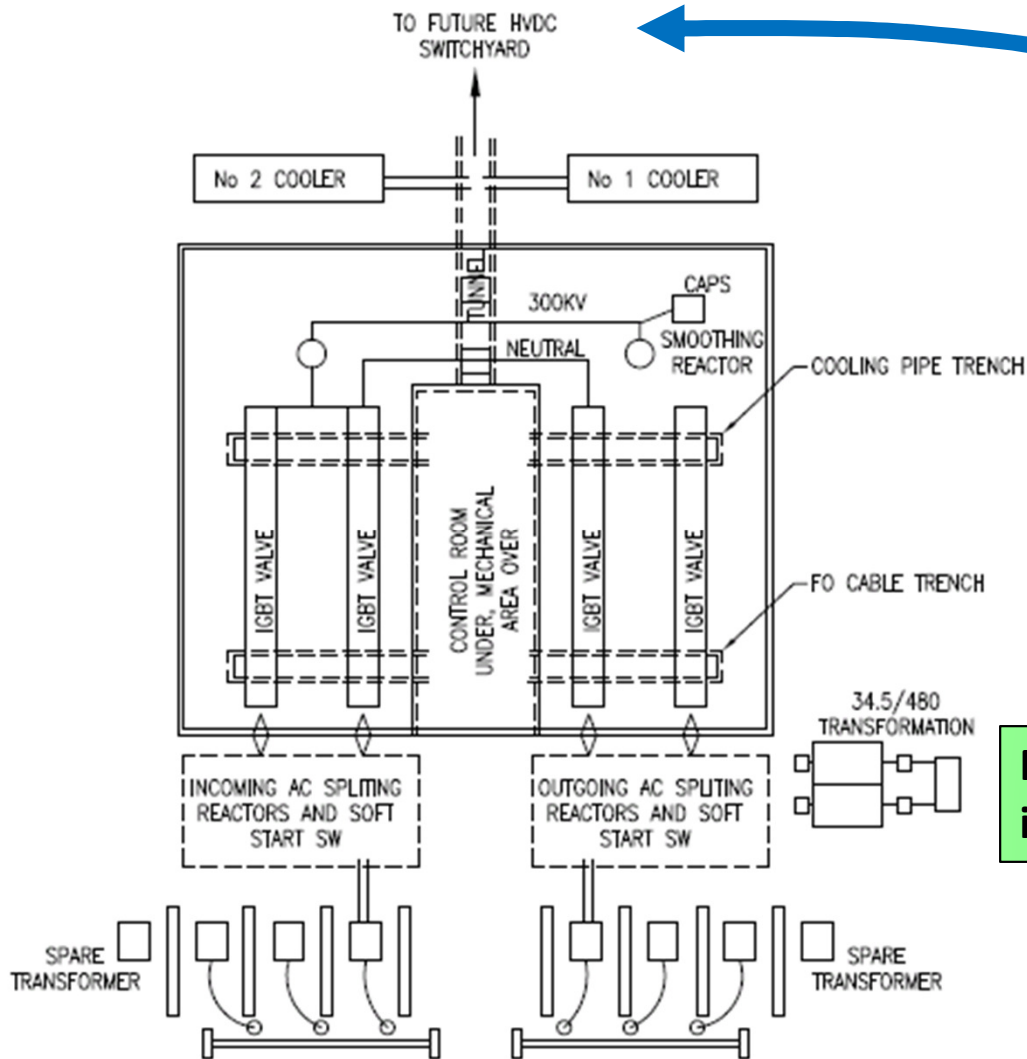
- Phase 1 will be a two-node (WECC ⇔ SPP) intertie, at 750 MW scale in order to take advantage of existing pricing and takeaway capacity
- Phase 2 will be an ERCOT ⇔ SPP intertie at 750 MW scale which will also provide ERCOT – WECC transfer capabilities
- Phase 3 will be a direct 750 MW ERCOT ⇔ WECC intertie
- Phase 4 will add a 2 GW SPP ⇔ ERCOT interconnection
- TA can be scaled to 30 GW

TA received FERC authorization in March 2010 to sell transmission service at negotiated rates

