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„Innovative Solutions for bulk power transmission“

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HVDC example from China:
Hydro power via an 800kV HVDC link

- **With conventional AC power transmission the hydro power could not be used:
5000 MW over 1400 km.**
- **World‘s first 800kV HVDC**
- **Commissioned 06/2010**

**CO_2 abatement:
30 Mt p.a.**

Station Chuxiong

Green towers:
800 kV DC overheadline in China:

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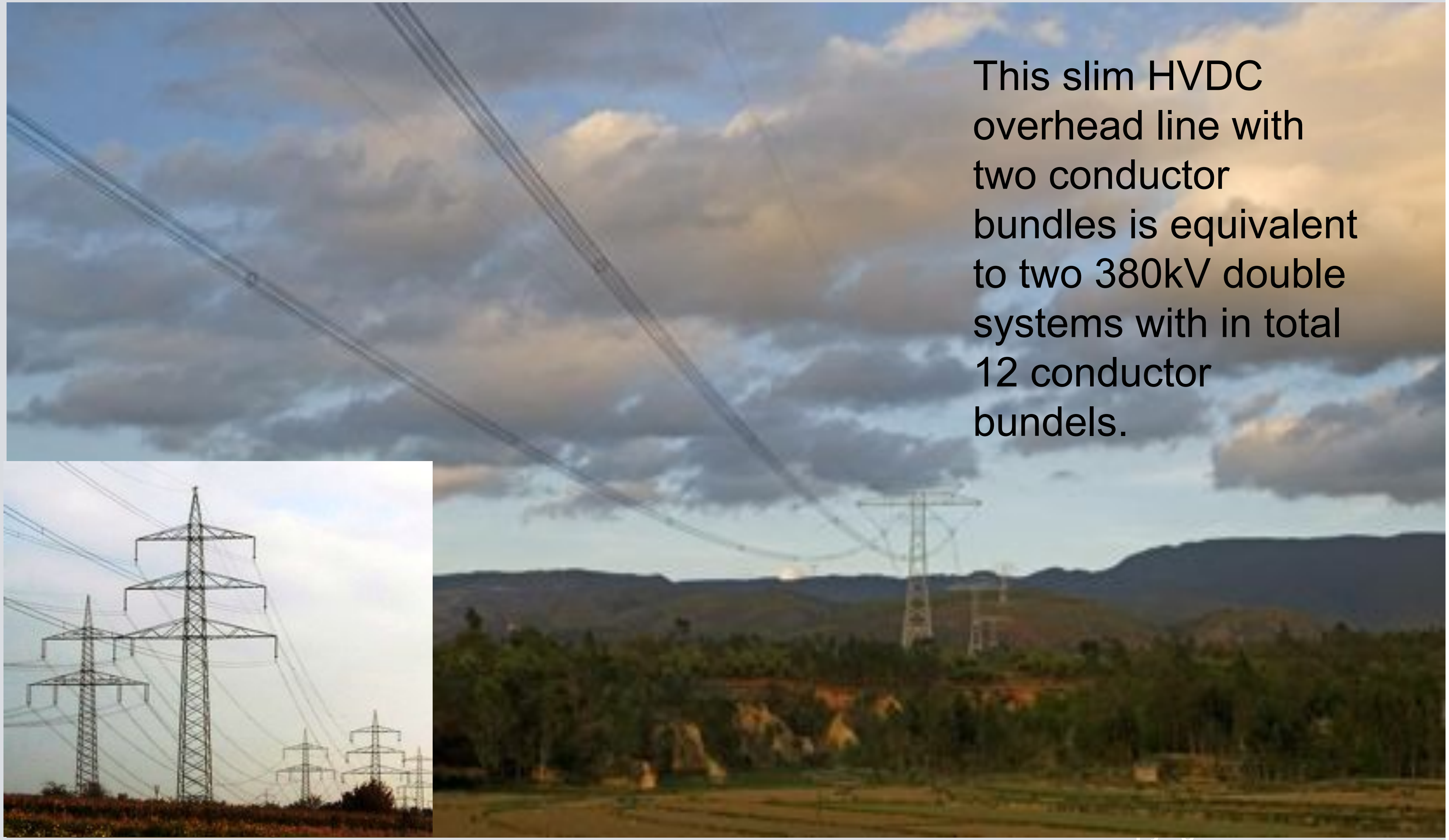

This slim HVDC overhead line with two conductor bundles is equivalent to two 380kV double systems with in total 12 conductor bundels.

