
AREVA

Energy Efficiency in Electrical Networks Challenges Ahead

Prof. Peter Kirchesch

Vice President R&D AREVA T&D

2009 IEEE Bucharest PowerTech

Bucharest/ROM, June 29 th, 2009

Opening statement (1/2)

- **Improved Energy Efficiency** means the more efficient (better) use of energy through energy savings and reduction of losses.
- It is seen as the quickest, most effective and most cost-effective manner for reducing greenhouse gas emissions (CO_2, others).

- T&D contributions to Energy Efficiency will be discussed in this presentation
  - Challenges
  - Answers (Technical solutions)

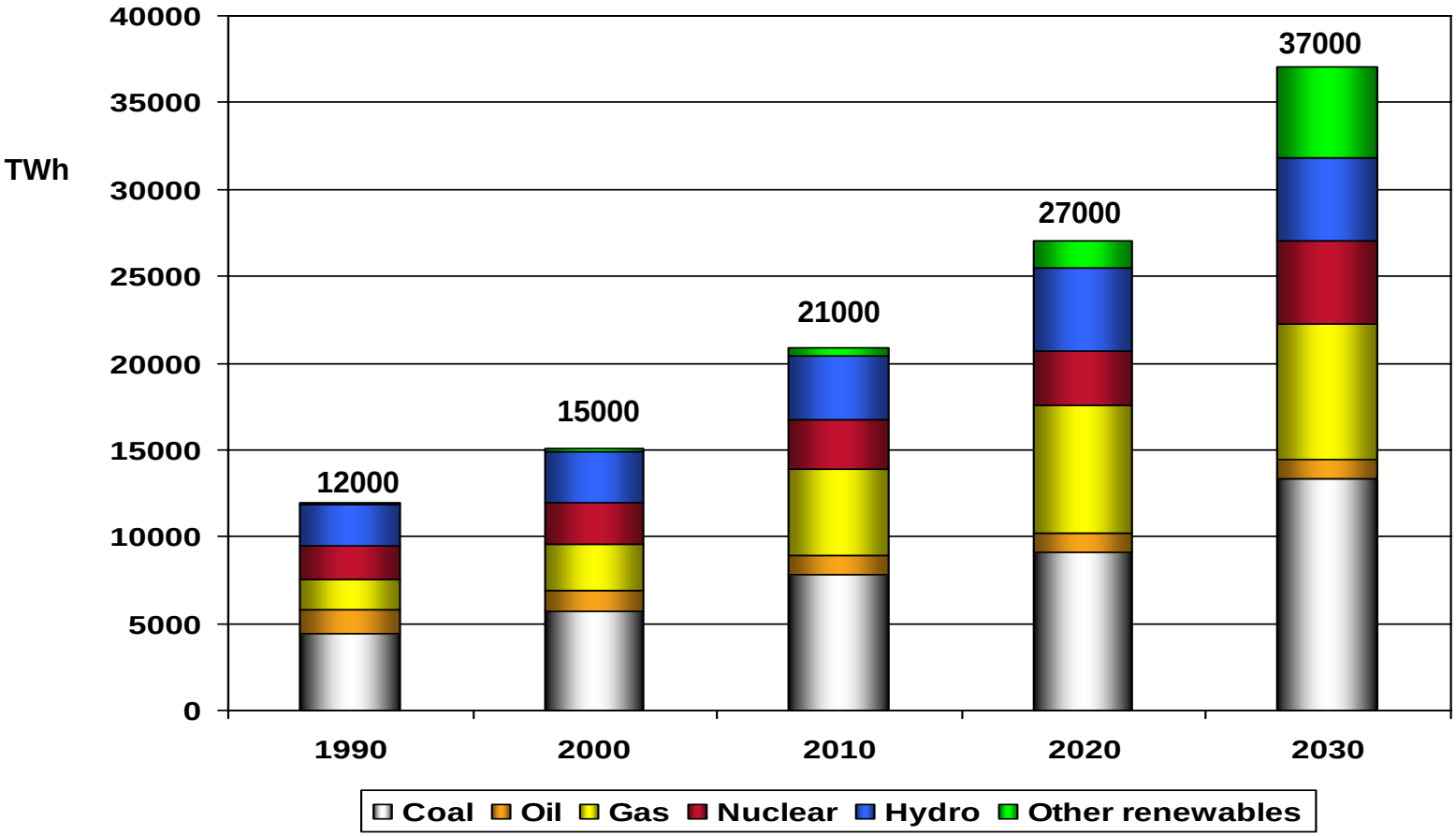
Opening statement (2/2)