First Phase Scope of Construction

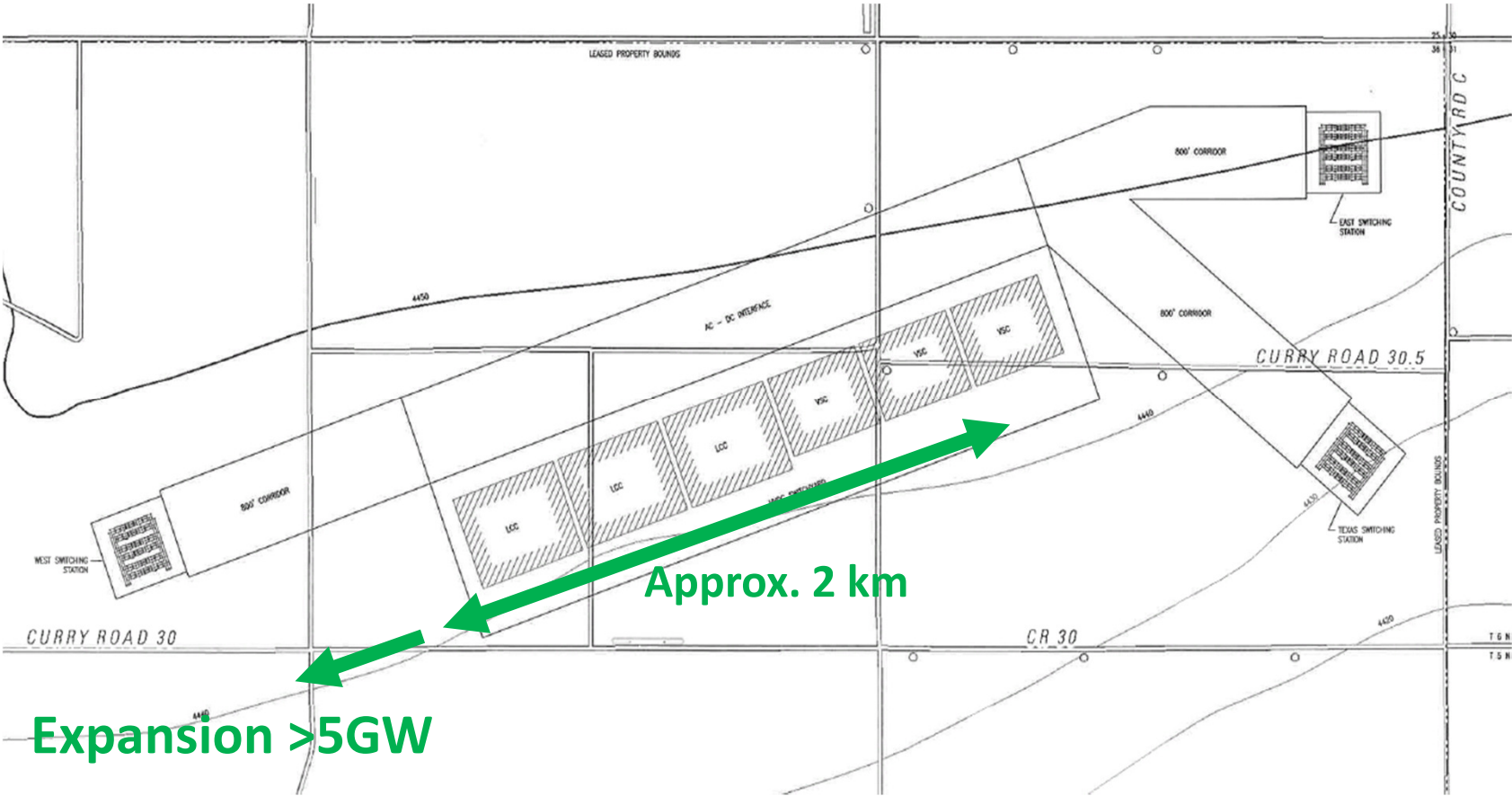


Folded Back-to-Back Converter Layout



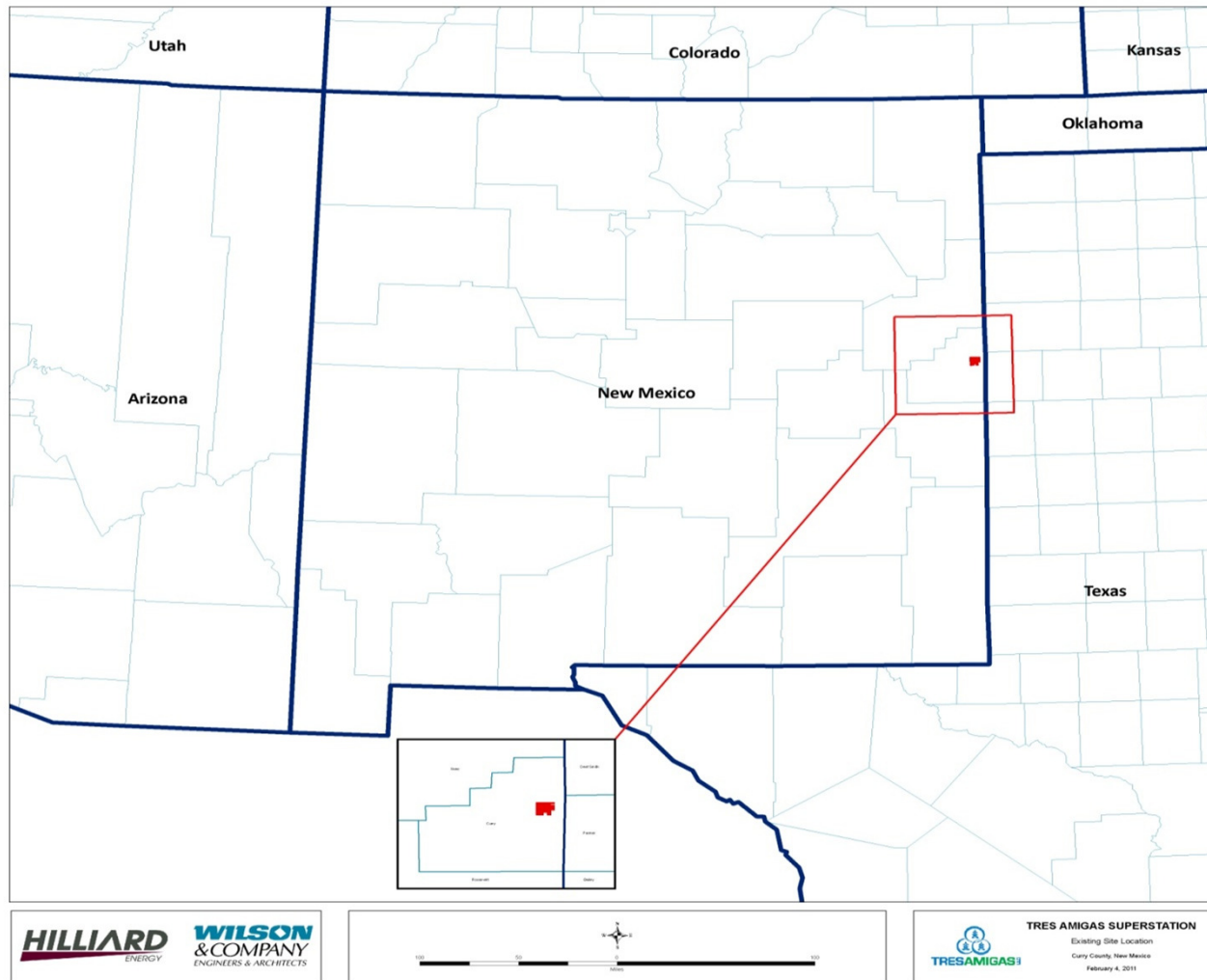
Provides for AC and DC/ HTS bus interconnections

