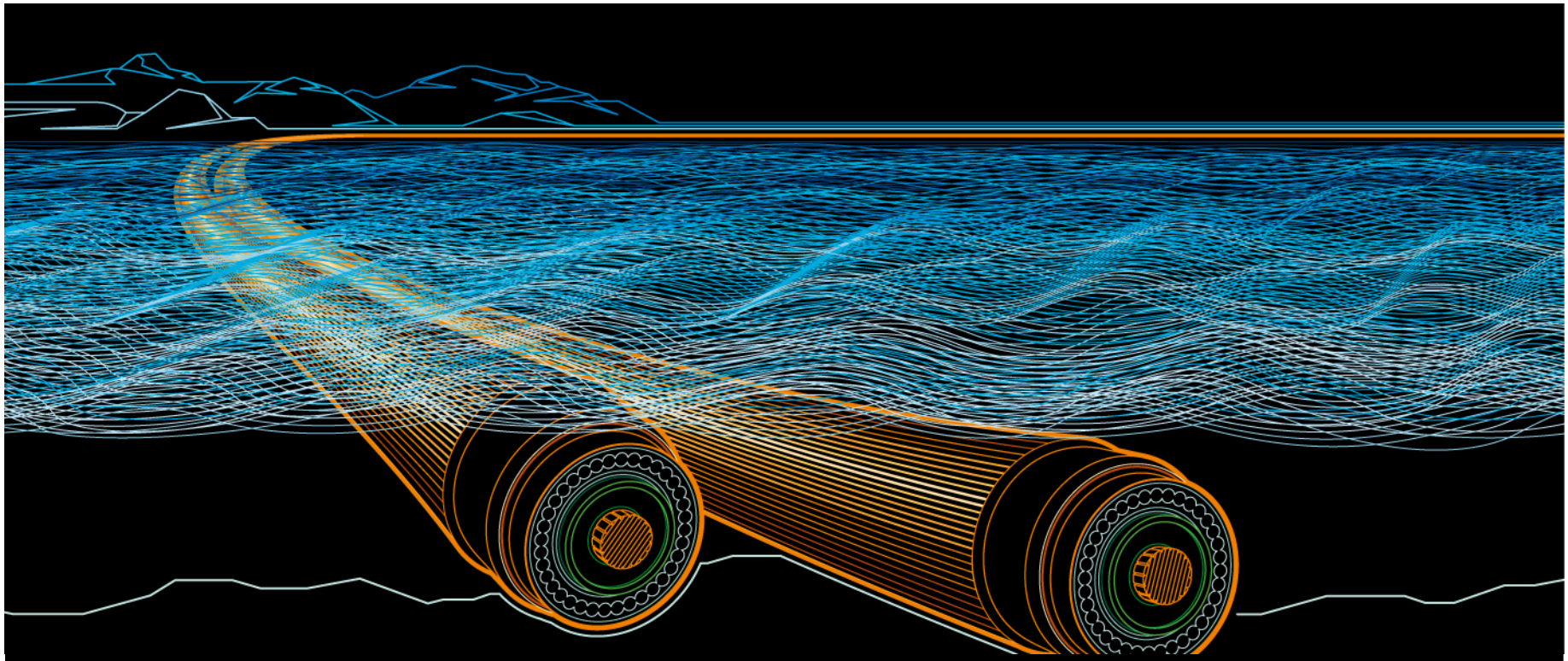


Magnus Callavik, Vice President Technology, Grid Systems, January 2015

ABB Power Systems

Grid Systems

ABB's unique position in HVDC

In-house converters, semiconductors, and cables

Key components for HVDC transmission systems

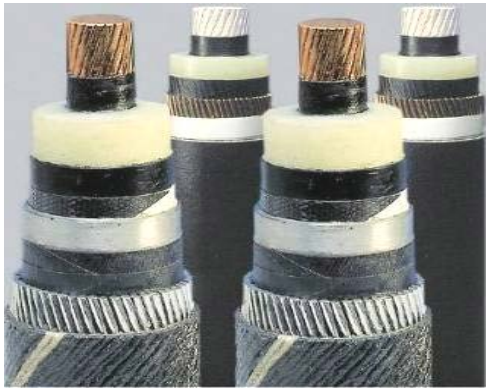
Converters	High power semiconductors	HV Cables
		
