HVDC Light - Power from shore
Content

 Driving forces

 Challenges

 Solutions

 Reference projects

 Summary
HVDC Light - Power from shore
Driving forces

- Maintenance & Operation Costs (OPEX)
- Emissions
- Efficiency – fuel utilization
- Space and weight on platform
- Safety and working conditions
**Offshore power supply**
**Performance driver**

<table>
<thead>
<tr>
<th>Increased reliability (Forced Outage Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 per year</td>
</tr>
<tr>
<td>3 per year</td>
</tr>
<tr>
<td>1 per year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Increased availability (Maintenance intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 per year</td>
</tr>
<tr>
<td>1 every 2 years</td>
</tr>
<tr>
<td>1 every 5 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduced start-up time (Commissioning time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
</tr>
<tr>
<td>Weeks</td>
</tr>
<tr>
<td>Days</td>
</tr>
</tbody>
</table>
HVDC Light - Power from shore

Challenges

- Availability
- Losses
- Installation time
- Environmental impact
- HSE requirements
Power from (to) Shore solutions
An example of economical window of opportunity for power from shore
Submarine cables
HVAC or HVDC?

Aspects to take into account
- Distance
- Power
- Depth

No exact general rules, but roughly
- Less than 50 km – generally AC
- More than 150 km – generally DC
- Between 50-150 km – depends
HVDC Light - Power from shore Solution

- HVDC Light (VSC) technology
  - Black-start capability
  - Control of the platform voltage and frequency
  - Low losses
- Proven high reliability and availability
- Compact design
- No need of local generation
- Oil-free, light-weight extruded cables
Overview of VSC offerings
Transmission capacities

- VSC station (Light®)
  - Customer's Grid
  - MI cables
  - Power levels > 1,200 MW

- Overhead lines
  - Power levels > 1,200 MW

- Land or submarine extruded d.c. cables
  - Power levels up to 1,200 MW

- VSC station (Light®)
  - Customer's Grid
  - No limitations in the converter
HVDC Light an intelligent transmission device

- HVDC Light is an intelligent link for transmitting electrical power
  - Active Power can be changed
    - Very quickly – the interfacing grid sets the limits
    - A variety of static and dynamic schemes
  - Reactive Power can be changed
    - Very high dynamic response
  - Add-on features possible
    - Black start, active filtering and power oscillating damping
- VSC converters are highly controllable
Technical development HVDC Light

- 1997
  - Hellsjön
  - +/- 10 kV

- 1999
  - 7 MW - 50 MW
  - +/- 80 kV

- 2002
  - up to 330 MW
  - up to +/- 150 kV

- 2010
  - up to 550 MW
  - up to +/- 200 kV

- 2013
  - up to 1200 MW
  - up to +/- 320 kV
What is HVDC Light?

- Voltage source converters – PWM with IGBTs (used in drives)
- Active and reactive power control – independent
- Voltage and frequency control – independent, dynamic
- No synchronous machine needed
- Black start capability
- HVDC Light Cable – flexible, economic extruded polymer
Control of active and reactive power
HVDC Light (VSC) is a mature technology

- Connecting remote generation
- Offshore wind connections
- Interconnecting grids
- DC links in AC grids
- Power from shore
Content

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- Challenges
- Solutions
- Reference projects
- Summary
Why Power From Shore?

**HSE**
- Reduced climate pollution (CO2)
- Improved Energy Efficiency
- Lower local pollution (NOX)
- Improved safety for personnel
  - Less heavy maintenance
  - Less heavy lifts
  - Reduced ignition sources
  - Stability
- Less need for transport to the offshore platforms
- Less vibration and noise

**Technology**
- Shorter delivery time
- Reduced installation time
- Easier installation offshore
- Higher overall efficiency compared to Gas Turbines
- Lower weight, less footprint

**Economics**
- Reduced maintenance and operating costs - OPEX
- High availability
- More gas left for sale
Our knowledge is based on a number of completed and ongoing offshore power projects

