HVDC Schemes under Construction or Planned

By
Poul Damgaard
Commissioning in 2010
- Getting permission for the converter station on Zealand has delayed the project with 4-5 months
- Contract for HVDC Converter stations placed at Siemens (2008)
- Contract for 400 kV cables and submarine return cable placed at ABB Cables (2008)
- Contract for land return cables placed at NKT
- Construction work started at the station on Funen. Will start on Zealand in January 2009
Planned HVDC link

- Feasibility study/business Case has been conducted
- Decision taken by Statnett and Energinet.dk in May 2008 to apply for permission to establish a 640 MW, 450 kVdc link in addition to the three running poles which have total capacity of 1050 MW
- Commissioning planned for 2014

Skagerrak 4
- the forth pole between Norway and Denmark

Skagerrak

Norway

Denmark

Kristiansand

Tjele

Stavanger

Göteborg

Aalborg
Victor Lescale

CIGRÉ 2008
SC-B4
Projects from Sweden
Ongoing projects

Full turn-key projects
- Caprivi Link (Namibia)
- Fenno-Skan 2 (Finland, Sweden)
- Nord E.ON 1 (Germany)
- NorNed (Norway, Nederlands)
- Outaouais (Canada)
- SAPEI (Italy)
- Valhall (Norway)
- Xiangjiaba – Shanghai (China)

Upgrades
- Apollo (South Africa)
- Blackwater (USA)
- Chateauguay (Canada)
Ongoing projects

Full turn-key projects
- Caprivi Link (Namibia)
- Fenno-Skan 2 (Finland, Sweden)
- Nord E.ON 1 (Germany)
- NorNed (Norway, Netherlands)
- Outaouais (Canada)
- SAPEI (Italy)
- Valhall (Norway)
- Xiangjiaba – Shanghai (China)

Upgrades
- Apollo (South Africa)
- Blackwater (USA)
- Chateauguay (Canada)
Caprivi Link (Namibia)

- 300MW, 350kVDC
- 970km overhead line with HVDC Light
- Order: 2007-11-09
- In service: January 2010
- Can be expanded to 600MW
Fenno-Skan 2

- Fenno-Skan 1 (commissioned 1989)
  500MW, 400kVDC

- Fenno-Skan 2 will add 800MW, 500kVDC
  - 200km Cable
  - Order: 2008-05-13
  - In service: 2011
NORD E.ON 1 - Summary

Owner
- E.ON Netz Offshore GmbH, Germany

Scope
- 400 MW HVDC Light System
- Offshore station on platform with sub-sea structure
- Onshore station at E.ON substation Diele
- 170 kV GIS switchgear on platform
- Cables
  - Submarine AC cable 170kV (1x1200 m)
  - DC cable submarine to onshore connection (2x128km)
  - DC cable on land (2x75km)
  - Fiber optic cable (203 km)
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-09-17</td>
<td>Contract award</td>
</tr>
<tr>
<td>2008-06-02</td>
<td>Start installation of land cable</td>
</tr>
<tr>
<td>2008-07-07</td>
<td>Start civil construction onshore</td>
</tr>
<tr>
<td>2008-11-10</td>
<td>Start installation onshore</td>
</tr>
<tr>
<td>2008-11-12</td>
<td>Start installation of equipment at offshore fabrication yard</td>
</tr>
<tr>
<td>2009-05-01</td>
<td>Module &amp; sub-sea structure ready to sail</td>
</tr>
<tr>
<td>2009-06-23</td>
<td>Start installation offshore cable</td>
</tr>
<tr>
<td>2009-08-07</td>
<td>Offshore platform ready for cable installation</td>
</tr>
<tr>
<td>2009-08-15</td>
<td>HVDC system ready for energization</td>
</tr>
<tr>
<td>2009-09-01</td>
<td>System ready for transmission testing</td>
</tr>
<tr>
<td>2009-09-15</td>
<td>Start trial run</td>
</tr>
<tr>
<td>2009-11-24</td>
<td>Acceptance</td>
</tr>
</tbody>
</table>
NORD E.ON 1 – layout platform - Overview

- Jacket
- Piles
- Crane
- Helipad
- Transformers
- Topside
- J-Tub
NorNed, Norway – The Netherlands
The longest underwater high-voltage cable in the world.

