UHV DC Stations

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Historical Development

The mid 1880’s development of electricity:
- Thomas Edison develops DC in the UK.
- George Westinghouse develops AC in the US.
- Nikola Tesla develops multi-phase AC.
The mid 1880’s development of electricity:
• A meeting between Westinghouse and Tesla sealed DC’s fate in the early years.
Nikola Tesla

The problem with HVDC:
• High voltages cannot be used for lighting and motors.
• Transformers only work with alternating current (AC).
• Hence, AC is favoured.

AC wins in the development race
Why DC transmission

Reasons for using DC connections

Connection of two networks where an AC connection would cause the short circuit levels in both networks to be exceeded.

Connection of two networks that operate at different frequencies
- 50 Hz and 60 Hz
- Marginally different frequencies

Connection of networks with different generation patterns

Long distance or submarine cable links
Rivera, Uruguay

- 72.5 MW.
- Back to Back.
- Brazil – Uruguay link.
- Brazil operates at 60 Hz
- Uruguay operates at 50 Hz
- Uruguay generation is largely hydro

**Frequency Converter:**
Brazil 60Hz, Uruguay 50Hz
India National Regions

- **Chandrapur**: 2 x 500 MW, 1997
- **Visakhapatnam**: 500 MW, 1998
- **Sasaram**: 500 MW, 2002

**2000 MW HVDC**
Previous Projects

Chandrapur, Back to Back HVDC
Previous Projects

Sasaram, 500 MW Back to Back HVDC
DC transmission links

Station Cost

Lines & Stations

DC Converter Station

AC Station

DC

AC

Break Even Distance

50km Submarine Cable

800km Overhead Line

Transmission Distance
Sardinia – Corsica – Italy HVDC Link

• 200 MW, 200 kV
• Overhead line and submarine cable.
• Commissioned 1967.
• Corsica tapping added 1986.
UK – France, Cross Channel

- 2 x 1000 MW.
- Commissioned:
  - Bipole 1, 1985.
  - Bipole 2, 1986.
- Availability:
  - Specified, 95%.
  - Actual, >97.5%.

Highest utilisation of all HVDC schemes
Remains the world's largest HVDC scheme
Submarine cable link

Korea – Cheju Link

- 300 MW.
- 100 Km submarine link.
Nelson River, Manitoba, Canada

- Bulk power transmission and AC system control.
- 1670 MW.
- Commissioned 1972-1977.

Hydro-electric power transmitted over 900km, supplying half of Manitoba’s load
DC lines

Advantages of DC lines

No inductance effects
No charging current
No reactive current
No skin effect
Geographical Challenges

D.C. 1850MW Per Circuit.
± 250k.V. 4 x 644 mm²

A.C. 1850 MW per Circuit.
400k.V. 12 x 282 mm²
Economic Value

1850MW

1850MVA

5550MW

DC

AC

DC
UHVDC Prospects 600kV-800kV

- Northern Lights 2014-2020
- Chicken Neck 4 terminal Phase 1 2009 Phase 2 2011
- Irkutsk (Russia) -Beijing: 2015
- Madeira 2012
- Chicken Neck 4 terminal
- WestCor 4 terminal North 2018
- WestCor each 3 terminal South W 2012 South E 2013
- Yunnan-Guangdong: 2009
- Xiangliaba-Shanghai: 2011
- Jingping-East China: 2012
- Xiluodu-Hunan: 2013
- Humeng-Jinan: 2015
- Nuozhadu-Guangdong: 2015
- Xiluodu-Hanzhou: 2015
- Humeng-Tianjing: 2016
- Jinsha River II-East China: 2016
- Humeng-Liaoning: 2018
- Jinsha River II-Fujian: 2018
- Hami-Central China: 2018
- Jinsha River II-East China: 2019
- Humeng-Liaoning: 2018
- Jinsha River II-East China: 2019
UHVDC projects in China up to 2007
Year is project in service

- Irkutsk (Rusia)-Beijing 800kV, 6400MW, 2015
- Hami- Central China 800kV, 6400MW, 2018
- Xianjiaba-Shanghai 800kV, 6400MW, 2011
- Xiluodu-Hanzhou 800kV, 6400MW, 2015
- Xiluodu-Hunan 800kV, 6400MW, 2014
- Jinsha River II-East China 800kV, 6400MW, 2016
- Jinping-East China 800kV, 6400MW, 2012
- Jinsha River II-East China 800kV, 6400MW, 2019
- Jinsha River II-Fujian 800kV, 6400MW, 2018
- Nuozhadu-Guangdong 800kV, 6000MW, 2015
- Yunnan-Guangdong 800kV, 5000MW, 2019
800kV HVDC Scheme

One Pole Only Shown

+800kV
+400kV
0kV

GRID
UHVDC scheme - one pole

Section 1

Converter transformer

Same as section 1
Transformer Model IM2
HV Lead from Bushing to Winding
Valve Winding - voltage distribution tests
Transformer Bushing
Converter transformer - test object

Transformer test object

Wuhan, China
UHVDC scheme - one pole

Thyristor valve

Section 1

Same as section 1

LVDC Filter

0kV

+800kV

+400kV
Thyristor Valves

Section 1

Same as section 1

LVDC Filter
High Current Thyristor

150mm (6 inch) thyristor devices
7.2kV, 5000A

Single tier of thyristor valve
3 - Axis Seismic testing - one valve tier
Valve Corona Shield Design - Boundary Element Simulation

Simulation of maximum stress points for various radii

Effect of main parameters on ground clearance
Valve Corona Shield Design - Boundary Element Simulation

Electrostatic Stress Variation

Electrostatic Stress Variation
HV Test Laboratory - Ukraine
Thyristor Valve - test object

Switching impulse test at UHV laboratory, Ukraine
Thyristor valve - test object
660kV Thyristor valve

Ningdong - Shandong 4000MW ±660kV Transmission project

Thyristor valve under test in Beijing, China

12m tall
660kV Thyristor Valve Hall - China
UHVDC scheme - one pole

Section 1

By-pass switch

+800kV

+400kV

DC Filter

LVDC Filter

Same as section 1
By-pass switch

By-pass switch erected for test

Villeurbanne, France
UHVDC scheme - one pole

Wall Bushing
DC Wall Bushing

Wall bushing erected for test
Graz, Austria
UHVDC scheme - one pole

Section 1

Same as section 1

LVDC Filter

DC Filter

+800kV

+400kV

0kV

Disconnects
Disconnect switch

Disconnect being erected for test

Ludvika, Sweden