Project „Trans Bay Cable“, USA
Secure the power supply of San Francisco

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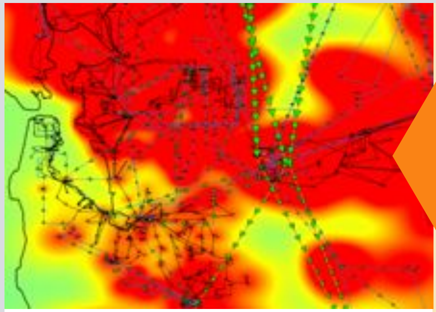
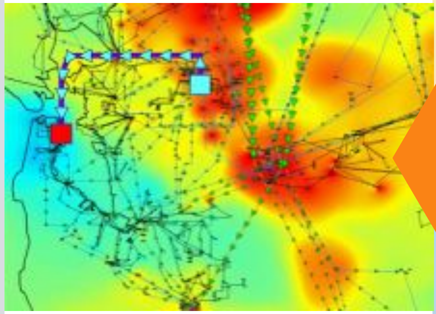
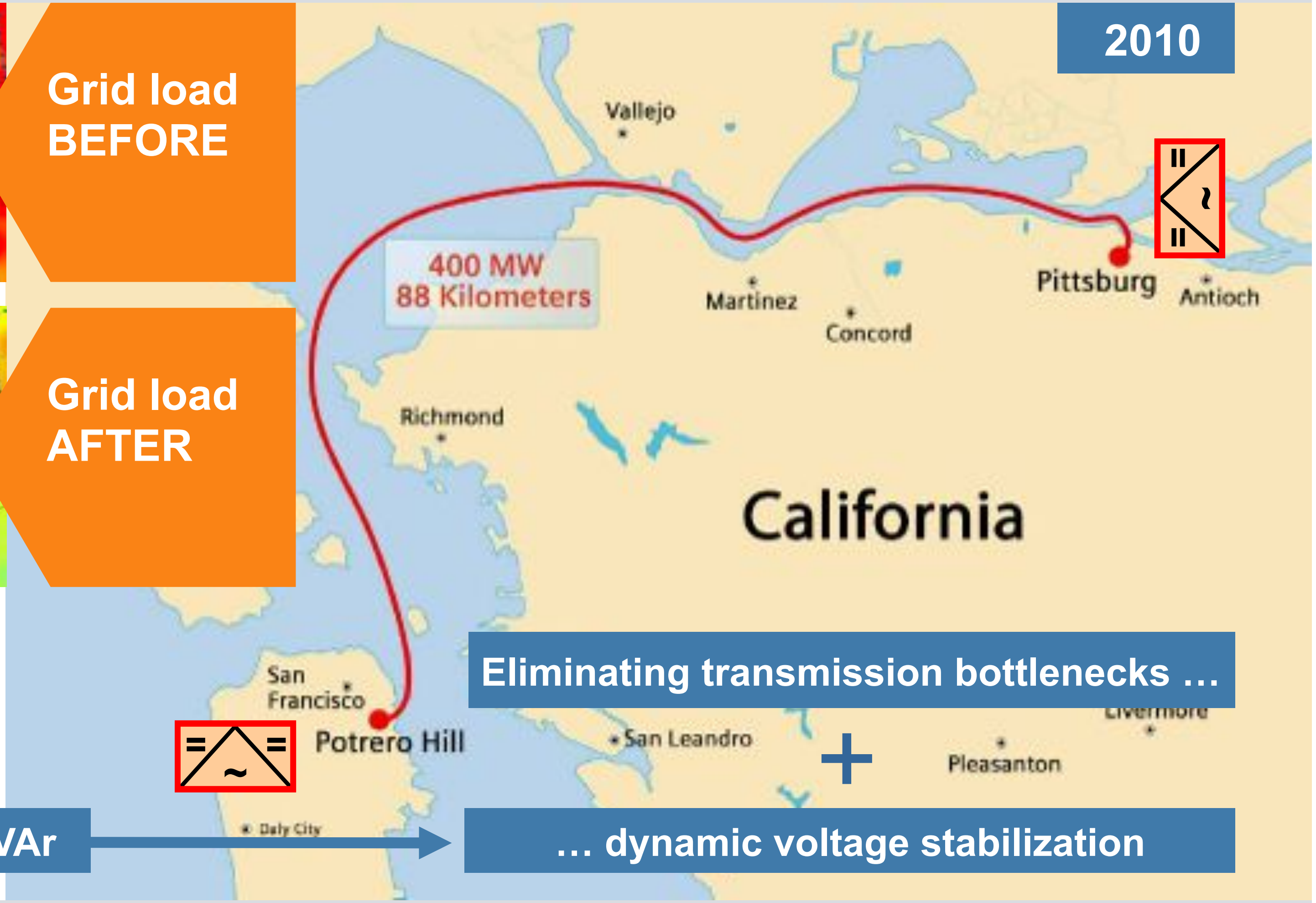


