Nandan Mahimkar, Business Development Manager, HVDC, ABB Ltd.
Gunnar Persson, Senior Project Manager, HVDC, ABB AB Sweden

Review of ABB & Its HVDC projects
Dhaka, September 18, 2011
A global leader in power and automation technologies
Leading market positions in main businesses

- 124,000 employees in about 100 countries
- $32 billion in revenue (2010)
- Formed in 1988 merger of Swiss and Swedish engineering companies
- Predecessors founded in 1883 and 1891
- Publicly owned company with head office in Switzerland
How ABB is organized
Five global divisions

- **Power Products**
  - $10 billion
  - 32,600 employees

- **Power Systems**
  - $6.8 billion
  - 17,500 employees

- **Discrete Automation and Motion**
  - $5.6 billion
  - 25,600 employees
  - (2010 revenues)

- **Low Voltage Products**
  - $4.5 billion
  - 20,300 employees

- **Process Automation**
  - $7.4 billion
  - 27,100 employees

- **ABB’s portfolio covers:**
  - Electricals, automation, controls and instrumentation for power generation and industrial processes
  - Power transmission
  - Distribution solutions
  - Low-voltage products
    - Motors and drives
  - Intelligent building systems
  - Robots and robot systems
Tackling society’s challenges on path to low-carbon era
Helping customers do more using less

ABB power and automation solutions are:

- Meeting rising demand for electricity
- Increasing energy efficiency and reducing CO₂ emissions
- Improving productivity to raise competitiveness of businesses and utilities

Rise in electricity consumption by 2035 (under current policies)

- Source: IEA, World Energy Outlook 2010

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<tr>
<th>Year</th>
<th>Terrawatt-hours (TWh)</th>
<th>2008</th>
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+96%
Renewable energy
Key growth driver for both power and automation

- Generation and transmission solutions for:
  - Hydro
  - Wind
  - Solar
  - Wave

**Project examples**
- Xiangjiaba-Shanghai (China)
- Wind Capital (US)
- Totana solar (Spain)
- Pelamis wave energy (Portugal)

**ABB scope**
- Grid connection
- Transformers
- Turnkey execution
- Customized generators
Shaping the world we know today through innovation
Pioneering technology since 1883

- Founding fathers
- Steam turbine
- Turbochargers
- Gas turbine
- Industrial robot
- Gas-insulated switchgear
- Gearless motor drives
- Variable-speed motor drives
- Electric propulsion systems
- Extended control systems
- HVDC
- Gas turbine
- Steam turbine
- Turbochargers
- Gas-insulated switchgear
- Gearless motor drives
- Variable-speed motor drives
- Electric propulsion systems
- Extended control systems
- HVDC
Innovation is key to ABB’s competitive advantage
Leadership built on consistent R&D investment

* Comprises non-order related R&D and order-related development

- More than $1 billion invested annually in R&D*
- 6,000 scientists and engineers
- Collaboration with 70 universities
  - MIT (US), Tsinghua (China), KTH Royal Institute of Technology (Sweden), Indian Institute of Science (Bangalore), ETH (Switzerland), Karlsruhe (Germany), AGH University of Science and Technology (Poland)
Global HVDC Presence
We are near our customers

- HVDC Sales presence in 50+ countries

- Ludvika, Sweden
  Global Execution Centre

- Chennai, India
  Global Operations Centre

- HVDC Centers
ABB operations in Ludvika
ABB – the HVDC pioneer

1954  First commercial HVDC with mercury arc valves
1970  First thyristor valves for HVDC
1984  The highest power, voltage Itaipu 6.300 MW, 600 kV
1992  First Bulk Power Multi terminal link, HQ-NE
1994  The longest submarine cable, Baltic Cable 250 km
1997  First commercial HVDC Light (VSC) installation
2000  First CCC HVDC
2010  800 kV HVDC in service
The history of HVDC
ABB’s pioneering spirit