- **Electrical networks have to be prepared to accommodate the change in generation mix and load profiles considering:**
  - **Reliability**
  - **Efficiency**
  - **Sustainability**
  - **Affordability**

This is not a new message,
it will however remain valid for the future

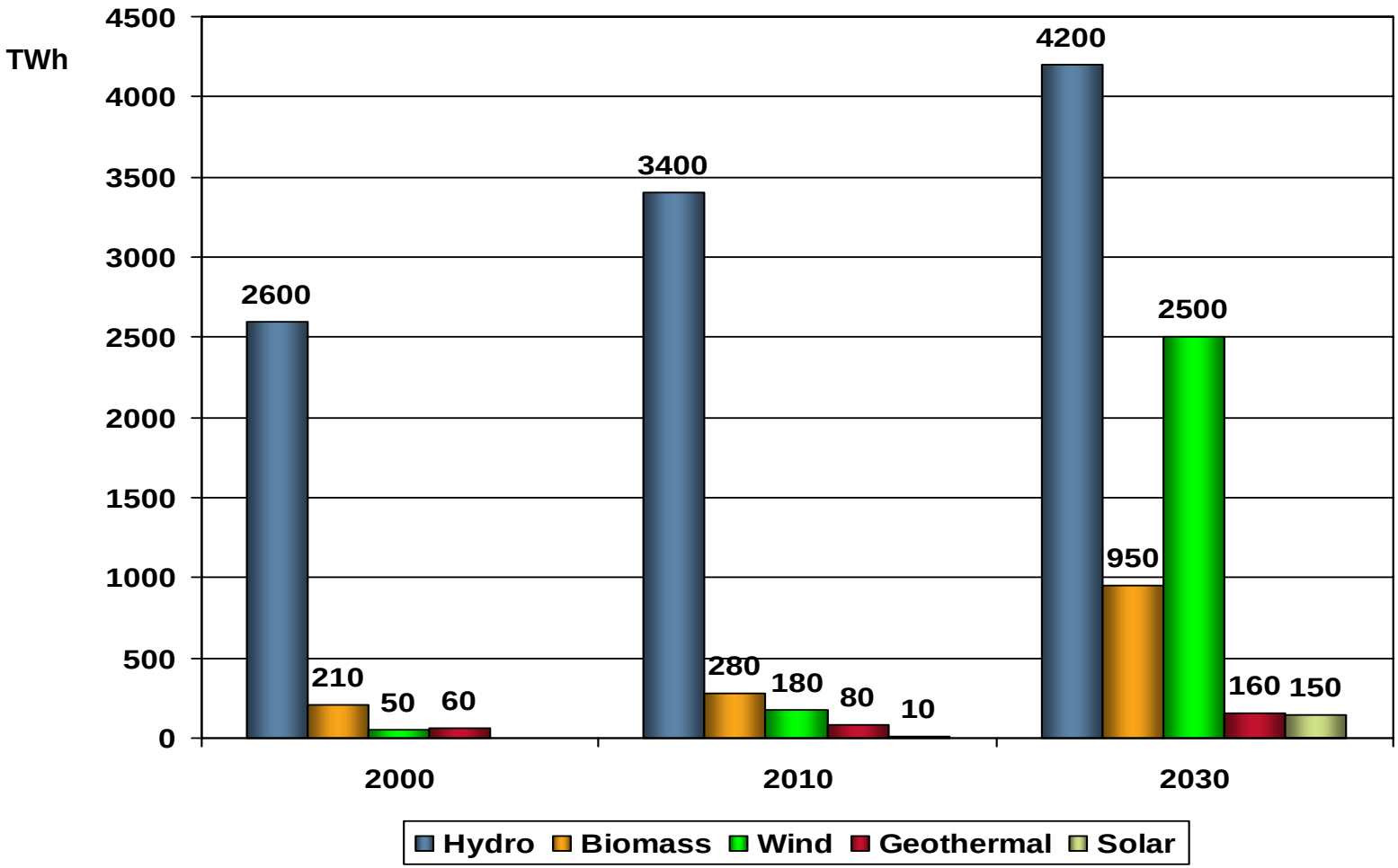
Challenges ahead

World Electricity Generation (by Energy Source), 1990 - 2030



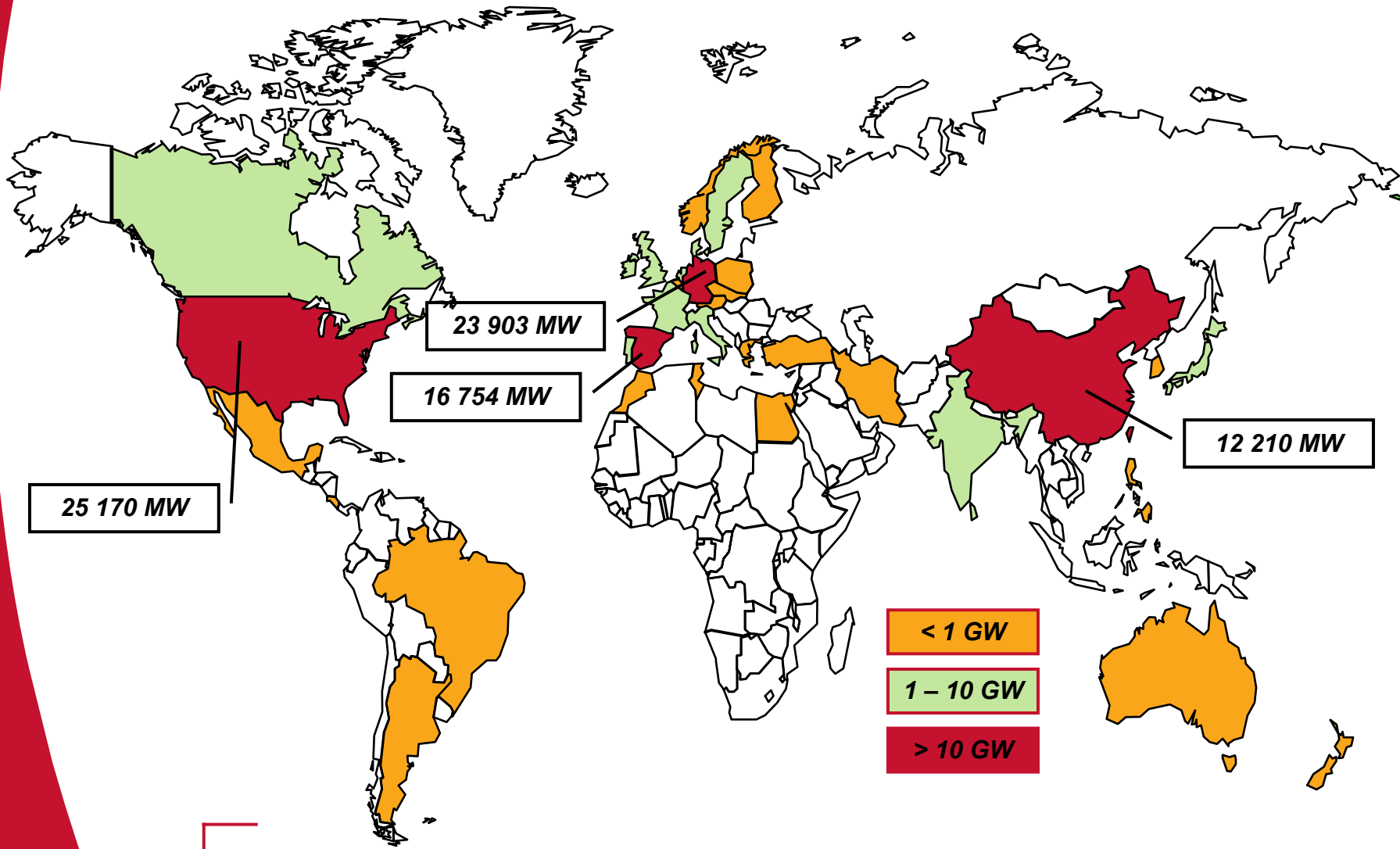
RES (w/o hydro) will increase from 3 % to 14 % (2010 to 2030)