Grid load BEFORE



Grid load AFTER

P = 400 MW,
± 200 kV DC
cable



Eliminating transmission bottlenecks …

\+

Q = +/- 170-300 MVAr → **… dynamic voltage stabilization**

Security of supply:
HVDC as a firewall during the US blackout 2003

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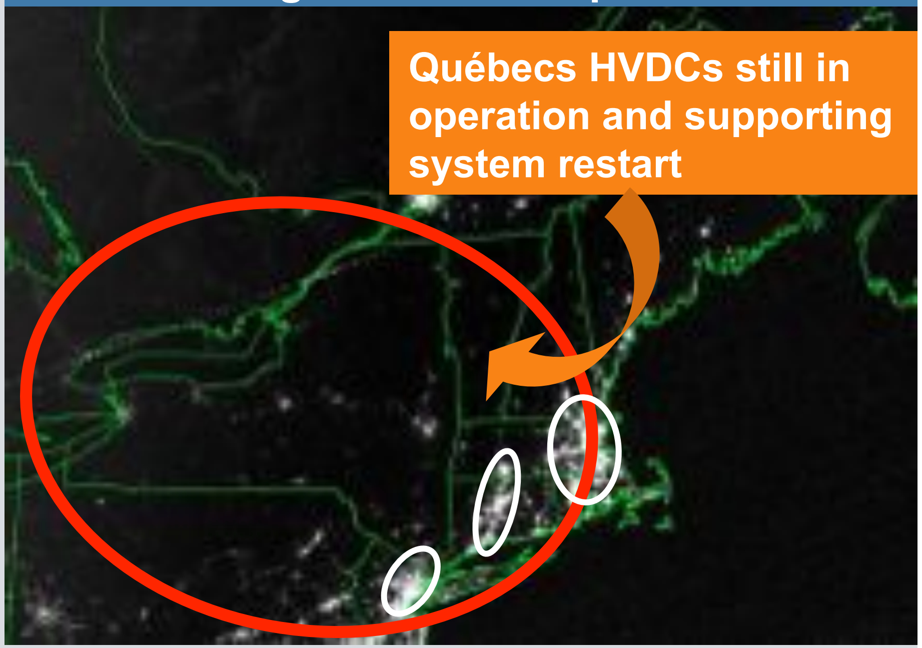
Before blackout

Blackout: huge area withou power



Quelle: EPRI 2003

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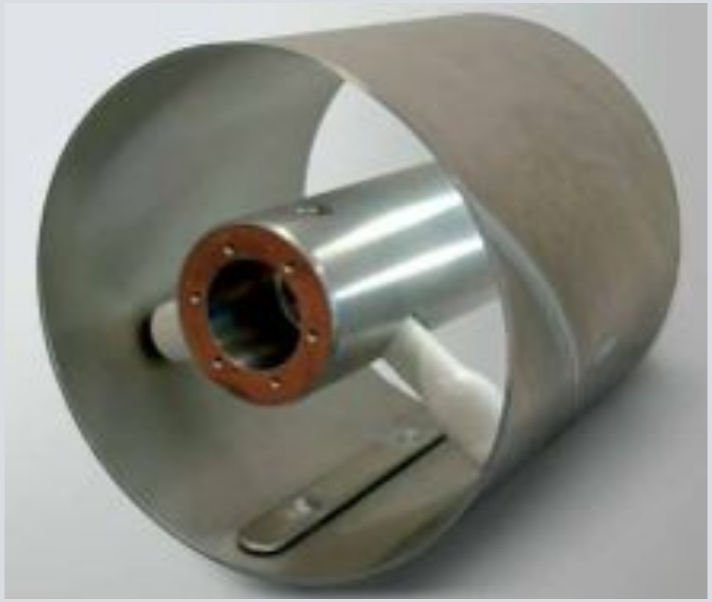
Overhead lines, cables, AC and DC …
… there is a third option commercially available!



GIL – Technical data	
Rated voltage	245 to 550 kV
Rated current	up to 4000 A
Rated short-time current	63 kA/3s
Insulating gas	N_2 and SF_6 gas mixture
System length	from 100 m to 100 km

Gas Insulated Lines (GIL)

GIL - Reference: Kelsterbach, Germany

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Customer: Amprion
Country: Germany
Date: 2011

Requirements

- Replacements of a 380 kV OHL by an underground transmission solution with gas insulated lines (GIL)
- Creation of space for a new runway at the airport Frankfurt
- Low environmental impact (safety, EMI, small width of route)
- Worldwide first pilot for directly earth buried GIL in this voltage level