Tres Amigas Ultimate Build Out- Detail

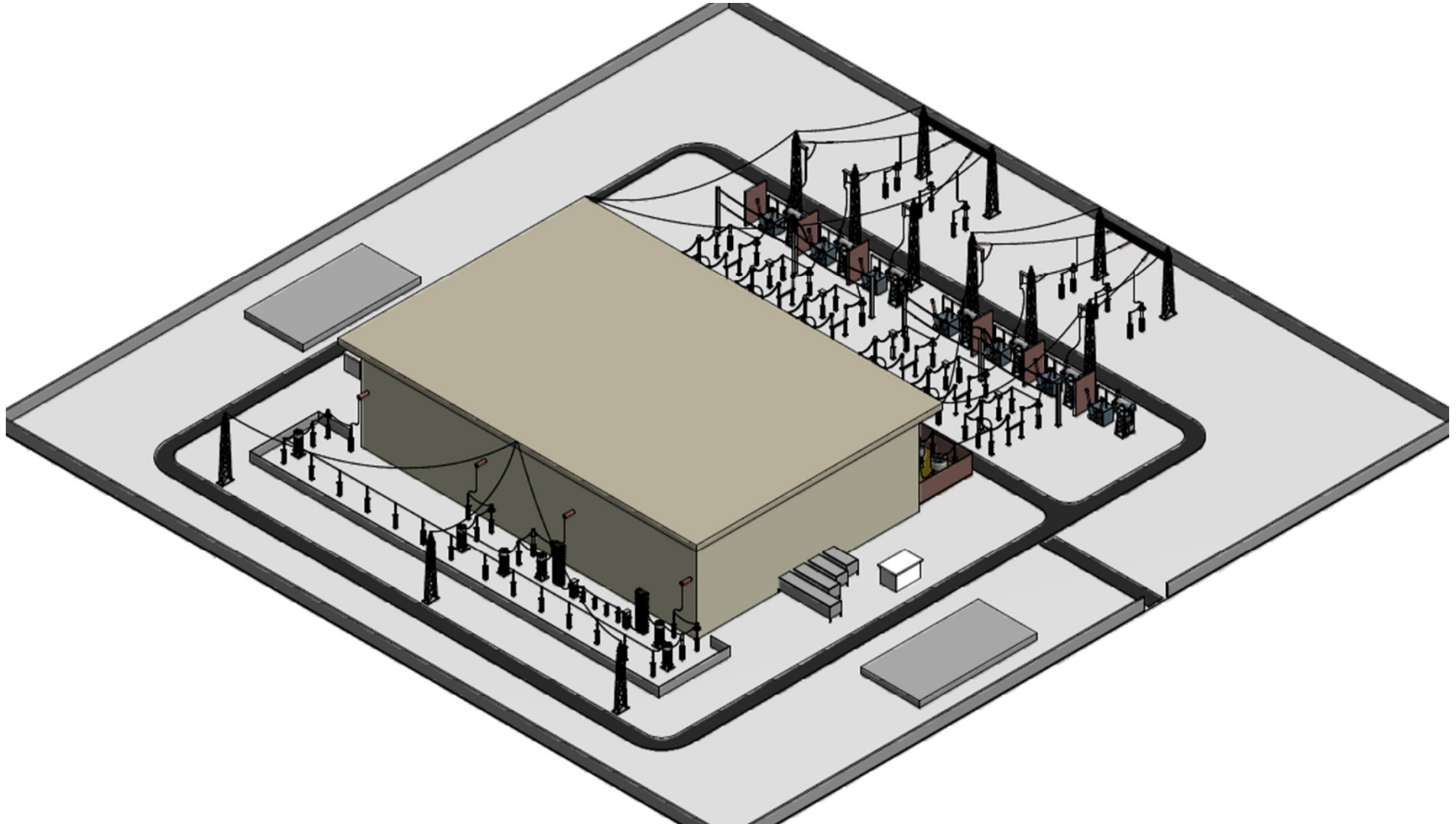


Full 5GW build out allows for high current DC bus

Site Location in New Mexico



Tres Amigas Back to Back Layout



What is VSC Transmission

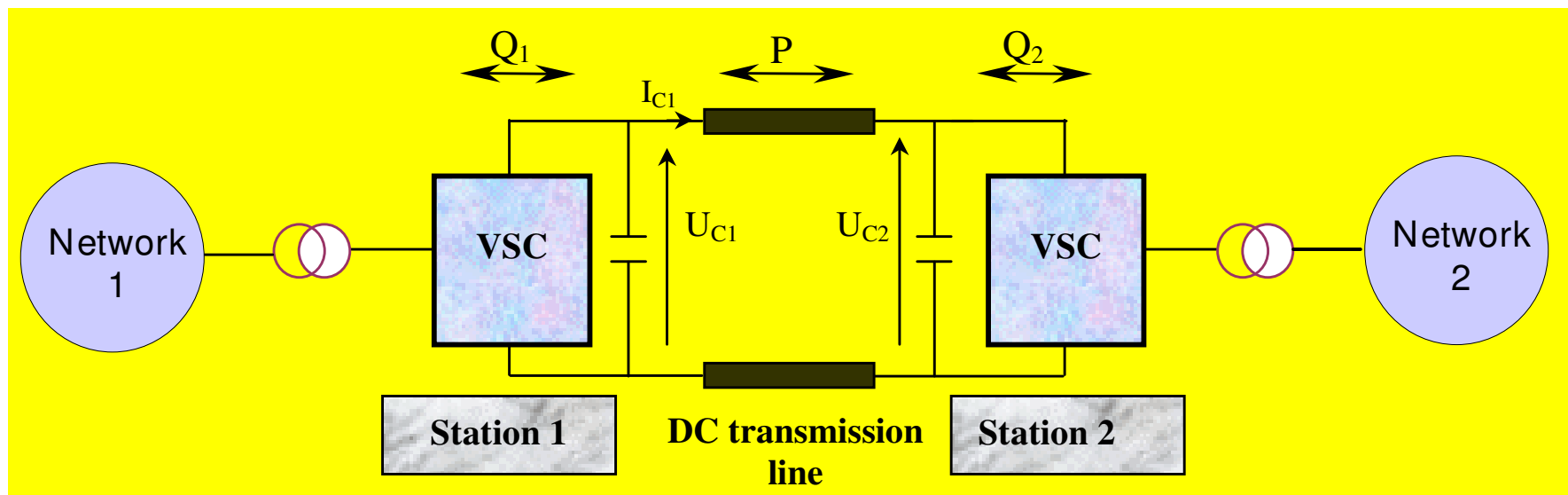
VSC = Voltage Source Converter

Capacitor is normally used as energy storage

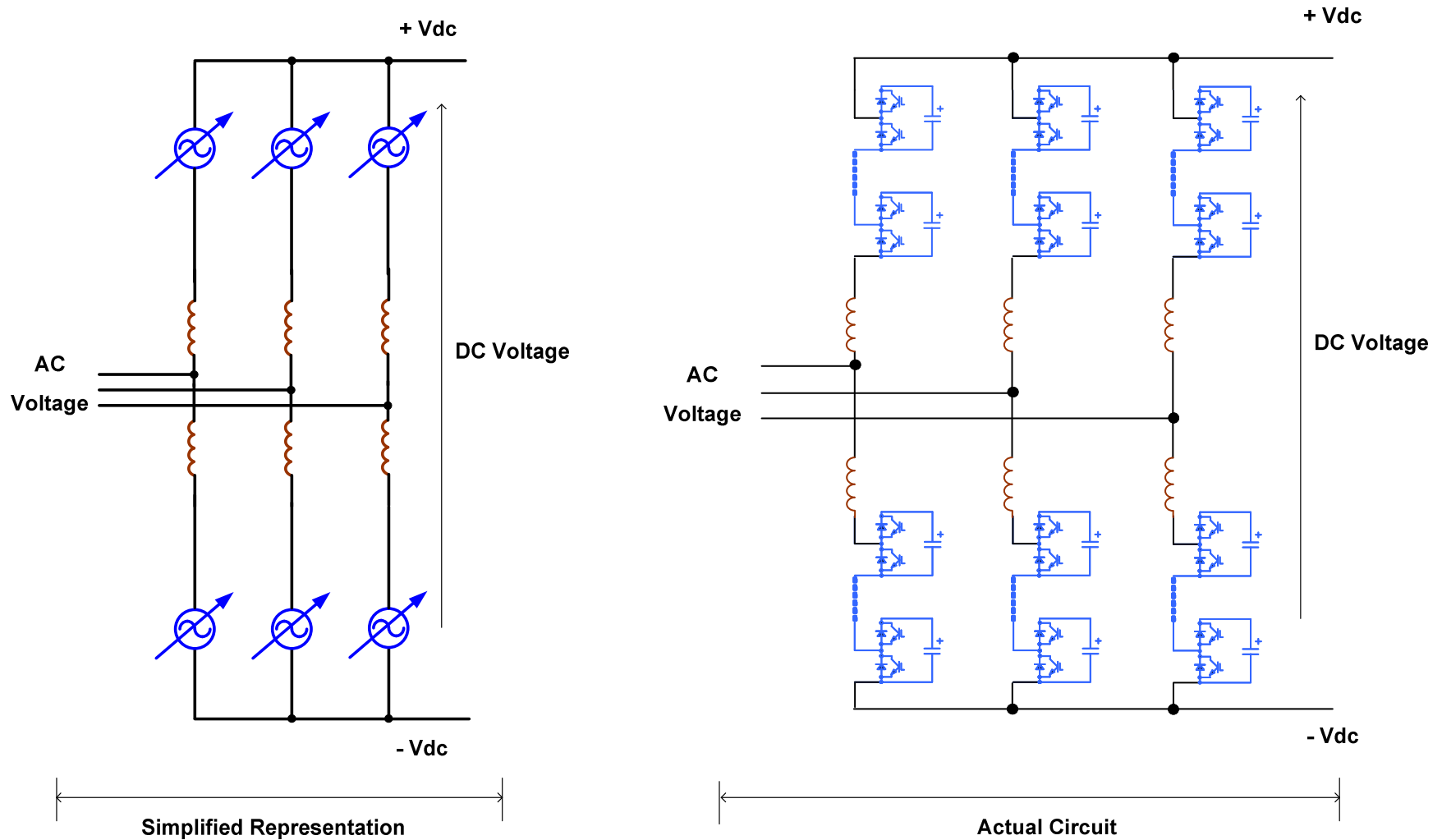
VSC uses a self-commutated switching device such as

- **GTO (Gate Turn Off Thyristor) - as used on ALSTOM STATCOM**
- **IGBT (Insulated Gate Bipolar Transistor)**

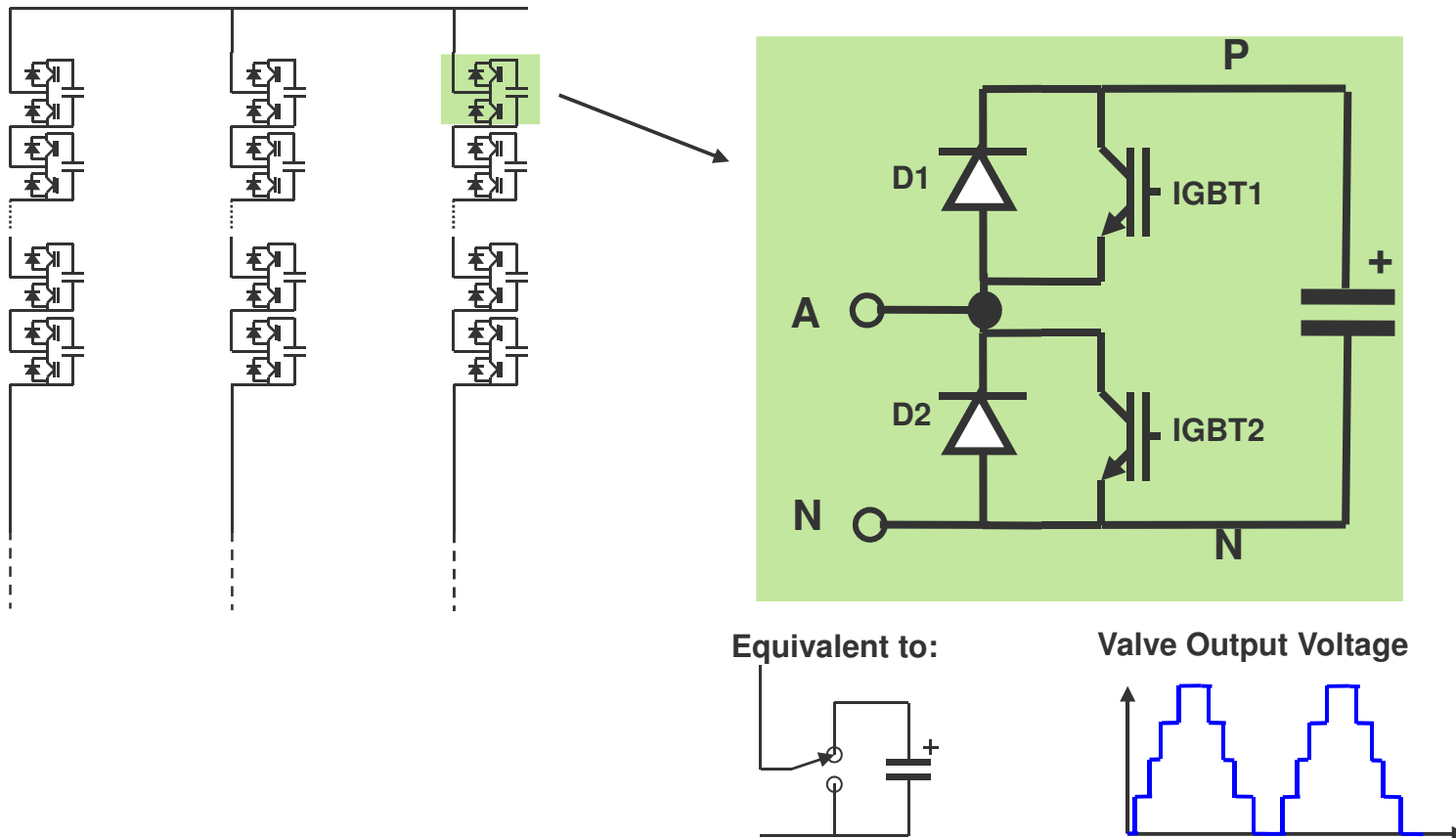
VSC generates its own AC voltage with controlled amplitude and phase angle