- **Princess Amalie**: 120 MW AC-connection
- **Borwin 1**: 400 MW HVDC-connection
- **Dolwin 2**: 900 MW HVDC-connection
- **Thornton Bank**: 325 MW AC-connection
- **Valhall**: 80 MW HVDC, Power from shore
- **Gjøa**: 40 MW AC, 100 km
- **Troll 1 & 3**: 80+80 MW HVDC, Power from shore
- **Dolwin 1**: 800 MW HVDC-connection
- **Goliat**: 60 MW AC, 100 km
HVDC Light project references
25 projects – 4 offshore O&G and 3 offshore wind

- Troll, 2004, 2X40 MW
- Troll, 2015, 2X50 MW
- Johan Sverdrup, 2018, 100 MW
- NordLink, 2020, 1,400 MW
- Skagerrak 4, 2014, 700 MW
- Valhall, 2009, 75 MW
- Tjäreborg, 2000, 7 MW
- Maritime Link, 2017, 500 MW
- Cross Sound, 2002, 330 MW
- Mackinac, 2014, 200 MW
- Eagle Pass, 2000, 36 MW
- BorWin1, 2009, 400 MW
- DolWin1, 2014, 800 MW
- DolWin2, 2015, 900 MW
- Caithness Moray Interconnector, 2018, 800/1200MW
- East West Interconnector, 2012, 500 MW
- Caprivi Link, 2009, 300 MW
- NSN, 2021, 1400 MW
- Åland, 2015, 100 MW
- Estlink, 2006, 350 MW
- NordBalt, 2015, 700 MW
- Gotland, 1999, 50 MW
- Kriegers Flak, 2020, 400 MW
- Directlink, 2000, 3X60 MW
- Murraylink, 2002, 220 MW
HVDC Light
Offshore platforms

System with converters and cables
- Easier permit procedure
- Low project risk
- Short installation and implementation time
- Low operation and maintenance cost

Grid improvement
- Voltage and reactive power control
- Connection in weak network points
- Passive load operation (Black Start)

Environmentally adapted
- Short permitting time
- Small footprint and low profile of converters
- Oil free cable
- Reduced magnetic fields
HVDC Offshore applications

- Power From Shore
  - Electrification
  - Pre-compression systems

- Offshore Renewables (wind, tidal etc)
- Interconnectors
- Offshore grids
# PFS – HVDC Light

HVDC from shore - NCS

<table>
<thead>
<tr>
<th>Project</th>
<th>No’s of HVDC Systems</th>
<th>Rating</th>
<th>Transmission voltage</th>
<th># of cables/Distance</th>
<th>Contract</th>
<th>Application</th>
<th>Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troll 1&amp;2</td>
<td>2</td>
<td>2x44MW, 56 kV (motor)</td>
<td>+/- 60 kV</td>
<td>4x70 km</td>
<td>EPCI</td>
<td>Drives VHV motors</td>
<td>2005</td>
</tr>
<tr>
<td>Troll 3&amp;4</td>
<td>2</td>
<td>2x50MW, 56 kV (motor)</td>
<td>+/- 60 kV</td>
<td>4x70 km</td>
<td>EPCI</td>
<td>Drives VHV motors</td>
<td>2014</td>
</tr>
<tr>
<td>Valhall</td>
<td>1</td>
<td>87 MVA</td>
<td>+150/0 kV</td>
<td>1x220 km</td>
<td>EPC</td>
<td>Transmission</td>
<td>2007</td>
</tr>
<tr>
<td>Johan Sverdrup</td>
<td>1</td>
<td>100 MW</td>
<td>+/- 80 kV</td>
<td>2x195 km</td>
<td>MEC</td>
<td>Transmission</td>
<td>2018</td>
</tr>
</tbody>
</table>
Customer: Statoil
Year of commissioning: 2005 & 2015

Customer’s need
- Enable power supply from mainland to platform to minimize emission of large amounts of CO2 and unnecessarily high fuel consumption

ABB’s response
- Turnkey 2x44 MW ±60 kV HVDC Light® offshore transmission system
- Turnkey 2x50 MW ±66 kV HVDC Light® offshore transmission system
- DC sea cables
- VHV (Very high voltage) motors

Customer’s benefits
- Lower CO2 emissions
- Better and safer work environment on platform
Valhall
Norway