Products

- Gas insulated line (GIL) for 400kV
- Two systems with 1.800 MVA transmission power each

Customer benefit

- Transmission of high power under ground
- Least possible width of route
- Low losses without need of tunnel works
- Environment friendly integration in to the landscape

500kV GIL Project ‘Jinping I’

Location

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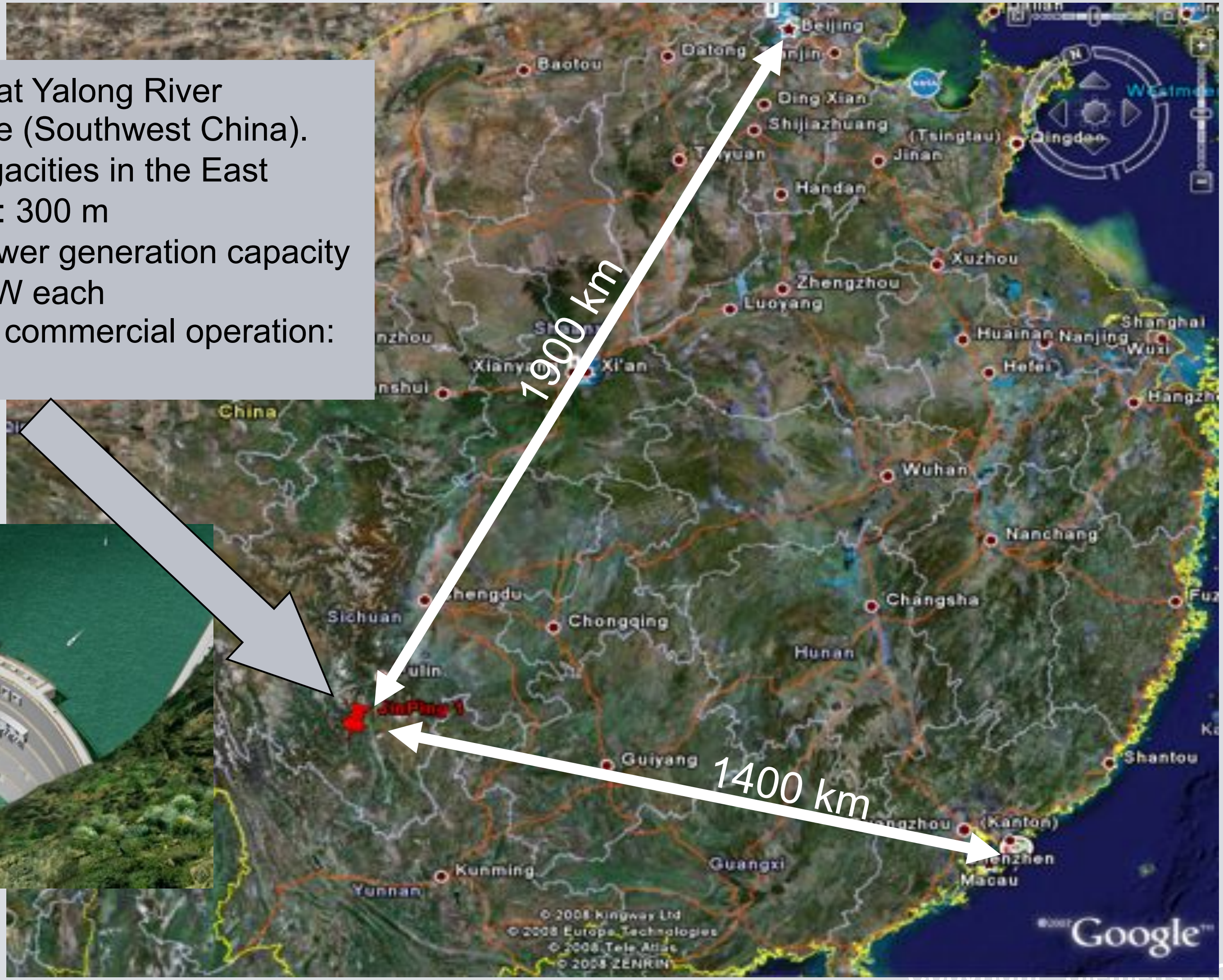
- Hydropower Plant at Yalong River in Sichuan Province (Southwest China).
- Energy for the Megacities in the East
- height of arch dam: 300 m
- 3600 MW rated power generation capacity
- six turbines 600 MW each
- commencement of commercial operation: 2012



