HVDC Light® transmission technology

Lars Stendius
ABB Power Systems
Grid Systems portfolio

High Voltage Direct Current (HVDC)
- Long distance bulk power transmission
- Interconnections
- Underground transmission

Flexible AC Transmission (FACTS)
- Increased power transmission
- Improved power quality

Power Semiconductors
- Enabling technology for HVDC and FACTS

Power Cables
- Product or complete system
- Key product for HVDC and FACTS

Service and upgrading
HVDC Technologies

HVDC Classic 300 – 3000 (6000) MW
- Thyristor controlled
- Switched Reactive Power Control
- Typical design valve building plus switchyard
- Mass impregnated cables

HVDC Light 50 -1200 MW
- Transistor (IGBT) controlled
- Continuous Voltage and Reactive Power Control
- Typical design with all equipment (excluding transformers) in compact building
- Extruded cables

120 x 200 m, height 22 m

50 x 120 m, height 11 m
Estlink, Nordic Energy Link AS

Customer’s need
- Improved security of the electricity supply in the Baltic States
- Reduced dependence of the Baltic power systems on Russia and an alternative electricity purchase channel to cover potential deficits in generating capacity.

ABB’s response
- Turnkey 350 MW ±150 kV HVDC Light® cable transmission system

Customer’s benefits
- Improvement of the voltage stability of the Estonian grid
- Access to the Nordpool power market
- Short implementation time
Murraylink - HVDC Light

Rating: 200 MW
Distance: 180 km
Ud = +/- 150 kV DC Power Cables
In operation 2002

HVDC Light project gets environmental awards in Australia!
Troll Gas Platform, Norway

Key data

- Troll is the biggest gas platform in the world- production 20-30 MEUR/day
- HVDC Light handle all power supply
- Mayor environmental advantages and reduced personnel off shore
- In operation since 2005, without failures
- 2 x 40 MW, 70 km sea cable
Valhall, BP

Key data

- Valhall is BP's biggest platform in the North Sea
- Under construction
- HVDC Light will supply all electric power to the platform
- Mayor environmental advantages and reduced personnel off shore
- 1 x 78 MW, 290 km sea cable
EON Netz, 400 MW HVDC Light®

Tailwind for grid reliability

400 MW Offshore VSC converter

Offshore Windpark-Cluster Borkum 2
- largest offshore wind park in the world
- largest distance from mainland
- first grid connection with direct current in Germany
HVDC Light® Platform Layout
SouthWestlink, SVK and Statnett

Stage 1, 2008
- 2 x 1200 MW convertors
- 200 km underground cable
- 200 km a.c. OHL upgrade 220 – 400 kV

Stage 2, 2010
- 1 x 1200 MW convertors
- About 350 km underground cable
HVDC Light® reference projects

- Tjäreborg 2000, 7 MW
- Cross Sound 2002, 330 MW
- Eagle Pass 2000, 36 MW
- Valhall 2007, 78 MW
- Troll 2004, 2X40 MW
- Estlink 2006, 350 MW
- Gotland 1999, 50 MW
- Hällsjön 1997, 3 MW
- Directlink 2000, 3X60 MW
- Nord E.ON 1 2009, 400 MW
- Caprivi Link 2009, 300 MW
- Murraylink 2002, 220 MW
Relative cost for on land transmission

- Overhead line
- Underground A.c. cable
Relative cost for transmission

- Underground A.c. cable
- Underground HVDC Light
- Overhead line
HVDC Light Transmission – Voltage Source Converters

- Applications
  - Off shore power supply
  - Wind power integration
  - Underground transmission

- Ratings
  - Power range 50-1200 MW
  - Voltages ± 80, ± 150 and ± 320 kV
  - Extruded cables with prefabricated joints
  - OH Lines and HVDC Light possible
HVDC Light Cable Development

1997
Hellsjön
95 mm² Al
+/- 10 kV, 3 MW

2000
Directlink
630 mm² Al
+/- 80 kV, 60 MW

2001
Murraylink
1400 mm² Al
+/- 150 kV, 220 MW

2004
Estlink
2000 mm² Al
+/- 150 kV, 350 MW

2006 - 2007
1600 mm² Al (Cu)
+/- 300 kV, 700 MW (1100 MW)
HVDC Light® – Building blocks

IGBT converter valves

DC capacitors

Cables

Phase reactors

AC harmonic filters

Transformers, breakers/disconnectors

Main-circuit diagram
HVDC Light® – basic principle

- Transformer
- Phase reactor
- Harmonic filter
- Valve: IGBT & diode
- DC cable
- P = \( \frac{U_1 \cdot U_2 \cdot \sin(\delta)}{X} \)
- Q = \( \frac{U_1 \cdot (U_1 - U_2 \cdot \cos(\delta))}{X} \)
Independant Active/Reactive Power Control

- Operating point can be selected anywhere inside area

P-Q Diagram (whole voltage range)
Connecting wind farms by HVDC Light® - Customer Values

- **Grid management**
  - Full grid code compliance
  - Superior controllability
  - Voltage and reactive power control
  - Independent active and reactive power control
  - Loss reduction in connected AC network
  - Support connections at weak network points
  - Passive Load Operation (Black Start)
Connecting wind farms by HVDC Light® - Customer Values

- Proven offshore concept
  - Troll A Precompression project
  - Valhall
  - Nord E.ON 1
'The Supergrid is based on the combination of two recent but proven technologies, large offshore wind turbines and voltage source converter HVDC transmission.'
Power and productivity for a better world™