		
Conversion of AC to DC and vice versa	Silicon based devices for power switching	Transmit large amounts of power- u/ground & subsea

ABB pioneer new grounds in HVDC

HVDC interconnect energy systems and integrate renewables

First: Gotland 1. 20 MW, 100 kV

First: Gotland Light 50 MW, 80 kV

Largest: Hami-Zhengzhou
8 GW, 800 kV(2210 km OHL)

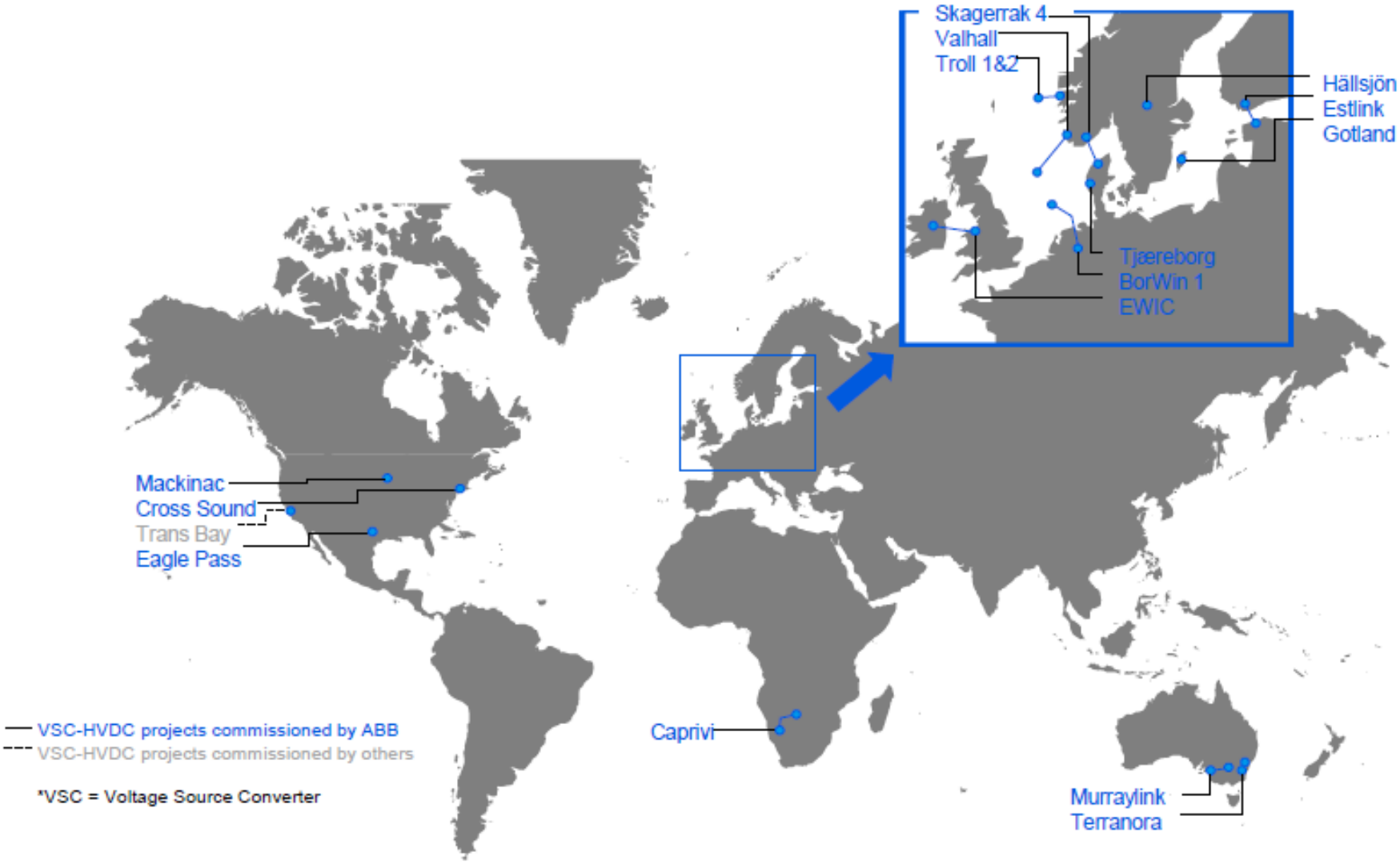
Largest: VSC HVDC Light EWIC
500 MW / 200 kV 262 km