Clients: Statnett SF, Norway and TenneT bv, Netherlands

Order date: December 2004
In service: April 2008
Transmission capacity: 700 MW
AC Voltage: 300 kV at Feda
400 kV at Eemshaven
DC Voltage: ± 450 kV
Length of DC cable: 2* 580 km

Main reason for choosing HVDC: Long submarine cable distance and non-synchronous AC systems, absolute control of power flow fits with the market coupling.
NorNed kabel HVDC Project *Symmetric monopole*

- Rating 600 MW ± 450 kV
- Low losses 3.7 %
- Continuous 700 MW
- Cable length 580 km
- No sea electrode
OUTAOUAIS Location
Outaouais BtB

- 2 x 625 MW
- Client: Hydro Québec (TransEnergie)
- Order: (NTP) 2006-10-23
- 2007-06-12 Access granted to site
- 2008-05-21 Start of installation
- 2008-10-xx Commissioning starts
- 2009-03-26 Commercial operation and PAC
Progress – June 2008

June, 10 – Building from Ontario yard

June, 10 – 240kV Bl.01 trafo foundations

June, 10 – Control Room – Second Floor

June 10, Québec side – NE filter
SAPEI - Map

SArdinia
PEninsular
Italy
Bipole, 1000MW
Cable, 435km, 1600m
SAPEI - General

- SAPEI – Client Terna, consultant CESI.
- Bipole 2 x 500 MW, 500 kV DC, 400 kV AC.
- Cables 2 x 435 km, 1600 m (+2 x 70 km MV).
- Special:
  - Use of existing SACOI anode on Sardinia.
  - High salt contamination level, indoor solutions.
  - Minor seismic requirements
  - Similar to Italy-Greece
- Scope: Everything except civil construction.
- Contract date: 2006-06-06
- Pole 1 in operation 2008-09-30
- Pole 2 in operation 2009-09-30
Sapei – Latina installation AC filter
Valhall – General

Power From Shore = PFS

Description

- One HVDC light station off-shore and one on-shore
- 292 km HVDC Cable

Main data

- \( P = 78 \text{ MW} \)
- \( U_{\text{DC}} = -150 / 0 \text{ kV} \)
- \( U_{\text{AC}} = 11 \text{ kV} \) on offshore and 300 kV onshore

In service

September 2010
The two valve cooling skids lifted/slide in place

IGBT-valves surrounded by corona shied
Xiangjiaba – Shanghai

- 6400MW, 800kVDC, 2000+ km (The world’s longest and most powerful transmission)
- Order: 2007-12-17
- In service: 2011-06-30
- Studies ready, and most reports approved
- Site activities already in full swing
The wall around the very large site is being erected. In some parts, it will be 16m high to reduce the noise level outside.
The piling material is transported to site in barges.
Ongoing projects

Full turn-key projects
- Caprivi Link (Namibia)
- Fenno-Skan 2 (Finland, Sweden)
- Nord E.ON 1 (Germany)
- NorNed (Norway, Nederlands)
- Outaouais (Canada)
- SAPEI (Italy)
- Valhall (Norway)
- Xiangjiaba – Shanghai (China)

Upgrades
- Apollo (South Africa)
- Blackwater (USA)
- Chateauguay (Canada)
Apollo refurbishment, new valves
Apollo refurbishment. Status as per June 2008

Order: 2006-08-04

AC-filter 2 in operation 15/1-08
Bridge 2 & 4 in operation 3/2-08
Bridge 6 & 8 in operation 14/2-08
Pole 2 in operation 17/2-08
Bridge 1 & 3 in operation 11/4-08
AC-filter 1 branch 24,13 & 11 in operation 22/4-08
AC-filter 1 branch 5 & 7 in operation 30/4-08
Bridge 5 in operation 7/5-08
Bridge 7 in operation 12/5-08
Pole 1 in operation 12/5-08

Trial operation completed 1/6-08
Blackwater Upgrade Project

- Owner: Public Service Company of New Mexico (PNM)
- Commissioning:
  - Cooling: April 2008
  - Control: November 2009
- Rating: 200 MW, +/- 56.8 kV, 3.6 kA
- Reason:
  - >20 years old
  - unsolved control problem
  - problem with maintenance and spare parts.
  - larger wind farms => reliable system important
  - The cooling system needs upgrade to run 220 MW continuously

- Upgrade of the Cooling System
- Upgrade of the Control System
- Replacement of DC Current Transducers
- Replacement of battery system.
Blackwater Upgrade Project

- Major events already covered:
  - Order 2006-12-21
  - Cooling system commissioned
  - System studies (stability, and similar) ongoing

- Exchange of control system: End of October 2009
  (PAC planned for November 2009)
Chateauguay Control Upgrade

- Upgrade of the Control System in Chateauguay. Replacement of light guides and DC Current Transducers.
- Owner: Hydro Québec
- Order date: February 2008
- Commissioning: June 2009
- Rating: 2 X 500 MW
- Reason for upgrade: Poor reliability of the existing Control & Protection system.