Equivalent Converter Circuit for a MaxSine Half-Bridge Converter



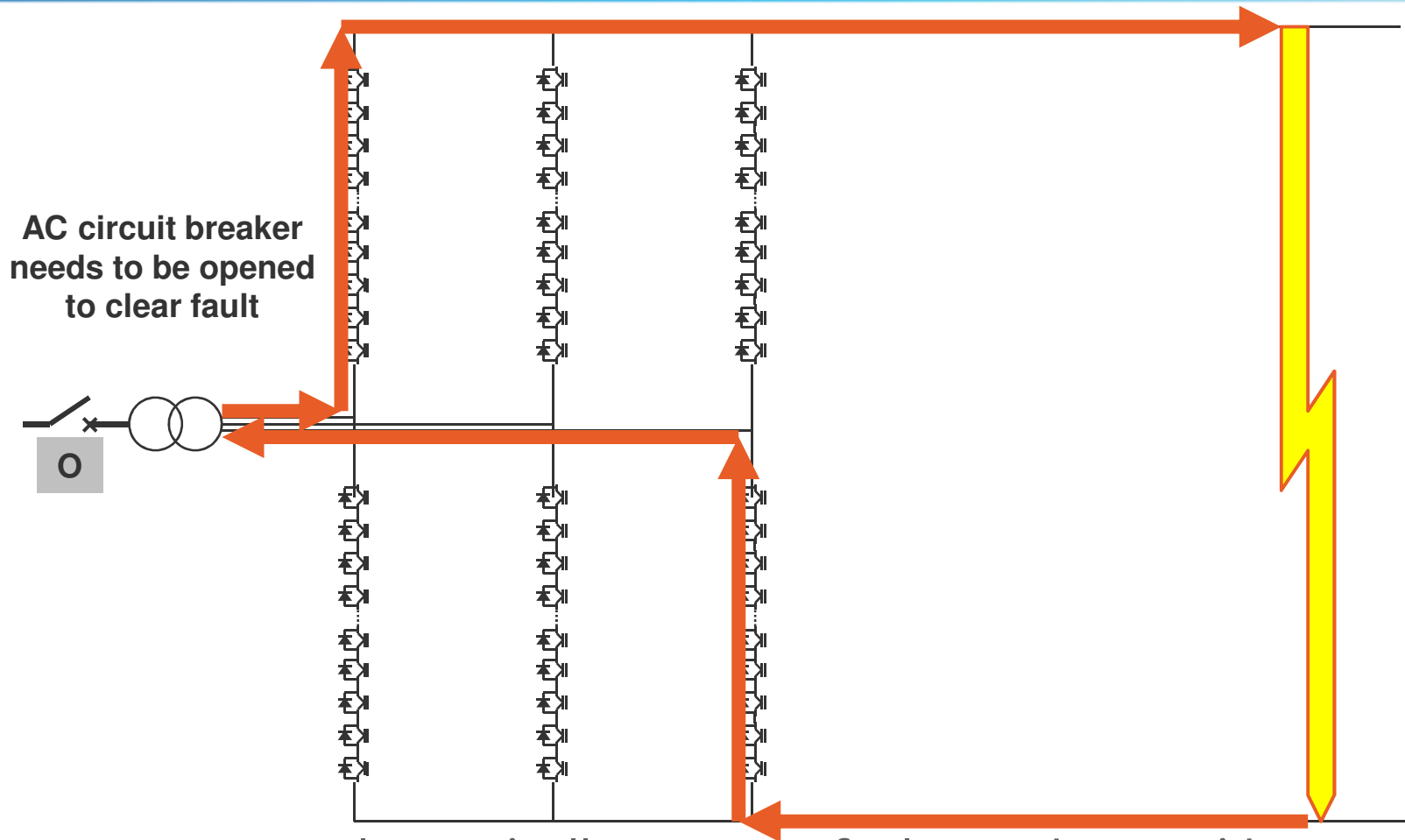
MaxSine Modular Multi-Level Converter with series-connected half-chain links



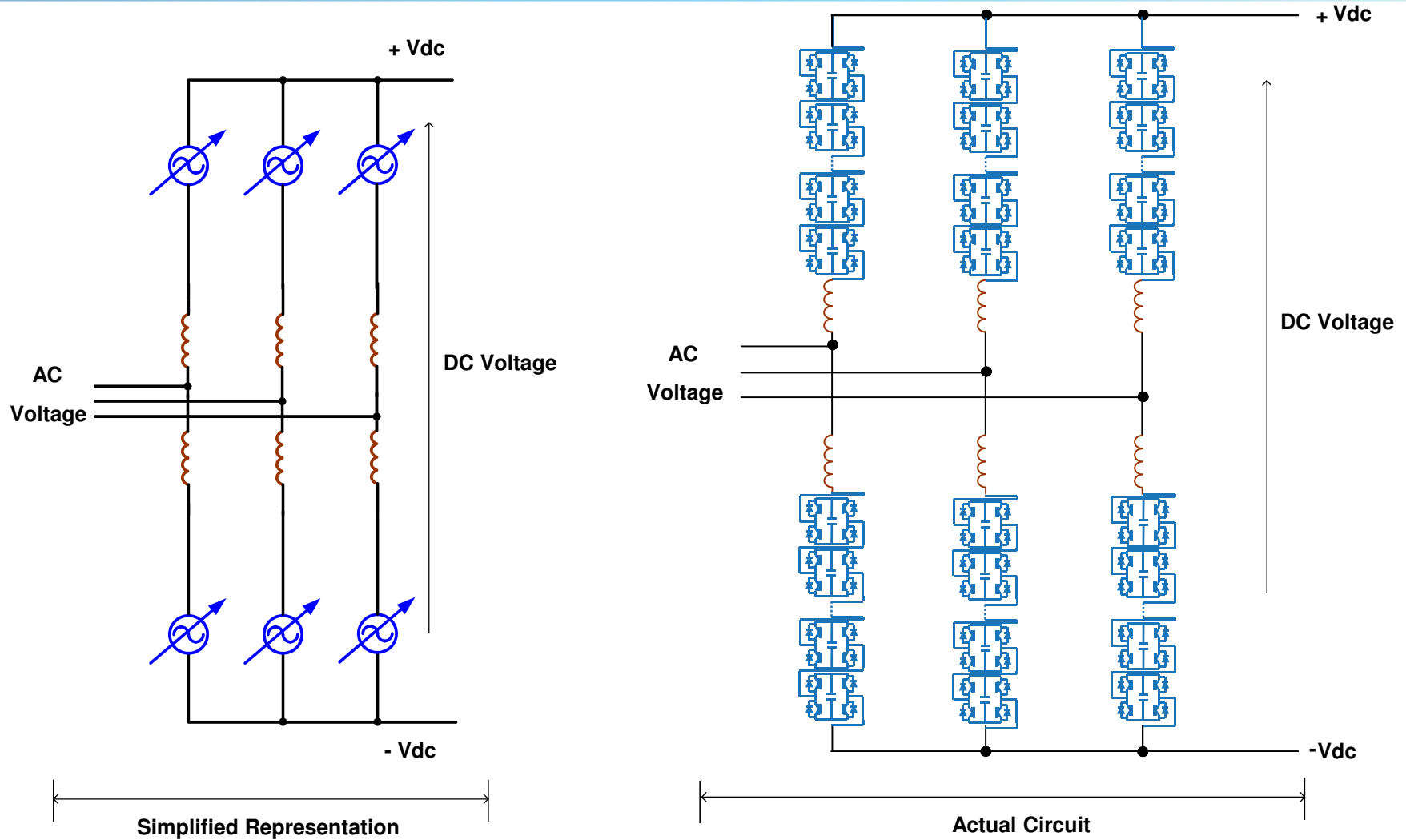
Cannot electronically suppress faults on the DC side.

Need to open the AC circuit breaker to clear DC fault.