‘GIL Jinping I’
Project Overview

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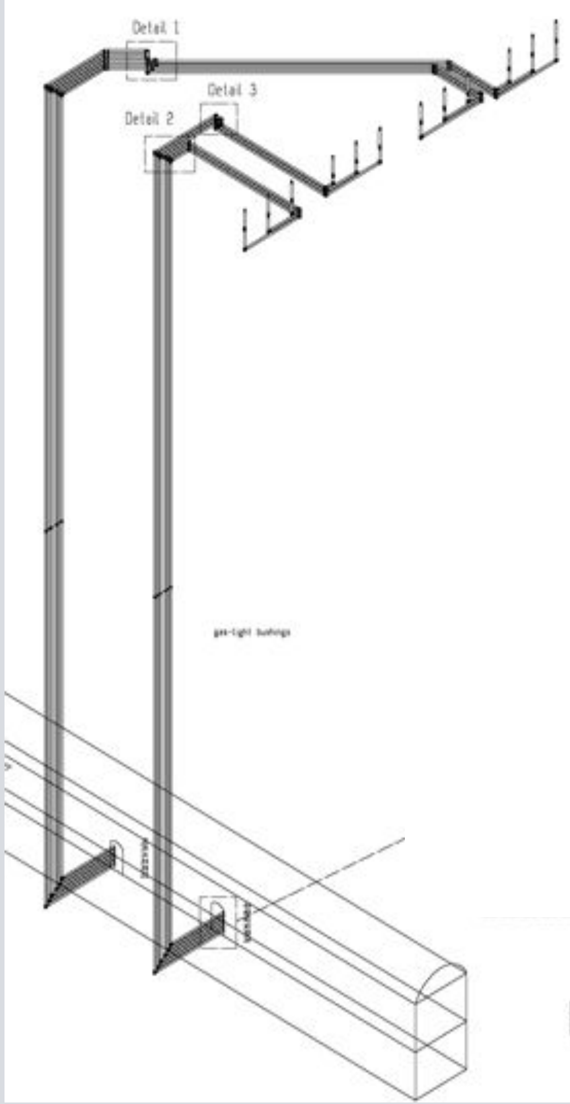

End User: ERTAN Hydropower Development Co. Ltd.

Project Highlights:
- First Siemens GIL in China
- First vertical and welded Installation of 2nd Generation GIL
- 3 GIL Systems, approx. 350 m each

Technical Data

Rated Power:	3500 MVA
Rated Voltage:	550 kV
Rated Current:	4,000 A
Insulation Gas:	100% SF_6
Contract Award:	25.07.2008
Commercial Operation (planned):	01.08.2011

Dead End Tower

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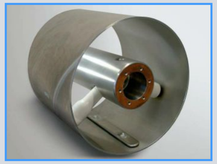
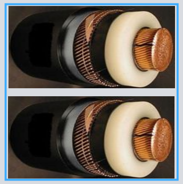
Guidelines/trends for transmission technology selection