The Gotland HVDC transmission link, first commercial project
- 20 MW
  ± 100 kV

In between
- 61 HVDC Classic projects and 16 HVDC Light projects
- 14 HVDC upgrade projects
- >50% global market share
- Continuous technology leaps
- Benefits to utilities, industries and power consumers

The Xiangjiaba-Shanghai project commissioned in July
- 6,400 MW
  ± 800 kV
HVDC by ABB
Let our experience work for you

61 HVDC Classic Projects since 1954
14 HVDC Classic Upgrades since 1990
16 HVDC Light Projects since 1997
Customer’s need

- 1978 it was decided to build a HVDC transmission system from Itaipu hydro power plant to São Paulo to meet the rapidly growing power demand

ABB’s response

- Turnkey 3150 + 3150 MW ±600 kV HVDC power link

Customer’s benefits

- Itaipu HVDC link brings power generated at 50 Hz in Itaipu hydropower plant, to the 60 Hz network in São Paulo, in the industrial centre of Brazil
Québec - New England
Canada - US

Customer: Hydro Québec and NEES

Year of commissioning: 1990 - 1992

Customer’s need

- Enable a pool of utilities in the New England to meet increasing power demand with clean economic hydro power from Quebec and to carry power from James Bay to southern Québec

ABB’s response

- Turnkey 2000 MW ± 450 kV multi-terminal HVDC power link

Customer’s benefits

- The HVDC multi-terminal system brings power from La Grande II hydro power station to loads in Montreal, Québec, Canada and to Boston, Massachusetts, USA
Existing multi terminal scheme

- Radisson: 2200 MW
- Nicolet: 2138 MW
- Sandy Pond: 1800 MW
- 1480 km
Radisson - Quebec-New England multiterminal
Chandrapur – Padghe
India

Customer: MSEB
Year of Commissioning: 1998

Customer’s need
- Increasing power demand in the Mumbai, Pune and Nasik regions of western Maharashtra state. The thermal power production is concentrated in the eastern part of the state.

ABB’s response
- Turnkey 1500 MW ±500 kV HVDC power link

Customer’s benefits
- The link carries the load of four 400 kV AC lines, stabilizes the Maharashtra grid, increases the power flow on the existing East-West 400 kV AC-lines and minimizes the total transmission losses
Padghe India Valve Hall, 500 kV 750 MW
Three Gorges HVDC links
China

Customer: State Grid Corporation of China

Years of commissioning: 2003, 2004 and 2006

Customer’s need
- Efficient long distance transmission of very large amounts of hydro power from the Three Gorges plant

ABB’s response
- Three turnkey 3 000 MW ±500 kV HVDC power links

Customer’s benefits
- Economic utilization of remote hydro power
- Supports the rapidly growing Chinese economy with sustainable electricity supply
- Highly efficient power transmission with minimum environmental impact
Longquan, China – 3000 MW Converter Station

Converter Station size:
600m x 360m
Baltic Cable
Sweden - Germany

Customer: Baltic Cable AB

Year of commissioning: 1994

Customer’s need
- Enable power exchange between Germany and Sweden and further integrate power systems of the Baltic Sea region

ABB’s response
- Turnkey 600 MW 450 kV HVDC sea cable system

Customer’s benefits
- The Baltic Cable HVDC project is an economic exchange between a thermal power system and a hydro/nuclear power system
NorNed HVDC Cable
Norway – The Netherlands

Customers: TenneT and Statnett
Year of commissioning: 2008

Customer’s need
- Optimize production system in northern Europe
- The hydropower in Norway is back-up to wind power in the Netherlands

ABB’s response
- Turnkey 700 MW HVDC system with innovative ± 450 kV converter system
- World’s longest cable - 580 km

Customer’s benefits
- Increased security of supply in both markets
- Sharing of balancing power
- Improved power market
- Low transmission losses – 3.7 %
- Reduced CO₂ emission with nearly 1.7 million tons per year
SAPEI
Italy