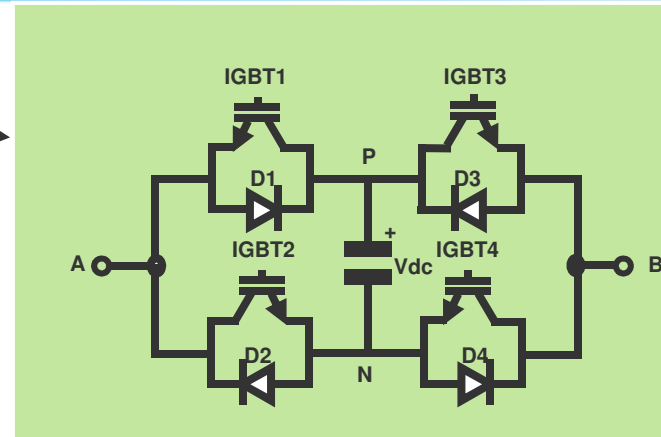
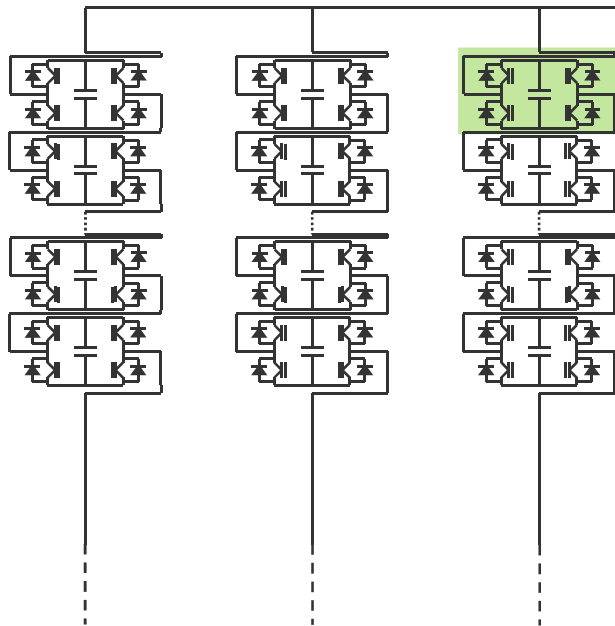
MaxSine Modular Multi-Level (Half-Bridge) Response to fault on DC side



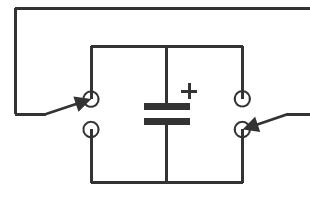
Equivalent Converter Circuit for a MaxSine Full-Bridge Converter



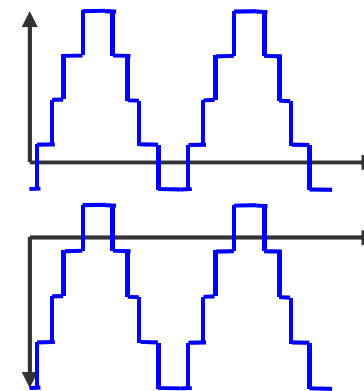
MaxSine Modular Multi-Level Converter with series-connected full-chain links



Equivalent to:

