

## **Appendix B, Underground High-Voltage DC Reference Papers**

Introductory information and technical data

1. City center in-feed feasibility, page 1
2. Connecting wind farms, pages 1, 2
3. Invisible Power, pages 1, 2, 3
4. It's Time to Connect, pages 10, 13, 14, 16, 17, 31, 33

## **City centre in-feed feasible by HVDC Light®**

HVDC Light® is a state-of-the-art power system designed to transmit power underground and underwater. It offers numerous environmental benefits, such as "invisible" power lines, neutral electromagnetic fields, oil-free cables and compact converter stations. These benefits make new transmission projects in densely populated areas acceptable for the public.

### **Your needs – Our response**

Utilities are under extreme pressure to meet consumer and regulatory demands for a high quality, competitively priced power supply that has low environmental impact.

A constraint in building transmission capacity in existing AC grids is the demands on compatibility to the environment along the transmission corridor and the extent to which the developments are acceptable to neighbouring communities.

Meeting these needs with underground HVDC transmission is not only economically feasible, but adds power quality benefits much in demand by today's power networks.

### **Customer Value**

The HVDC Light Cross Sound Cable was energized overnight after the North American blackout in 2003. Millions of consumers in the New York area benefited from the quick network rebound. Beyond its black start capability, the system offers:

- AC grid enhancements
- Reliable power supply
- Black start capability
- Easier permit procedure
  - Underground invisible cable system
  - Environmental friendly oil-free cables
  - Short installation and implementation time
  - Environmentally adapted converter stations
- Low project risk by
  - Easy permitting
  - Short construction and commissioning time
  - Minimizing time from decision to commercial operation
- Flexible, modular systems
  - Can easily be built or expanded to multiterminal system
  - Modular systems can be staged and installed to meet capacity demand
  - Comprehensive factory testing and fast installation
  - Short installation and implementation time
- Underground invisible cable system
  - Enables installations in existing right of ways e.g. existing cable ducts, roads, subways, railways, channels
- Compact, environmentally adapted converter station design
  - Reduction of station foot-print
  - Lower costs for land and civil works
- Health Safety and Environment (HSE) impact
  - Twin cable installation neutralizes magnetic fields
  - Enclosed equipment gives efficient noise suppression
- Low operation and maintenance costs



City centres: high power demand, significant network constraints

### **Scope of supply**

- Feasibility studies to facilitate customer's business development process, including optimization of the entire project/system
- System analysis and network studies
- Engineering and project management
- State of the art HVDC Light® technology including turnkey supply of
  - Converter stations with compact design, adapted to the environment
  - Light-weight, oil-free cables
- Quality assurance ensures the customer systems, operations, and maintenance staff receives proper training and documentation for a smooth transfer at Take Over
- Maintenance Support with short response thanks to remote diagnostics from supplier home base

### **ABB – pioneers of HVDC**

ABB pioneered HVDC technology 50 years ago when the company built the world's first commercial high-voltage direct current transmission link in Sweden. Building on this world first, ABB has maintained its undisputed world leadership in HVDC transmission technology. We have supported our customers with more than 55 HVDC projects around the world providing more than 45, 000 MW of transmission capacity.

And since 1999, with its new HVDC Light® technology, ABB is once again building a technological lead with solutions to customers' transmission challenges around the world.

**Continuing to meet these needs will maintain ABB's leadership position.**

More information can be found on [www.abb.com/hvdc](http://www.abb.com/hvdc)



# Connecting wind farms by HVDC Light®

HVDC Light® is a state-of-the-art power system designed to transmit power underground and underwater. It offers numerous environmental benefits, such as "invisible" power lines, neutral electromagnetic fields, oil-free cables and compact converter stations. These benefits make it possible to connect wind farms far away from the AC network without distance limitations or constraints on the AC grid.

## Your needs – Our response

The demand for large wind farms far away from shore creates the need for higher power and longer transmission connections than before. Often the connection points will be in a weak part of the grid and power quality and voltage stability criteria need to be fulfilled.

Environmental restrictions on overhead power lines in coastal areas are common, thus making the option of undersea and underground cables attractive.