Customer: Terna SpA
Year of commissioning: 2009

Customer’s need
- Transmission of power from Sardinia to mainland Italy
- Frequency support of Sardinia

ABB’s response
- 1,000 MW ±500 kV HVDC power link

Customer’s benefits
- Export of surplus power from Sardinia
- Import to mainland network at load centre
- Frequency and emergency support to Sardinia
Customer’s need
- Development of renewable hydro power
  2,000 km from load centre

ABB’s response
- World’s longest and largest transmission system
- ± 800 kV UHVDC, 6,400 MW

Customer’s benefits
- High efficiency - 93%
- Compact - land use 40% less than conventional technologies
- Reliable transmission – forced unavailability < 0.5%
Rio Madeira - the world’s longest transmission link
Brazil

Customer’s need
- Transport power from two new hydropower plants in the northwest down to the São Paulo area

ABB’s response
- 3,150 MW 600 kV HVDC power link stretching over 2,500 km
- 800 MW back-to-back station for regional power

Customer’s benefits
- Highly efficient power transmission
- Possibility to use remote renewable energy
North East to Agra UHVDC Transmission
Customer Power Grid Corporation of India

Customer’s need
- Development of renewable hydro power
  1730 km from load centre

ABB’s response
- ± 800 kV UHVDC, 6000/8000 MW
- Multi terminal

Customer’s benefits
- High efficiency - 94%
- Compact - land use 40% less than conventional technologies
- Reliable transmission – forced unavailability < 0.5%
North East to Agra UHVDC Transmission

What is Special?

- Largest rating ever of an HVDC transmission, 8000 MW
- Largest transmission contract ever
- India second country in the world to install 800 kVdc
- Multi-terminal operation second in the world, first with 800 kV
- First 800 kV indoor dc yard 77x77 m
- Longest transmission in India
Project references
HVDC Light technology

- East West Interconnector, 2012, 500 MW
- Tjäreborg, 2000, 7 MW
- Troll, 2004, 2X40 MW
- Skagerrak 4, 2014, 700 MW
- Valhall, 2009, 75 MW
- Estlink, 2006, 350 MW
- Hellsjön, 1997, 3 MW
- NordBalt, 2015, 700 MW
- Gotland, 1999, 50 MW
- Directlink, 2000, 3X60 MW
- Murraylink, 2002, 220 MW
- Cross Sound, 2002, 330 MW
- Eagle Pass, 2000, 36 MW
- BorWin1, 2009, 400 MW
- DolWin1, 2013, 800 MW
- Caprivi link, 2009, 300 MW
Cross Sound Cable
US

Customer’s need

- Enable power exchange between Connecticut and Long Island in the US

ABB’s response

- Turnkey 330 MW ±150 kV HVDC Light® transmission system

Customer’s benefits

- The Cross Sound link improves the reliability of power supply in the Connecticut and New England power grids, while providing urgently needed electricity to Long Island
Estlink HVDC Light®
Finland - Estonia

Customer: Nordic Energy Link AS
Year of commissioning: 2006

Customer’s need
- Create a common open electricity market in the enlarged European Union

ABB’s response
- Turnkey 350 MW HVDC Light® transmission system

Customer’s benefits
- Environmentally adapted to sensitive coastal region by compact converters and totally under sea/ground system
- Increased security of supply and loss reduction in existing network through voltage and VAR control
- Delivery time: 19 months!
BorWin1, offshore wind in Germany
The world’s largest offshore wind park in operation

Customer: transpower
Year of commissioning: 2010

- Customer’s need
  - 125 km subsea and 75 km underground power connection operational in 24 months
  - Robust grid connection