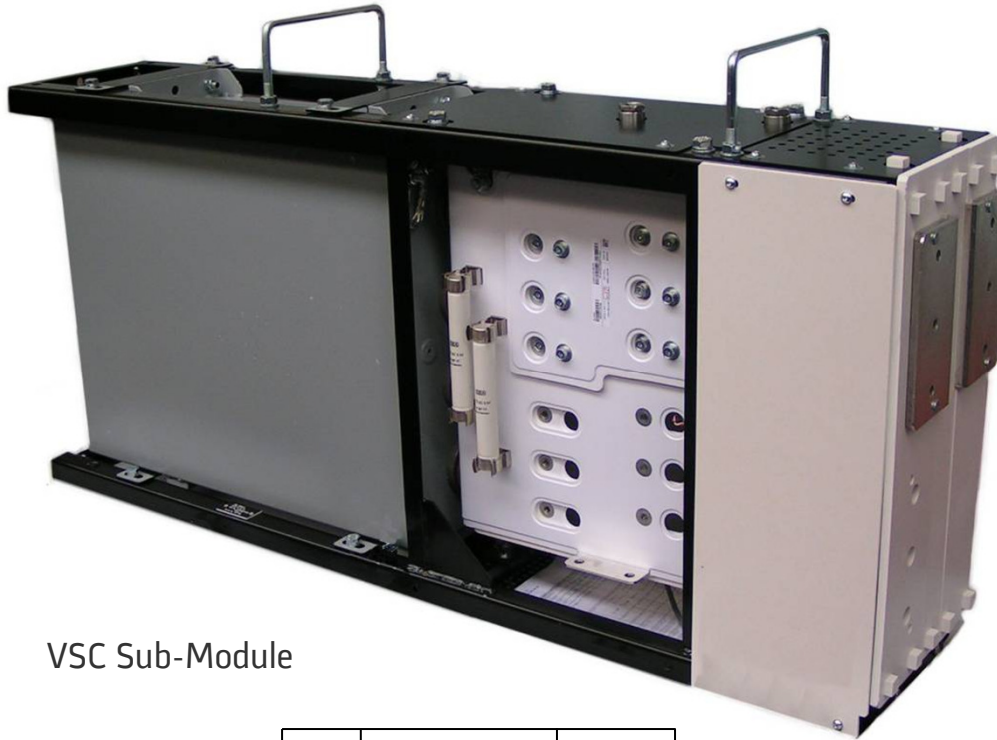


Valve Output Voltage



Can suppress faults on the DC side

VSC Valves - Sub-module Components



VSC Sub-Module



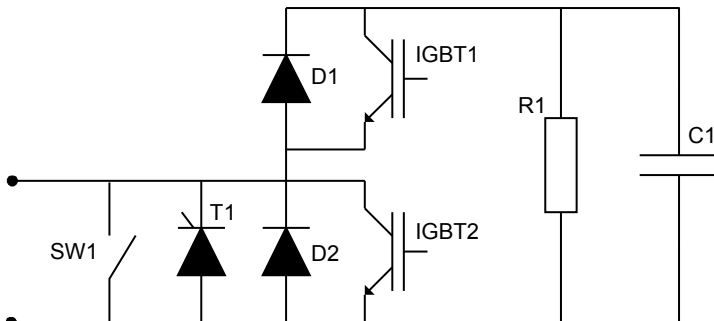
Inter Sub-module Connector



Bypass Switch



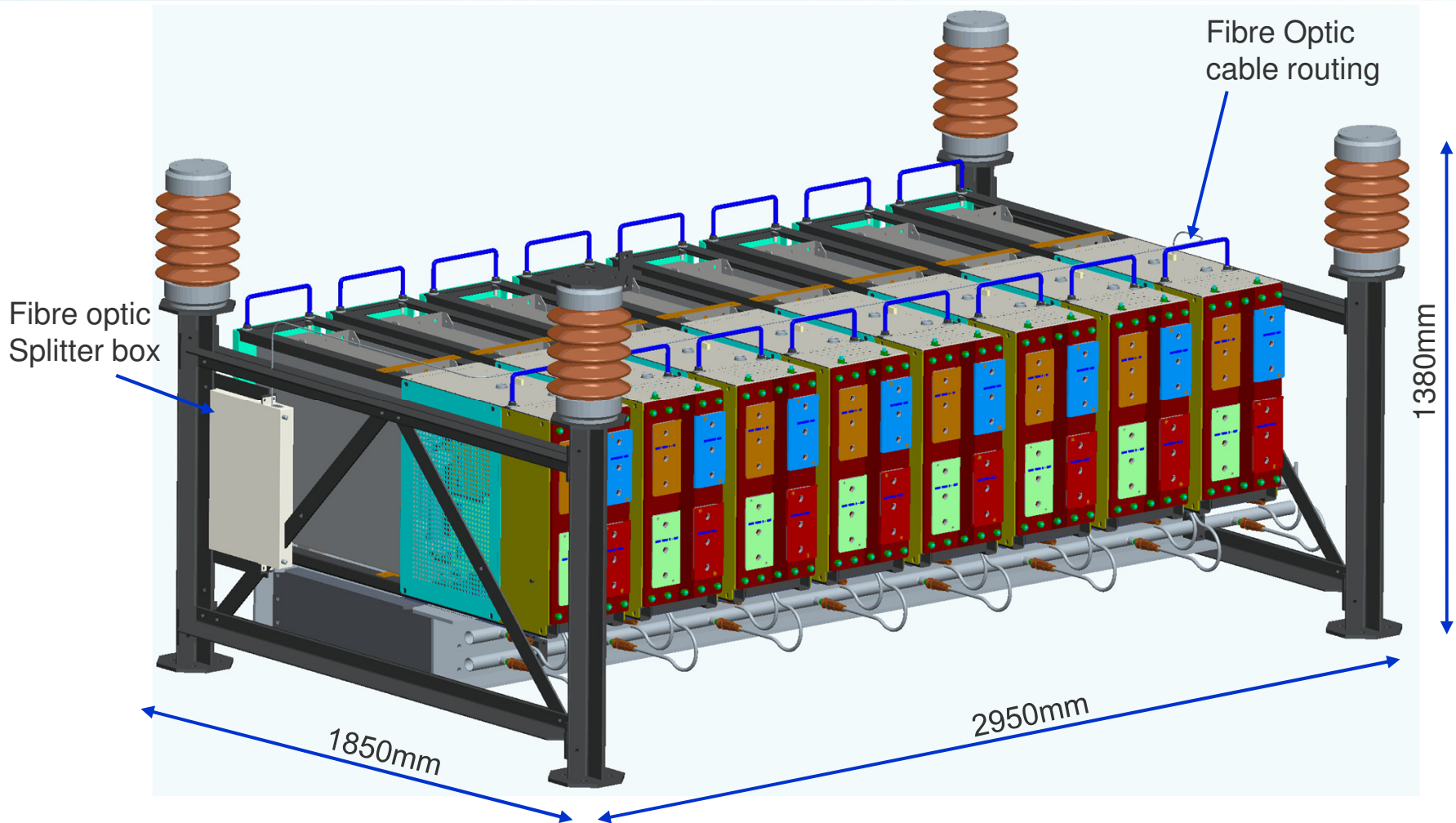
IGBT



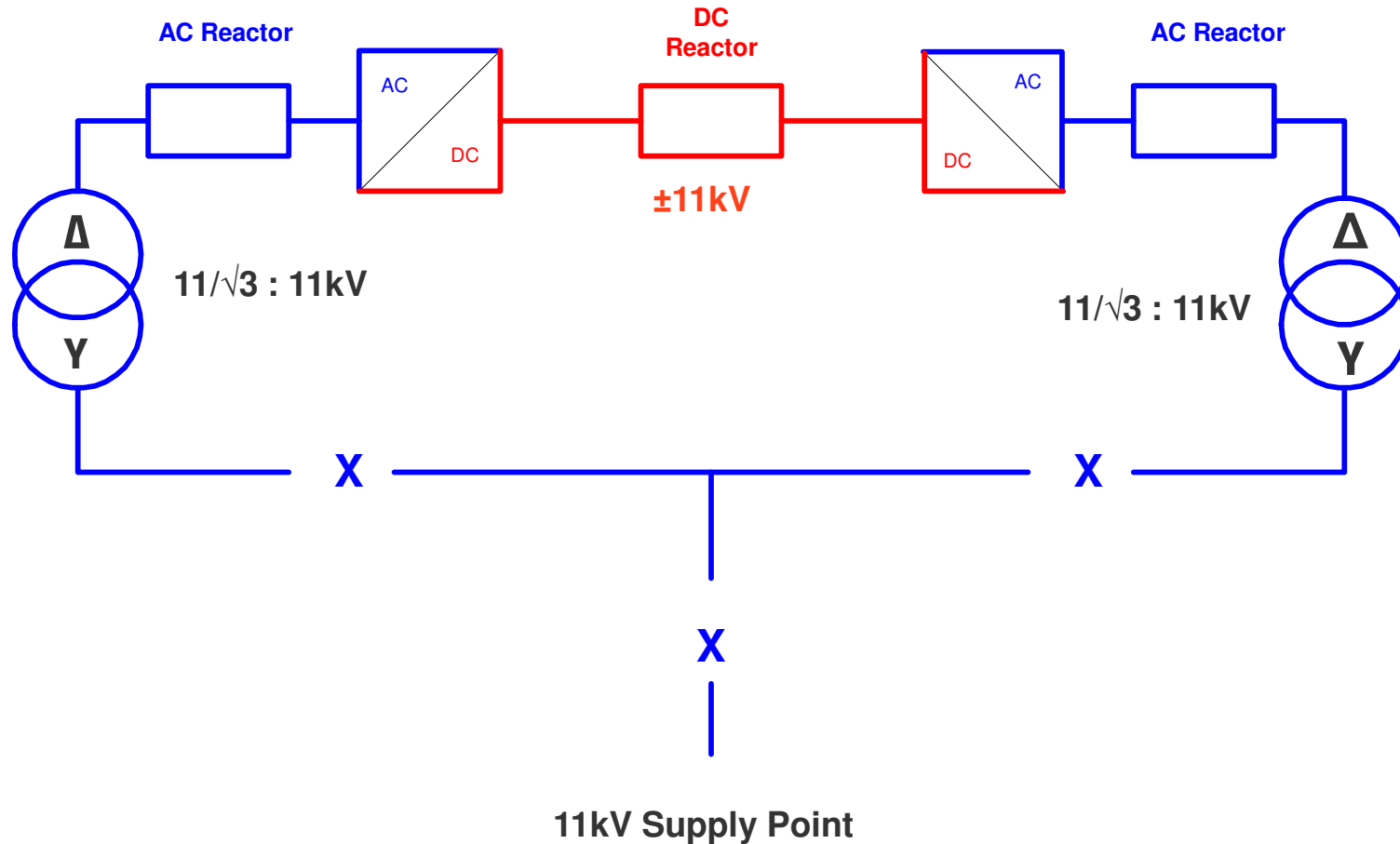
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Power Module Tier Assembly