- Planned stop times:
  - Block 1: 28 days
  - Block 2: 22 days
Other Control Upgrades Already Done

- Skagerrak (Norway, Denmark)
  - Stop time: 14 days (18 days)

- CU (USA)
  - Stop time: 23 days

- Square Butte (USA)
  - Stop time: 6 weeks (of 8 weeks planned due to generation stop, anyway)
HVDC Projects and Activities

Energy Sector
Power Transmission Division
## HVDC Projects under execution, status Aug./08

<table>
<thead>
<tr>
<th>Project</th>
<th>Country</th>
<th>In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballia-Bhiwadi</td>
<td>India</td>
<td>2009</td>
</tr>
<tr>
<td>Yun-Guang</td>
<td>China</td>
<td>2010</td>
</tr>
<tr>
<td>Storebelt</td>
<td>Denmark</td>
<td>2010</td>
</tr>
<tr>
<td>Brit-Net</td>
<td>UK - Netherland</td>
<td>2010</td>
</tr>
<tr>
<td>Xiangjiaba-Shanghai</td>
<td>China</td>
<td>2010</td>
</tr>
<tr>
<td>Cometa</td>
<td>Spain</td>
<td>2011</td>
</tr>
<tr>
<td>Trans Bay Cable</td>
<td>USA</td>
<td>2010</td>
</tr>
</tbody>
</table>
### Yun - Guang, China, 2010

<table>
<thead>
<tr>
<th>Customer</th>
<th>China Southern Power Grid Co., Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project name</td>
<td>Yunnan-Guangdong ±800kV UHVDC Transmission Project</td>
</tr>
<tr>
<td>Location</td>
<td>Province Yunnan to province Guangdong</td>
</tr>
<tr>
<td>Type of plant</td>
<td>Long distance transmission</td>
</tr>
<tr>
<td>Power rating</td>
<td>5000 MW, bipolar</td>
</tr>
<tr>
<td>Transmission distance</td>
<td>1418 km</td>
</tr>
<tr>
<td>Voltage levels</td>
<td>800 kV DC, 525 kV, 50 Hz</td>
</tr>
<tr>
<td>Thyristor voltage</td>
<td>Direct-light-triggered, 8 kV</td>
</tr>
<tr>
<td>Number of thyristors</td>
<td>5760</td>
</tr>
</tbody>
</table>
**Factory Tests of first 800 kV DC Equipment**  
Already completed for Yun-Guang UHVDC Project  
(Status August 2008)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converter Valves</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800kV DC Surge Arrester</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800kV DC Bypass Breaker</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800kV DC Disconnectors</td>
<td>100% Completed</td>
</tr>
<tr>
<td>DC Filter Capacitor C1</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800 kV DC Insulators (Shenmatech)</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800kV DC Voltage Divider</td>
<td>100% Completed</td>
</tr>
<tr>
<td>800kV DC Wall Bushing</td>
<td>on-going</td>
</tr>
<tr>
<td>800kV DC Current Measuring system</td>
<td>on-going</td>
</tr>
<tr>
<td>800 kV converter transformer</td>
<td>on-going</td>
</tr>
</tbody>
</table>
First 800 kV Converter Transformer in Factory
800 kV Thyristor Valve during Dielectric Type Test
800 kV Bus Arrester with Composite Housing

- Height = 12.2 m
- Weight = 1000 kg
- LIWL = 1900 kV
- SIWL = 1600 kV
800 kV Bypass Breaker during Type Testing
800 kV Double Break Disconnector with composite insulator
800 kV DC Voltage Divider during Type Testing

Composite housing
SF$_6$ insulated

<table>
<thead>
<tr>
<th>LIWL</th>
<th>1900 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIWL</td>
<td>1600 kV</td>
</tr>
</tbody>
</table>