World Electricity Generation from Renewable Sources, 2000 to 2030



Massive increase of wind power and biomass

Massive Integration of Wind Power (12.2008)



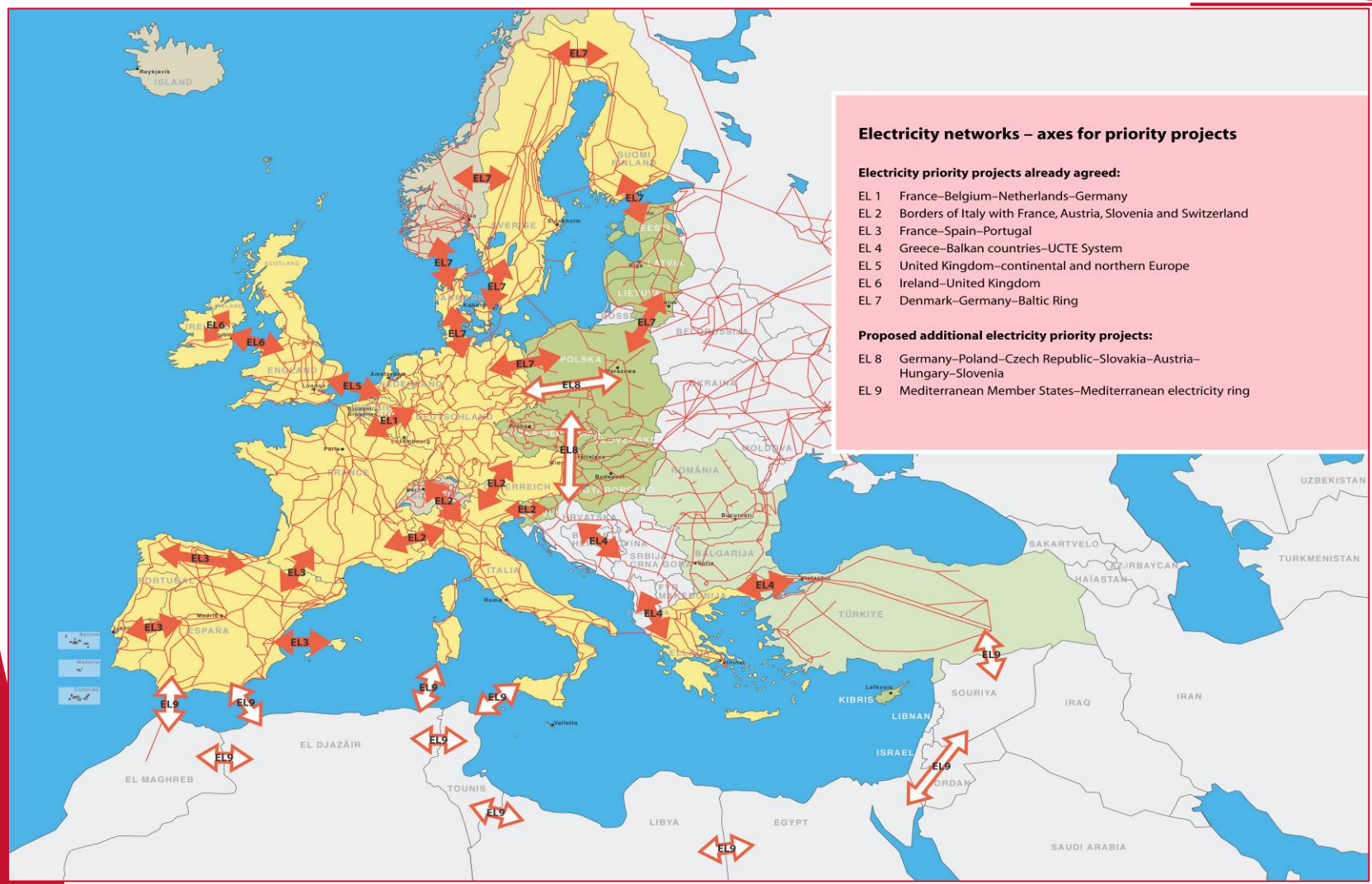
Wind generation is expected to grow to 240 GW by 2012 and to 1000 GW by 2020