Customer: BP
Year of commissioning: 2009

Customer’s need
- Expansion increases need for power

Alternatives
- Gas turbines on platform
- Supply from land - 310 km. Only possible with DC transmission

ABB response
- HVDC Light system – 150 kV, 78 MW

Customer’s benefits
- Compact and low weight design reduces investments on platform
- Reliable power supply
- Reduced CO₂ emissions
- Reduced operation and maintenance cost
BP Valhall Power From Shore Project
System overview
Valhall Power From Shore
Offshore converter module

Main data for the module

- L=22 m
- W=15 m
- H=13 m
- Volume: 4.200 m³
- Weight: HVDC Equipment ~ 150 tons
Customer’s need

- Enable power supply from mainland to platform complex to minimize emission of large amounts of CO2

ABB’s response

- Two 100 MW ±80 kV HVDC Light converter stations

Customer’s benefits

- Reliable power supply
- Better and safer work environment on platform
- Lower operation and maintenance costs
Johan Sverdrup
Norway

Power from shore to Utsira High

Aldous / Avaldsnes
C

Aldous / Avaldsnes
B

Aldous / Avaldsnes Field center
A

Onshore grid
300 kV incomers

Dagny

Draupne

Luno

Hub platform Converter

Kårstø

Substation Converter

DC land cable

AC subsea cables
0 - 60 km

Future wind farm

Future

DC subsea cable
200 km

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HVDC Light
Connecting wind farms

System with converters and cables
- Easier permit procedure in coastal areas
- Low project risk
- Short installation and implementation time
- Low operation and maintenance cost

Grid improvement
- Voltage and reactive power control
- Loss reduction in connected AC network
- Increased transfer capability in AC lines
- Connection in weak network points
- Passive load operation (Black Start)

Environmentally adapted
- Short permitting time
- Small footprint and low profile of converters
- Oil free cable
- Reduced magnetic fields
- “Invisible” transmission
BorWin1 – the world’s most remote offshore wind park
400 MW HVDC Light system

- 400 MW offshore converter
- 400 MW converter
- 125 km sea cable
- 75 km land cable
Layout of HVDC Light Station +/- 150 kV
One/two levels

- Topside weight approx 3300 t (incl. 800 t ABB equipment)
- Size approx 50 x 33.5 x 22 m
- Jacket 1500 t (Height 62 m, sea level to topside approx 20 m)
Customer’s need
- 165 km long subsea and underground power connection
- Robust grid connection

ABB’s response
- Turnkey 800 MW HVDC Light system
- First ± 320 kV extruded cable delivery

Customer’s benefits
- Environmentally sound power transport
- Low losses and high reliability
- Reduce CO$_2$ emissions by 3 million tons per year by replacing fossil-fuel generation
- Supports wind power development in Germany
Customer: TenneT
Year of commissioning: 2015

Customer’s need
- 135 km long subsea and underground power connection
- Robust grid connection

ABB’s response
- Turnkey 900 MW HVDC Light system
- ± 320 kV extruded cable delivery

Customer’s benefits
- Environmentally sound power transport
- Low losses and high reliability
- Reduce CO₂-emissions by 3 million tons per year by replacing fossil-fuel generation
- Grid connection 90 km inland
HVDC Light - Power from shore

Summary

- OPEX cost savings
- Reliable power supply
- Safety and working conditions
- Reduce emissions
ABB HVDC and HVDC Light web portal: www.abb.com/hvdc

HVDC and HVDC Light

HVDC (High Voltage Direct Current) is a highly efficient alternative for transmitting large amounts of electricity over long distances and for special purpose applications. As a key enabler in the future energy system based on renewables, HVDC is truly shaping the grid of the future.

Have a look at how Tomorrow's HVDC grid

Learn the basics of HVDC: Introduction to HVDC and HVDC Light

Our offering

→ HVDC Classic
  HVDC Classic is used mainly for transmission of bulk power and AC system interconnections.

→ Service
  ABB ensures continued support to the project throughout its lifetime. Upgrades of plants delivered by others is also supplied.

→ HVDC Light
  HVDC Light - The invisible power transmission based on underground cables.

Features

→ Tomorrow's HVDC grid
→ Applications of HVDC
→ HVDC films
→ What's new in ABB's HVDC web pages?
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