www.abb.com/hvdc

HVDC Classic for bulk transmission since 1954
HVDC Light for self-controlling transmission since 1999

ABB's HVDC Light® leads the way in VSC* technology

With Skagerrak 4, ABB has delivered 15 of the VSC projects commissioned around the world



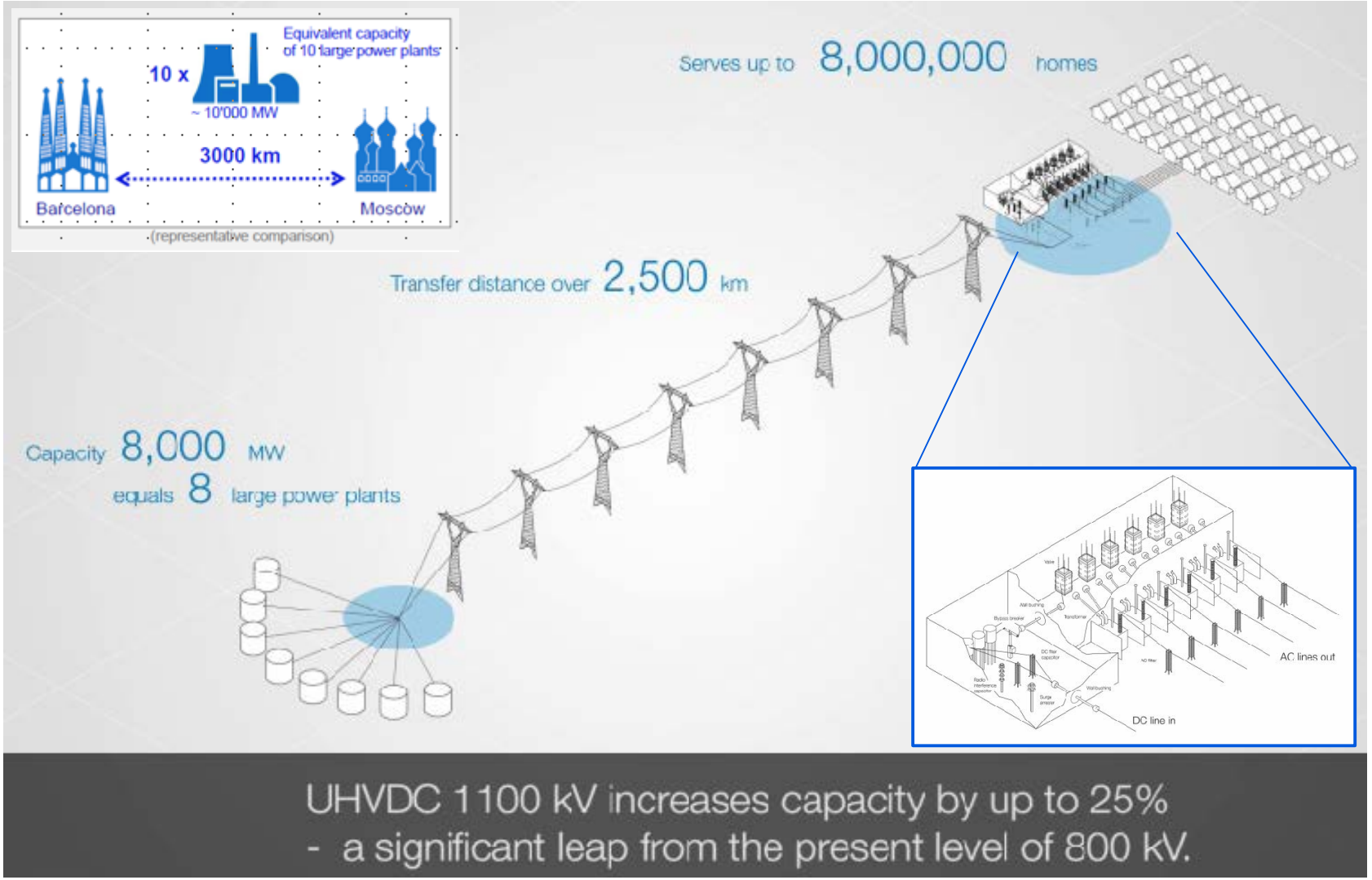
New extruded HVDC cable system takes underground & subsea transmission to the next level