Underground HVDC Light® transmission is not only economically feasible, but meet these special needs.

## Customer Value

In 1999 ABB installed the Gotland HVDC Light® underground transmission system that connected the wind farm in the south of Gotland with a remote load centre. The project has demonstrated the following values:

- Reliable grid connection
  - Facilitates grid connections in remote areas without need for grid reinforcements
  - "Ride-through-capability" in case of grid faults
  - AC grid enhancements
- Can connect any type of windmill technology
- Easier permit procedure
  - Underground invisible cable system
  - Environmental friendly oil-free cables
  - Short installation and implementation time
  - Environmentally adapted converter stations
- Low project risk by
  - Easy permitting
  - Short construction and commissioning time
  - Minimizing time from decision to commercial operation
- Flexible, modular systems
  - Can easily be built or expanded to multi terminal system
  - Modular systems can be staged and installed to meet capacity demand
  - Comprehensive factory testing and fast installation
  - Short installation and implementation time
- Compact, environmentally adapted converter station design
  - Reduction of station foot-print
  - Lower costs for land and civil works



Middlegrund wind farm, Denmark

- Health Safety and Environment (HSE) impact
  - Twin cable installation neutralizes magnetic fields
  - Enclosed equipment gives efficient noise suppression
- Low operation and maintenance costs

## Scope of supply

- Feasibility studies to facilitate customer's business development process, including optimization of the entire project/system
- System analysis and network studies
- Engineering and project management
- State of the art HVDC Light® technology including turnkey supply of
  - Converter stations with compact, light-weight offshore module design
  - Light-weight, oil-free cables
- Quality assurance ensures the customer systems, operations, and maintenance staff receives proper training and documentation for a smooth transfer at Take Over
- Maintenance Support with short response thanks to remote diagnostics from supplier home base

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## Continuing to meet these needs will maintain ABB's leadership position.

For reference projects, please see the reverse side. More information can be found on [www.abb.com/hvdc](http://www.abb.com/hvdc)

## Reference list - HVDC Light®

PROJECT	In service	Power MW	DC voltage kV	Station location and AC grid	Length of cable, km	Application	Customer
HÄLLSJÖN Sweden	1997	3	±10	Hällsjön, 10 kV Grängesberg, 10 kV	10 (overhead)	Pilot system	VB Elnät, Sweden
GOTLAND Sweden	1999	50	±80	Näs, 77 kV Bäcks, 77 kV	70	Wind, Undergrounding	GEAB, Sweden
DIRECTLINK Australia	2000	3 x 60	±80	Terranora, 110 kV Mullumbimby, 132 kV	65	Undergrounding	TransEnergy, USA North Power, Australia
TJÆREBORG Denmark	2000	7,2	±9	Enge, 10,5 kV Tjæreborg, 10,5 kV	4,4	Wind, Undergrounding	Eltra, Denmark
EAGLE PASS USA	2000	36	±15.9	Eagle Pass, 138 kV (both sides)	NA (back-to-back)	Grid reliability	AEP, USA
CROSS SOUND USA	2002	330	±150	New Haven, 345 kV Shoreham, 138 kV	40	Grid reliability	TransEnergie US, USA
MURRAYLINK Australia	2002	220	±150	Berri, 132 kV Red Cliffs, 220 kV	180	Undergrounding	TransEnergie US, USA
TROLL A Norway	2005	2 x 41	±60	Troll A, 56 kV Kollsnes, 132 kV	67	Offshore	Statoil, Norway
ESTLINK Estonia - Finland	2006	350	±150	Espoo, 400 kV Harku, 330 kV	105	Grid reliability, Undergrounding	Nordic Energy Link AS, Estonia
VALHALL Norway	2009	78	150	Lista, 300 kV Valhall, 11 kV	292	Offshore	BP Norway

More information regarding each specific project can be found on  
[www.abb.com/hvdc](http://www.abb.com/hvdc)



**ABB Power Technologies AB**  
**Grid Systems - HVDC**  
 SE-771 80 Ludvika, Sweden  
 Tel: +46 240 78 20 00  
 Fax: +46 240 61 11 59  
[www.abb.com/hvdc](http://www.abb.com/hvdc)