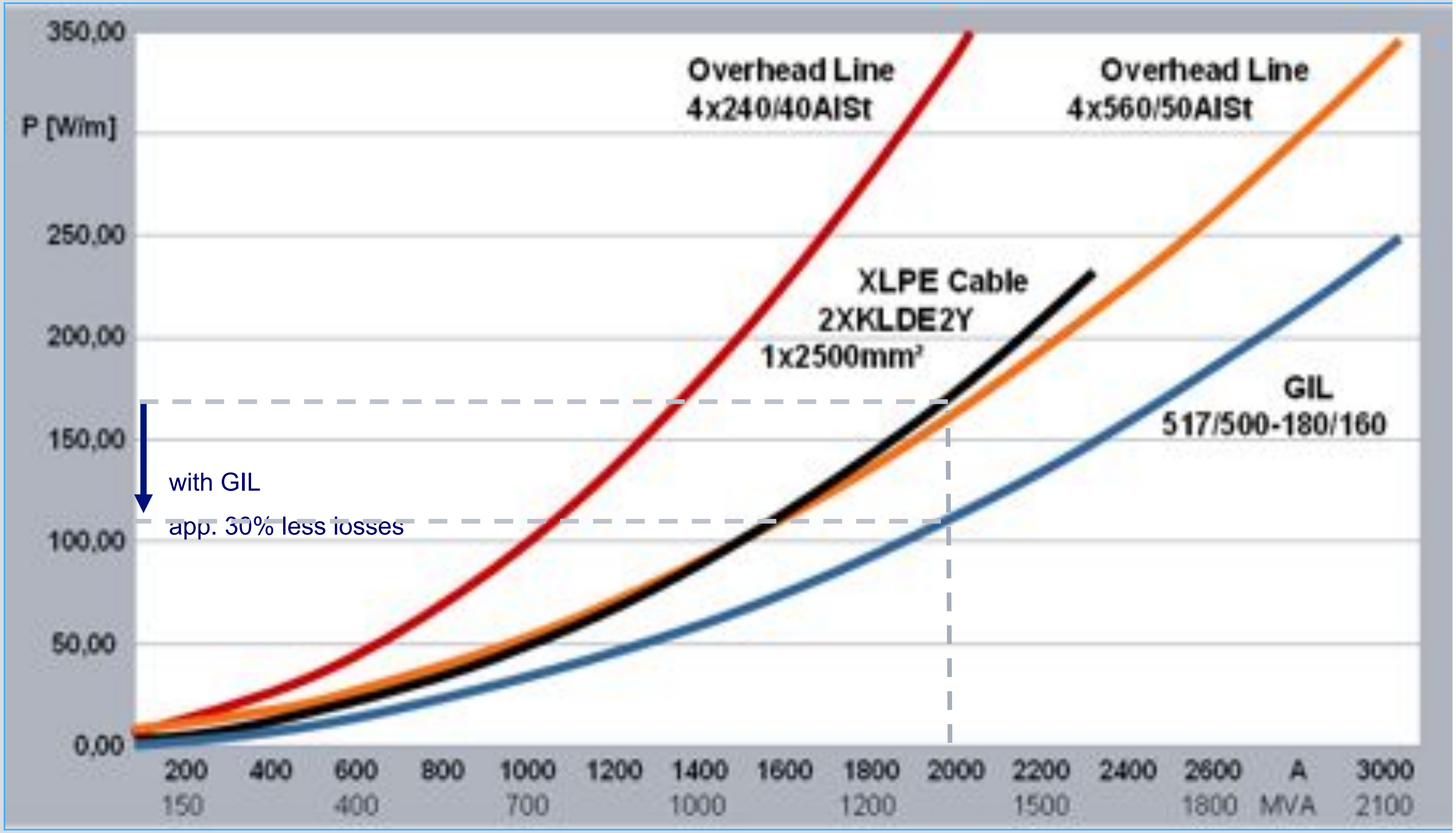




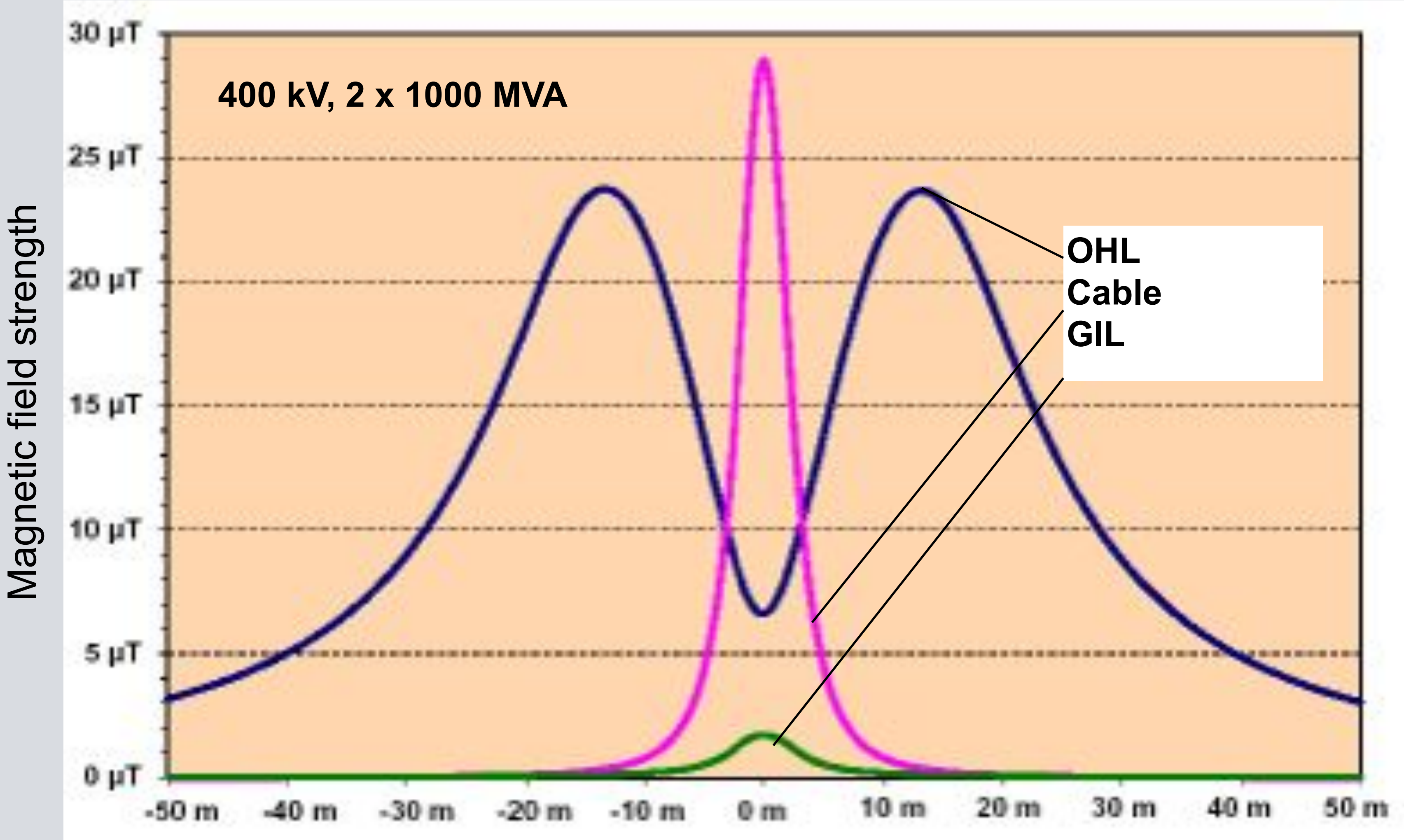
Equipment	OHL	GIL	Cable
Standard lines in rural area	X		
Lines with special constraints, requiring underground solutions (e.g. close to airports, through cities or villages, in space-restricted areas etc.)		X	X
Lines with transmission power < ~ 1,500MVA	X	(X)	X
Lines with transmission power > ~ 1,500MVA	X	X	May need double cable system
Special requirements concerning EMF		X	
Special requirements concerning fire protection and/or explosion protection		X	