- ABB’s response
  - Turnkey 400 MW HVDC Light system

- Customer’s benefits
  - Environmentally friendly power transport
  - Reduce CO₂ emissions by 1.5 million tons per year by replacing fossil-fuels
  - Supports German wind power development
BorWin1 – the world’s most remote offshore wind park

- 400 MW offshore 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
- 125 km sea cable
- 75 km land cable
- Tailwind for grid reliability
- Power 400 MW

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Slide 33
08MR0045
Customer's need

- Connect the grid in the north west with the grid in the central parts of the country

ABB’s response

- Turnkey 350 kV 300 MW HVDC Light®
- Option for another 300 MW
- First HVDC Light® with overhead lines

Customer’s benefits

- Stability in two very weak AC networks
- Enables future power trading in the expansive region of southern Africa
East West Interconnector
Ireland – Wales, UK

Customer: EirGrid
Year of commissioning: 2012

Customer’s need
- Connect the grids of Ireland and Wales to enable power trade

ABB’s response
- Turnkey 500 MW HVDC Light®
- 186 km sea cable + 70 km land cable
- First HVDC Light® with ±200 kV cables

Customer’s benefits
- Security of supply
- “Black start"
- Active AC voltage support
DolWin1 Offshore Wind Power Connector
800 MW, ±320 kV DC

- 165 km long subsea and underground power connection to offshore wind farm
- Robust grid connection
- Turnkey 800 MW HVDC Light system
- First ± 320 kV extruded cable delivery
- Invisible, sustainable transmission
- Low losses and high reliability
- Reduce CO₂ emissions by 3 million tons per year replacing fossil-fuel generation
- Supports German wind power

Customer: transpower
Year of commissioning: 2013
Customer’s need
- Strengthen security of supply in Baltic region and southern Sweden
- Integrate electricity markets of the Baltic and Nordic countries

ABB’s response
- Turnkey 700 MW HVDC Light system
- Designed for integration into a future pan-European DC grid

Customer’s benefits
- Low losses and high reliability
- Network stability through active AC voltage support
- Quick grid restoration with black-start capability
Skagerrak 4  
Norway - Denmark

Customer: Energinet.dk & Statnett

Year of commissioning: 2014

Customer’s need
- Boost transmission capacity with 700 MW
- Use electricity more efficiently
- Enable networks to add more renewable energy

ABB’s response
- Two 700 MW HVDC Light converter stations
- 500 kV – new voltage record for the HVDC Light technology

Customer’s benefits
- Network stability
- Low losses and high reliability
- Quick grid restoration with black-start capability
HVDC by ABB
Let our experience work for you

- 61 HVDC Classic Projects since 1954
- 14 HVDC Classic Upgrades since 1990
- 16 HVDC Light Projects since 1997
ABB HVDC Project Management Experience (2/3)

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### ABB HVDC Project Management Experience (3/3)

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**Legend:**
- **HVDC**
- **HVDC Light**
- **HVDC CCC**
ABB HVDC and HVDC Light® web portal: www.abb.com/hvdc

HVDC and HVDC Light

HVDC (High Voltage Direct Current) and HVDC Light are highly efficient alternatives for transmitting bulk power and for special purpose applications.

The classic HVDC technology is used to transmit electric power over long distances by overhead transmission lines or submarine cables. It is also used to interconnect separate power systems, where traditional alternating current (AC) connections cannot be used.

HVDC Light® is an underground and submarine cable power transmission technology developed by ABB, that offers additional benefits compared to HVDC Classic.

Read more basics about transmitting power by HVDC and HVDC Light here!

Direct shortcut to this page: http://www.abb.com/hvdc

Product & Service Range

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

- **Service**
  - Through the service organization for HVDC, ABB ensures continued support to the project throughout its lifetime. The unit is not limited to serve the ABB converter stations but also does upgrades of plants supplied by ABB or others.

- **HVDC Light**
  - HVDC Light - The invisible power transmission based on underground cables.
All HVDC publications and films
Power and productivity for a better world™