Onshore and Offshore

Studland Bay/AUS
onshore

Alpha Ventus/GER
offshore

Interconnect Regions, Countries, Networks
Avoid Congestions
Enable Trading



European Priority Projects Main Axes

Source: EU – TEN-E Priority Projects

Some facts

Some facts

- **Generation of electricity**
  - **Worldwide 19 000 TWh (2006)**
  - **EU 27 3 500 TWh (2006)**

- **Efficiency**
  - **Energy consumption worldwide:**
    - **10 900 Mtoe equivalent to 127 000 TWh**
  - **About 40 % of the primary energy (50 800 TWh) is used to generate the electrical energy (19 000 TWh)**
  - **Efficiency 19 000/50 800 = 37.4 %**

About 60 % of the primary energy is lost and released to the atmosphere

Energy efficiency – full chain

Supply side (loss reduction)

Primary energy

Electrical energy

Transmission

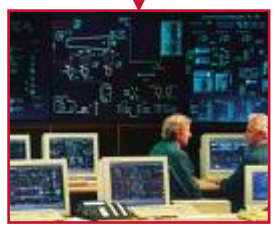
Distribution

Losses: 60 %* | 3 - 4 % ** | 5 - 6 %***

Demand side (energy savings)

Motors

Drives



Process automation

Lighting systems

* Mean value. Old: 70 %; CHP: 15 %

** depending on line length and voltage level up to 20 – 25 % *** Transformers 3 %, Cables 3%

Economics