Details are extremely dependent upon project conditions!

Lifecycle considerations: Ohmic losses



EMC considerations: Magnetic fields



Safety and Security of Supply Considerations: Auto Reclosure on GIL

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Scenario: - fault detection by protection system
- line drop-off and arc extinguishing

Auto Reclosure:
- gas insulation is self-recovering
- in case of successful auto re-closure by-products are collected in the particle trap
- in case of unsuccessful auto re-closure no impact or fire outside the GIL

View inside the GIL:
Test Conditions: 63 kA, 500ms

No external impact, no fire risk due to non inflammable materials

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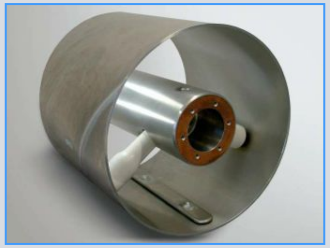
Cost comparison of 400kV transmisson systems



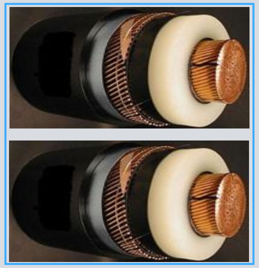


Table is for 2,000MVA

Equipment	OHL	GIL	Cable
Number of necessary systems	1	1	x2 (if double system needed)
Installation cost	1	Circa x10	Circa x10 (double system)
Operation losses Maintenance costs Replacement needed	1 1 Circa 100yrs	lower lower Expect 50+yrs	lower lower Circa 30+yrs

Details are extremely dependent upon project conditions!

Technical Features and Commercial Aspect

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- High transmission power → Low expenses for right of way
- High reliability → Low invest for redundancy
- Sealed for lifetime → Low maintenance cost
- Low losses → Low operation cost
- No ageing of insulating gas & Long lifetime through particle trap → No cost for replacement
- Low capacitance → No expensive reactors
- Automatic reclosure functionality → No invest for new protection
- Low external electromagnetic fields → Optimised short routing possible
- High safety (no fire hazard) → No invest for fire protection needed, Possibility to share civil cost with other utilities

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Thank you for your attention!

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Gas-Insulated Transmission Lines, Status Oct 2010*