- 2nd generation of high power transmission system for HVDC underground and subsea transmission launched in 2014 after type testing at 1.9 times rated voltage of 525 kV
- Cable, joints and terminations
- From 80 to 525 kV in 15 years

1st generation XPLE extruded HVDC Light Cables

Installed	Voltage	Power	Example
2014	320 kV	900 MW	Dolwin 1
2014	320 kV	700 MW	Southwestlink
2012	200 kV	500MW	EWIC
2009	150 kV	400MW	Borwin 1
2005	150 kV	350MW	Estlink 1
2002	150 kV	220 MW	Murray Link
1999	80 kV	50 MW	Gotland Light

Ultra-high voltage direct current (UHVDC) systems for transmission up to 11 GW in one tower line



900 MW Dolwin 2 HVDC Light Converter station for offshore wind connections. At the yard in Norway

Recently commissioned Skagerrak 4.
World record HVDC Light 500 kV, 700 MW

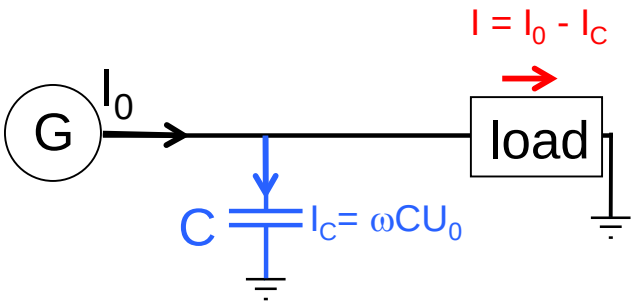
- The subsea links balance hydro power from Norway and wind power from Denmark while stabilizing the grid in both countries
- A bipole with one Classic and Light in parallel at new record 500 kV

Power and productivity
for a better world™

WHY HVDC? It is ideal for long distance transmission

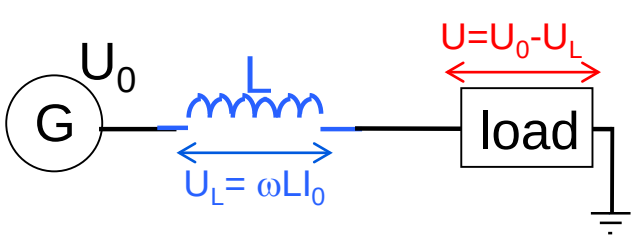
Capacitance of high power cables. Inductance of power lines

Cable



In cable > 50 km, most of AC current is needed to charge and discharge the “C“ (capacitance) of the cable

Overhead Line



In overhead lines > 200 km, most of AC voltage is needed to overcome the “L” (inductance) of the line

⇒ C& L can be compensated by reactors/capacitors or FACTS
or by use of DC, which means ω = 2πf = 0