25MW Demonstrator – Single Line Diagram



HVDC - VSC Development Centre – Stafford, UK



VSC Valve Hall



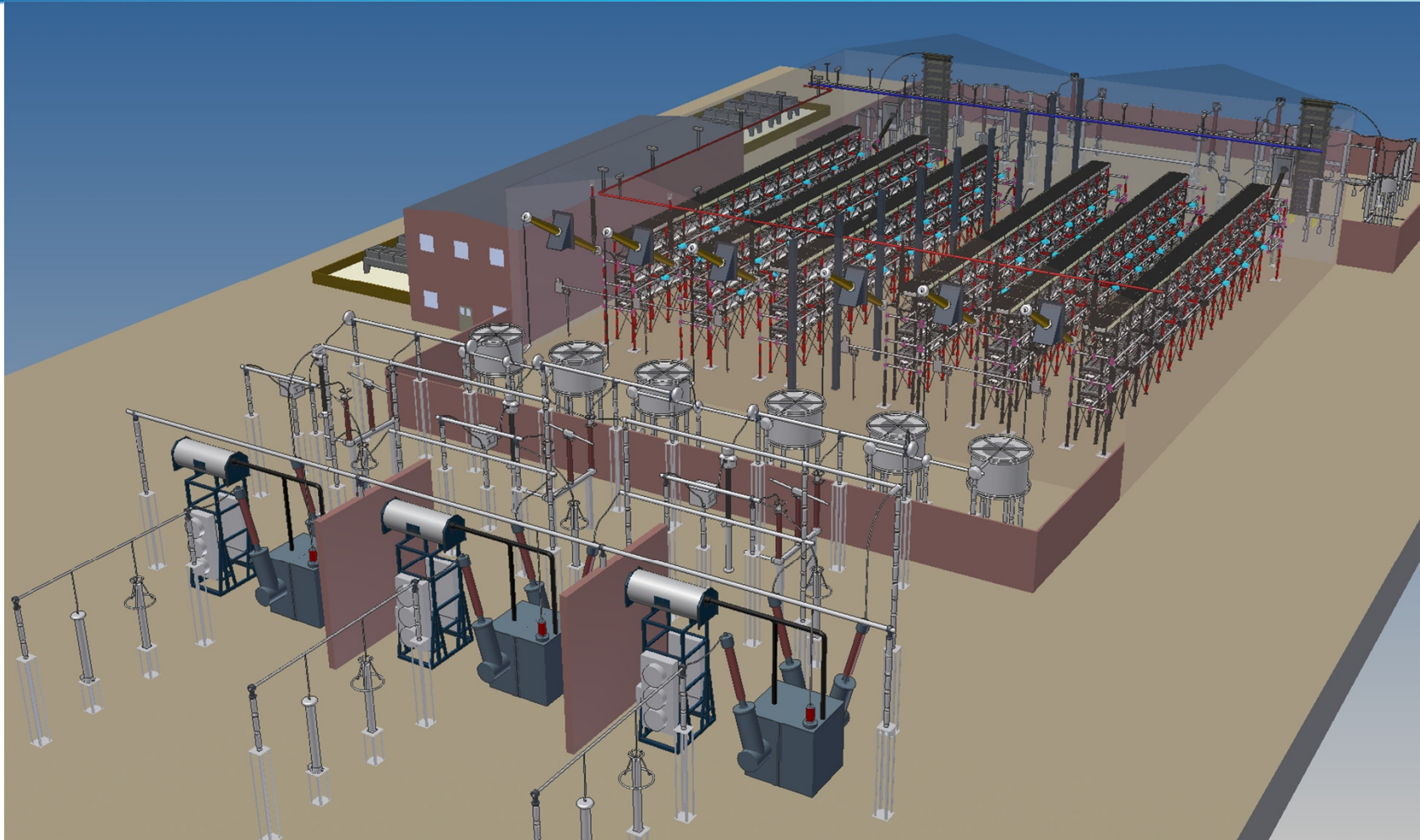
VSC Controls



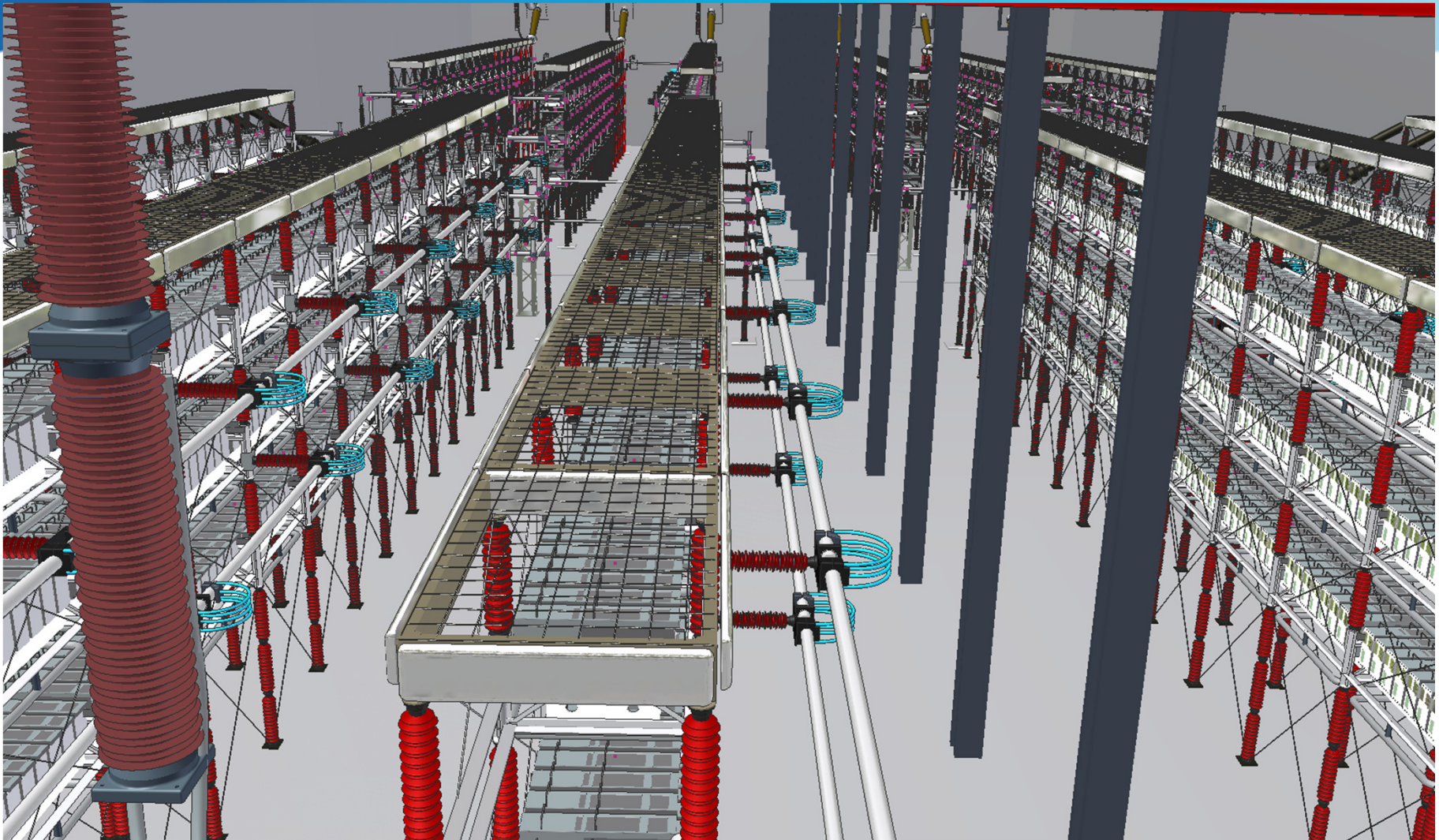
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VSC Station Layout



VSC Station Layout



Tres Amigas Super-Station



Project in Development

Multi-directional facility for renewable energy exchange between regions

Stage 1

- Interconnection between WECC and Eastern Interconnected System
- 750 MW VSC BTB

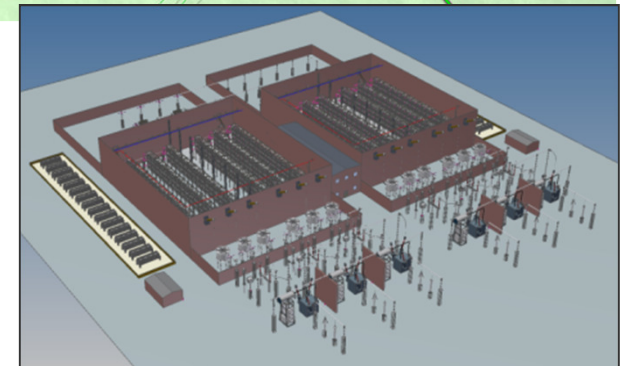
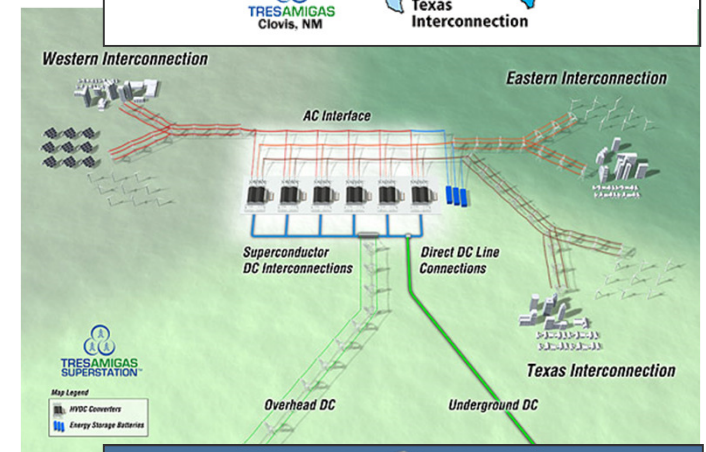
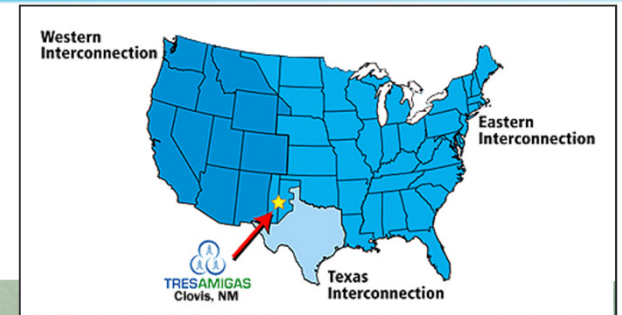
Future Stages

- Future link with ERCOT to be added
- Additional capacity for all directions
- 2 x 750 MW VSC BTB
- 3 x 920 MW LCC BTB

Exposed DC Busbar for future creation of multi-terminal with superconductor bus

Battery Storage included

Auxiliary power from renewable generation



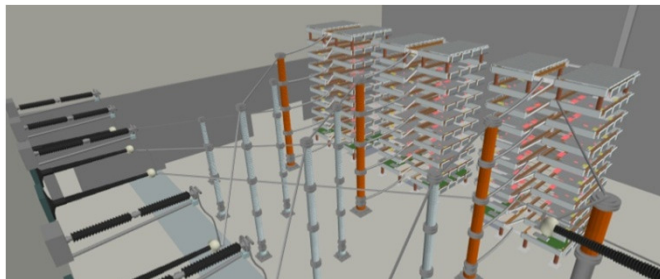
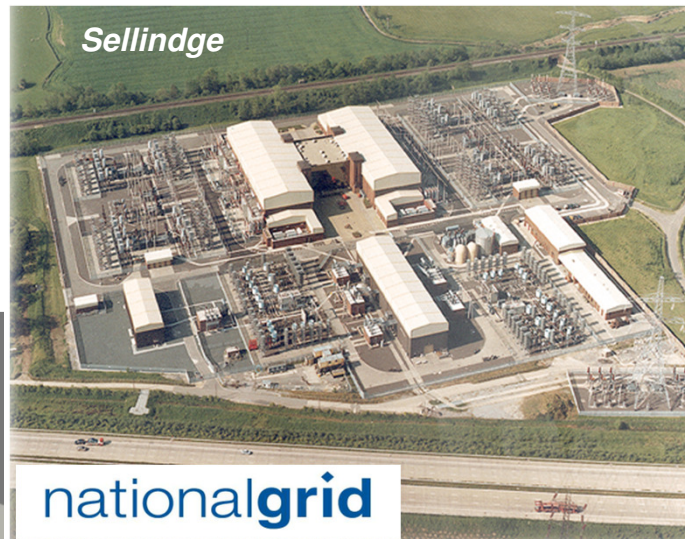
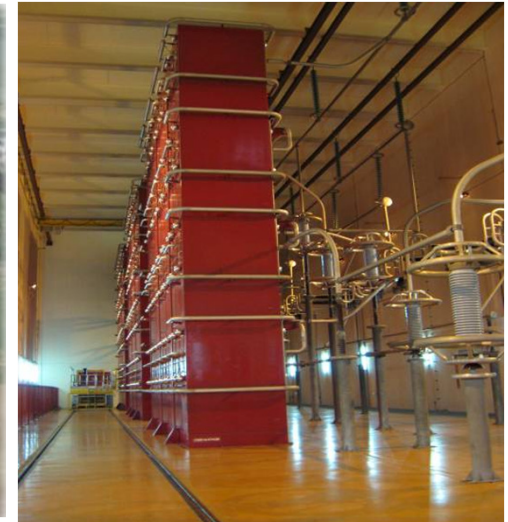
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IFA 2000 : Valve + Controls replacement