National Grid Transco
Elstree, Great Britain
750 m / 2004

Statkraft (NVE)
RoD, Norway
110 m / 1981

Rheinisch Westfälische
Elektrizitätswerke
Kelsterbach, Germany
5400 m / 2009

Badenwerk
Rheinhafen, Germany
Steampower station unit 7
800 m / 1982

Schluchseewerk AG
Wehr, Germany
4000 m / 1975

Stadtwerke München
HKW-Nord, Germany
800 m / 1990

Neckarwerke
Altbach, Germany
800 m / 1985

ERTAN Hydro Power
Jinping I, China
3300 m / 2011

National Grid
Stella West, GB
1258 m / 2010

National Grid
Penwortham, GB
770 m / 2010

China Three Gorges
Project Corporation,
Xiluodu, China
12750 m / 2012

Austria Hydro Power
Limberg II, Austria
480 m / 2010

Tehri Hydro Develop-
ment Corp., Tehri
Hydro Project, India
4550 m / 2006

Ontario Hydro
Bowmanville, Canada
1257 m / 1987

Electricity Generating
Authority of Thailand
Sai Noi, Thailand
3510 m / 2002

NEEWS Northeast Utilities
Service Co., USA
1275 m / 2011

Public Utilities Board
Senoko, Singapore
401 m / 1993

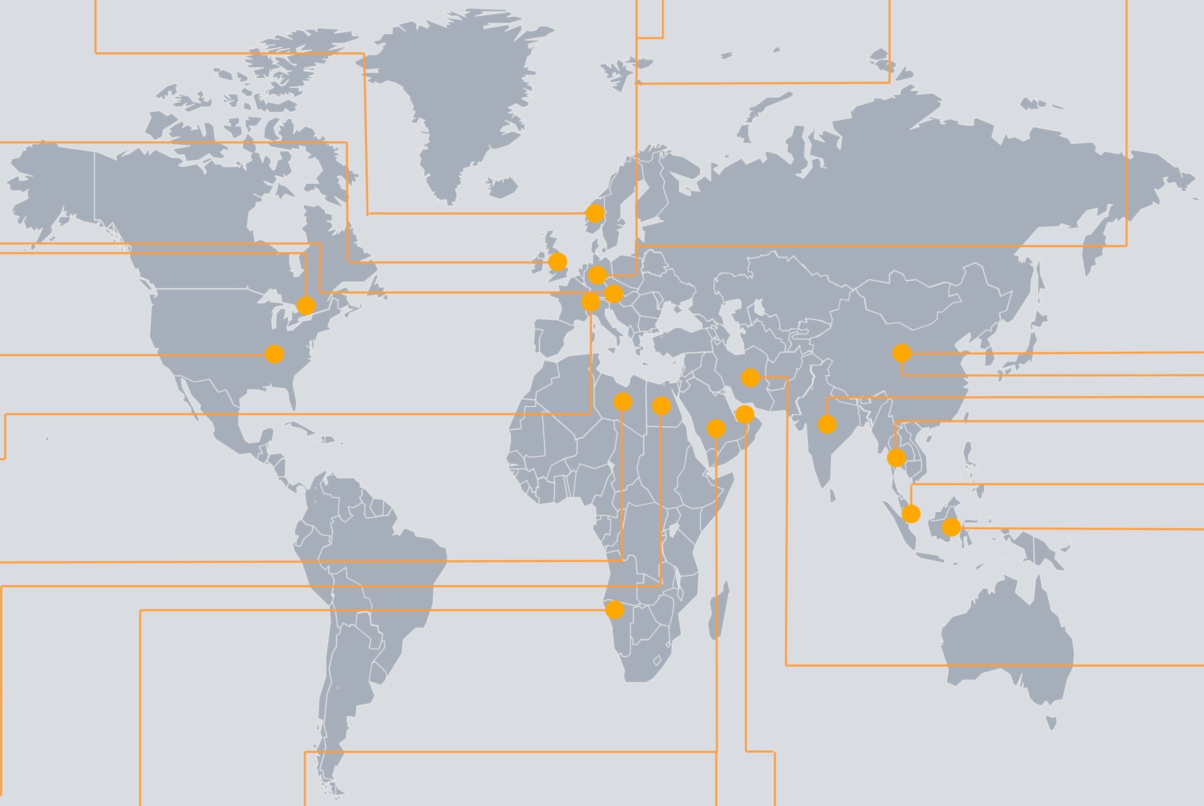
Energie Ouest Suisse
PALEXPO, Switzerland
2560 m / 2001

Perusahaan Umum
Listrik Negara PLN
Gresik Power Plant,
Indonesia
2300 m / 1992

Deutsche Babcock AG for
Ministery of Electricity
Homs P.S., Libya
800 m / 1980

Energy Org.
Power Station Iran 1,
Iran
3700 m

Egyptian Electricity Authority
Itay el Baroud, Egypt
670 m / 1993



Cairo Electricity
Power Corp.
Cairo, Egypt
1850 m / 2004

Swawek, Windhoek
Ruacana, Namibia
800 m /1976

SNEC Jeddah,
Saudi Arabia
300 m / 1981

Saudi Consolidated
Electricity Company
Rabigh/Yanbu,
Saudi Arabia
1340 m / 1988

Saudi Consolidated
Electricity Company
9023, Saudi Arabia
21,000 m / 2010

Dubai Electricity and
Water Authority
Warsan, Dubai
4050 m / 2007

Dubai Electricity and
Water Authority
Series Reactors, Dubai
1100 m / 2011

above ground installation
tunnel installation
directly buried installation

*) overall tube length 86,704 m