Creepage distance ≥ 32.7 m
Clearance ≥ 9.1 m

Height 10.4 m
Weight 1400 kg
New Generation of Thyristors
6” Thyristor (8 kV /4.5 kA) for XJB-SHA UHVDC Project
Modular Multilevel Voltage Sourced Converter for HVDC and FACTS Applications

HVDC PLUS

SVC PLUS
Active Filter PLUS
First Application of Modular Multilevel Converter Active Filter Installation in Neptune HVDC Project
32 MW HVDC PLUS in BtB Configuration
HVDC PLUS
Trans Bay Cable Project, USA, 2010

- Converter: Modular Multilevel HVDC PLUS Converter
- Rated Power: 400MW @ AC Terminal Receiving End
- DC Voltage: ± 200kV
- Submarine Cable: Extruded Insulation Submarine Cable
New HVDC Projects in China

Guangfu Tang

China Electric Power Research Institute
August, 2008
HVDC Projects in Service

Power Transmission
- Central–East China
- Central–South China
- Southwest–Southeast China

<table>
<thead>
<tr>
<th>Location</th>
<th>Voltage (kV)</th>
<th>Capacity (MW)</th>
<th>Year</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gezhouba to Shanghai</td>
<td>±500</td>
<td>3000</td>
<td>1989</td>
<td></td>
</tr>
<tr>
<td>Three Gorges to Guangdong</td>
<td>±500</td>
<td>3000</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>Three Gorges to Changzhou</td>
<td>±150</td>
<td>2×3000</td>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>Three Gorges to Shanghai</td>
<td>±150</td>
<td>2×3000</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>Guizhou to Guangdong</td>
<td>±500</td>
<td>2×3000</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>Gaoling BTB</td>
<td>±120</td>
<td>750</td>
<td>2008</td>
<td></td>
</tr>
</tbody>
</table>

- Long distance
- BTB
HVDC Projects Under Construction

HVDC and UHVDC for grid interconnection and long-distance power transmission.

- **Northeast China**
  - ±500 kV 3000 MW 2010 Hulunbuir-Liaoning
  - ±125 kV 750 MW 2009 Heihe BTB

- **North China**
  - ±500 kV 3000 MW 2010 Deyang-Baoji
  - 167 kV 750 MW 2009 Lingbao II BTB

- **Northwest China**
  - ±800 kV 5000 MW 2009 Yunnan-Guangdong

- **Central China**
  - ±800 kV 6400 MW 2010 Xiangjiaba-Shanghai

- **East China**
  - ±500 kV 3000 MW 2010 Hulunbuir-Liaoning

- **South China**

- **Tibet**
HVDC Projects in Planning By the End of 2008

- UHVDC transfer long distance power
- Expected capacity of UHV: above 200GW
Jinping - Sunan UHVDC project

- Overview of the UHVDC project
  - From Yulong of Sichuan to Tongli of Jiangsu
  - Totally 7200MW at bipolar

- System Scheme
  - Converter topology: Bipolar
  - DC voltage: ±800kV
  - AC voltage: 500kV
  - Transmission distance: 2098km

- Schedule
  - Start at 2008, Commission at 2011 (Bipolar)
Ningxia - Shandong HVDC project

Overview of the HVDC project
- From Yinchuan of Ningxia to Qingdao of Shandong
- Totally 4000MW at bipolar

System Scheme
- Converter topology: Bipolar
- DC voltage: ±660kV
- AC voltage: 500kV, 330kV
- Transmission distance: 1348km

Schedule
- Start at 2008, Commission at 2010 (Bipolar)
Jingmen - Fengjing HVDC project

- **Overview of the HVDC project**
  - From Jingmen of Hubei to Fengjing of Shanghai
  - Totally 3000MW at bipolar

- **System Scheme**
  - Converter topology: Bipolar
  - DC voltage: ±500kV
  - AC voltage: 500kV
  - Transmission distance: 970km

- **Schedule**
  - Start at 2008, Commission at 2011 (Bipolar)
Qinghai - Tibet HVDC project

- Overview of the HVDC project
  - From Geermu of Qinghai to Lasa of Tibet
  - Totally 1200MW

- System Scheme
  - DC voltage: ±500kV
  - AC voltage: 500kV
  - Transmission distance: 1038km

- Schedule
  - Start at 2008, Commission at 2010 (Monopolar)
Thanks !