Cross-Channel 2000MW submarine inter-connector

- RTE/NGrid will replace
 - Air cooled thyristor valves
 - Valve cooling plant
 - Control and protection system
- Order placed June 2008
- Bipole 1 replacement 2011
- Bipole 2 replacement 2012
- 7 week outage for each replacement
- Alstom supplied original project in 1985/86

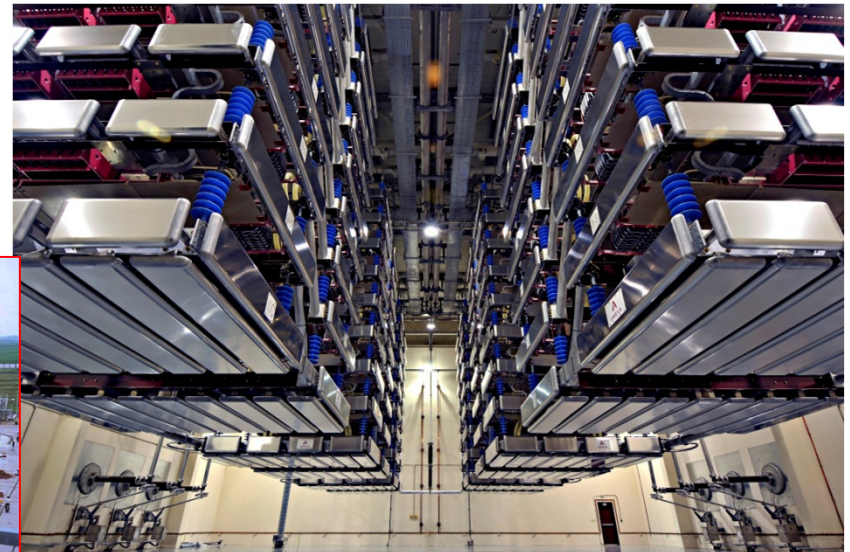


MELO : Back – to – Back Project

Melo – Uruguay

- **Interconnection between :**
 - 500kV 50Hz Uruguay
 - 525kV 60Hz Brazil
- **500MW Pole Rating**
 - ± 80 kV DC Voltage
 - 3125A DC Current
- **Turn-key project**
 - 31 months

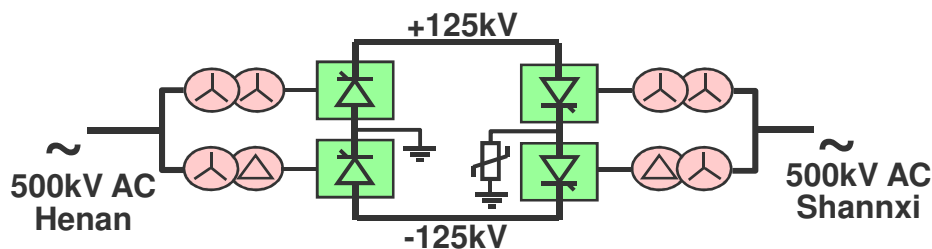
Rivera 80MW BtB project supplied by ALSTOM in 2001



China HVDC Projects

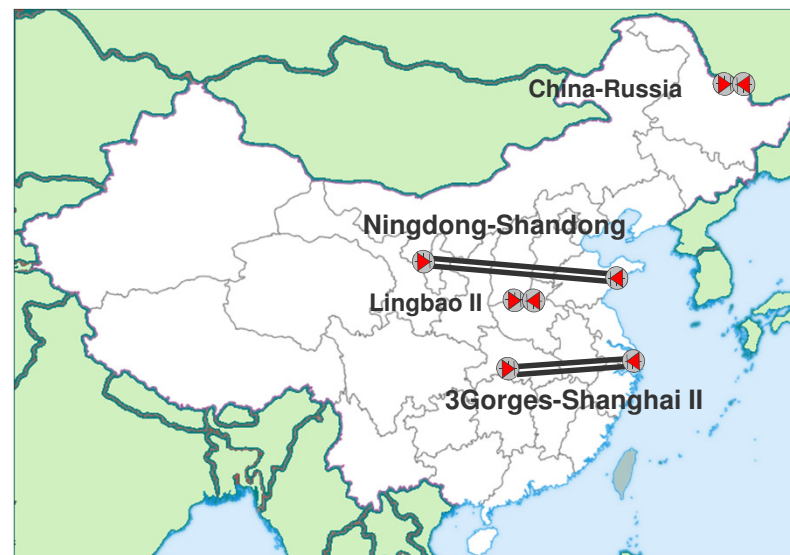
Back-to-Back Transmission

- Lingbao II
 - Interconnection between Henan and Shannxi provinces (NW & N grids)
 - Contract signed : February 2008
- China-Russia
 - Interconnection China - Russia
 - Contract signed : July 2007
- Topology :
 - 750 MW Back-to-Back
 - earthed neutral to reduce insulation stresses in converter transformers
 - DC voltage : +/- 125 kV DC
 - 500 kV for both AC systems
- **World's highest rated BTB**



HVDC Overhead Line Transmission

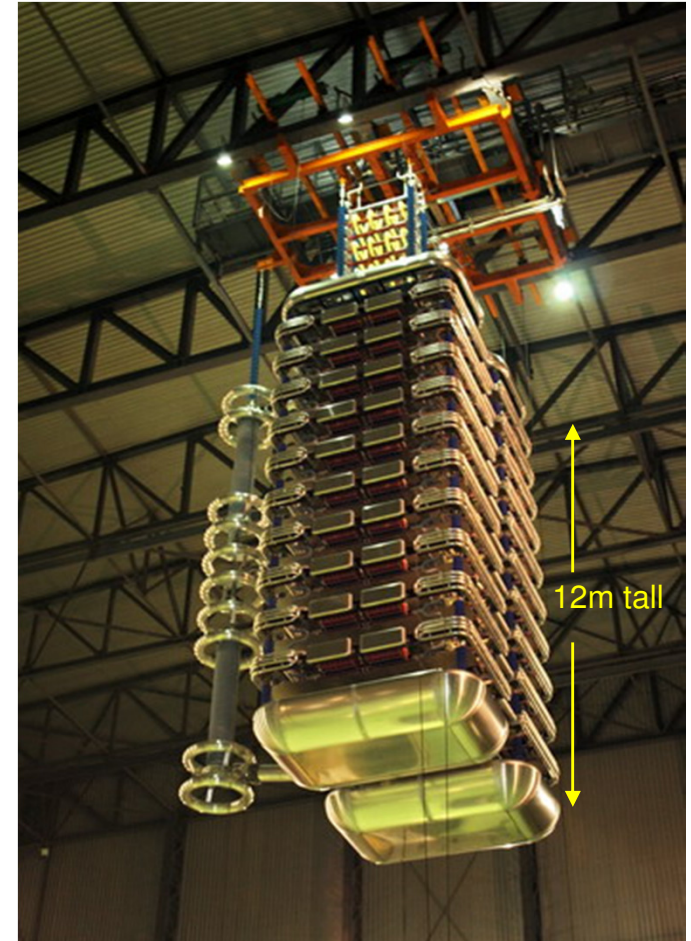
- 4 Contracts Signed with CEPRI in 2009
- Ningdong-Shandong HVDC Project
 - Bipole ± 660 kV, 4000 MW, 3030 A, 1335 km
- 3Gorges-Shanghai II HVDC Project
 - Bipole ± 500 kV, 3000 MW, 3000 A, 970 km



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660kV Thyristor Valve



South Korea - Jeju Island Second HVDC Submarine Cable Link for KEPCO



400 MW, ± 250 kVdc, 800 Adc

122 km submarine cable link

- 105km submarine cable
- 17km underground cable
- Metallic Return

Contract Award April 2009

Commissioning Feb 2012

Scope

- Converter Design, Supply & Supervision of Installation of New Jeju-Jindo Link
- Replacement and extension of Existing Jeju-Haenam Control System in 2013/2014
- Turn-key project (excluding cables)

First 300MW bi-pole scheme supplied by ALSTOM in 1997



Rio Madeira HVDC Project

Location: BRAZIL

Purpose:

- Interconnect Rio Madeira Hydro-plants (Santo Antonio and Jirau) in NW Brazil to major load centres in South / Southeast Brazil

Project:

- 3150 MW / 600 kV Bipole HVDC
- 2375 km World's Longest HVDC Link

Contract Value

- 300 MEuro (\$ 480 MUSD)

Date:

- Contract Signed September 2009

End Customer:

- ANEEL – Agencia Nacional de Energia Eletrica

Consortium

- Consórcio Madeira Transmissão
 - Furnas (ALSTOM)
 - CHESF
 - CTEEP





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