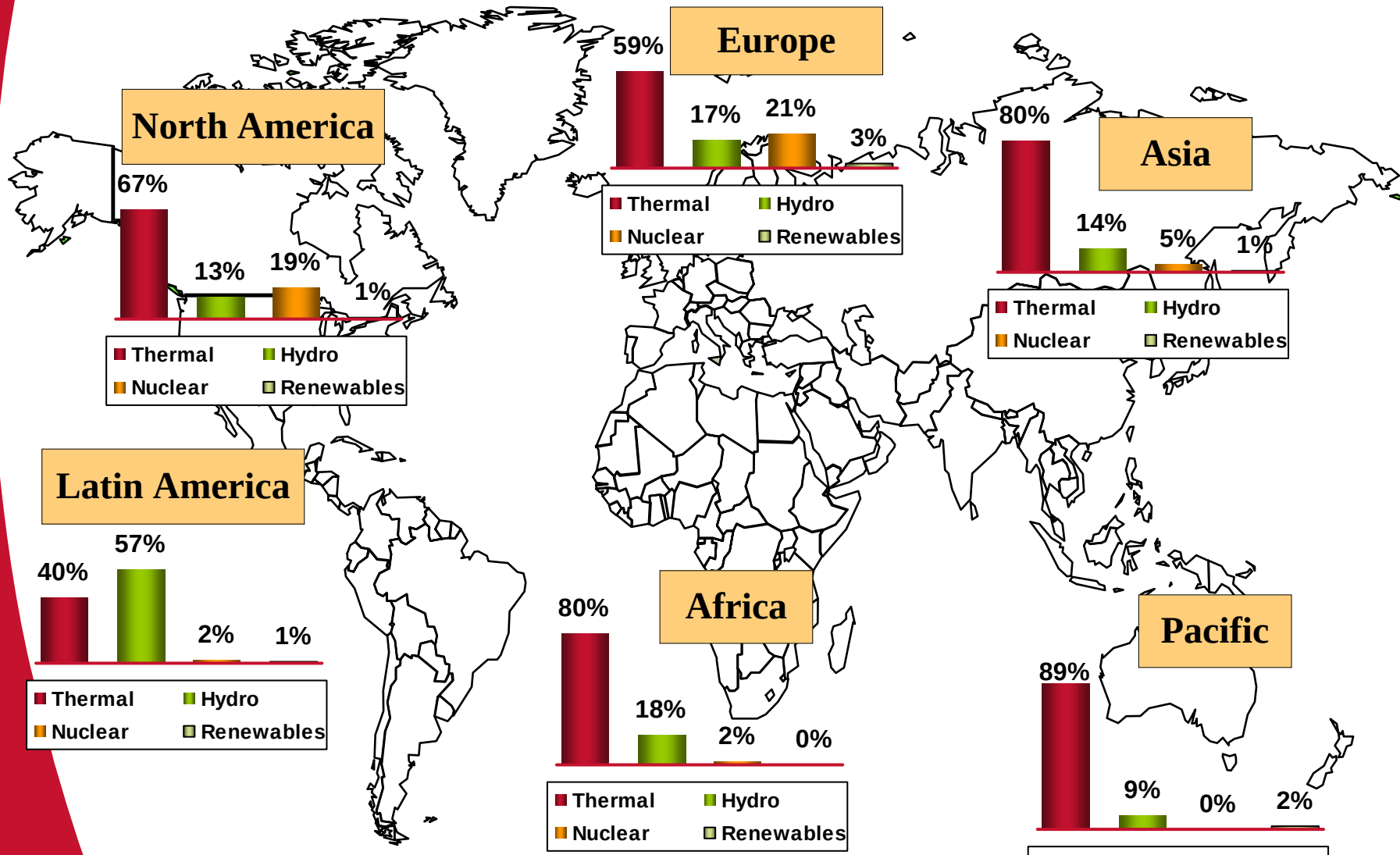
- **Energy losses**
  - Depending on network structure 7 % to 30 % (incl. non technical losses)
  - In Europe about 7 % to 8 %
- **Costs**
  - Total consumption Europe (EU 27) about 3 500 TWh p.a.
  - 1 MWh is about 40 € (average market clearing price) i.e. 1 TWh is worth 40 M€
  - Losses: 7 % of 3 500 TWh = 245 TWh are equ. to 9.8 b€




A loss reduction of 1 % is worth 1.4 b€ p.a.

However

Each region/country has its own needs

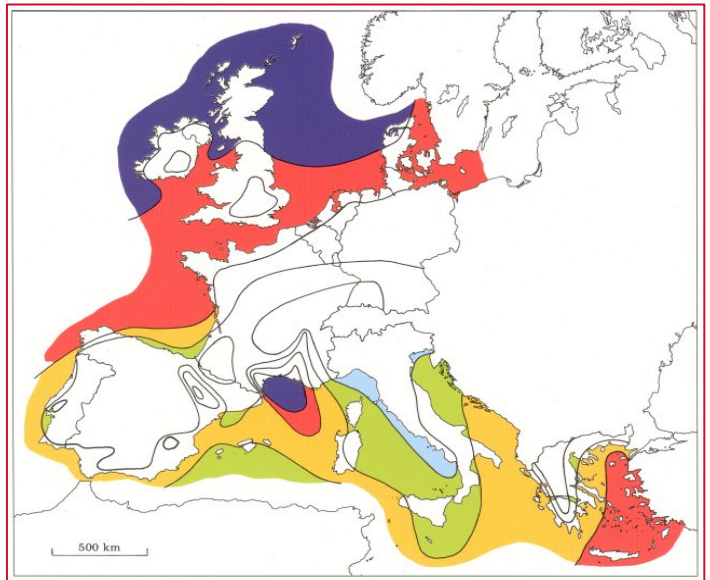


Contribution of fuel type to electricity generation 2007

Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

Multi-Terminal HVDC Solutions



Wind resources over open sea (more than 10 km offshore) for five standard heights

	10 m		25 m		50 m		100 m		200 m	
	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}
	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
	4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300

European wind atlas off-shore

Connect off-shore wind parks

Offshore versus Onshore

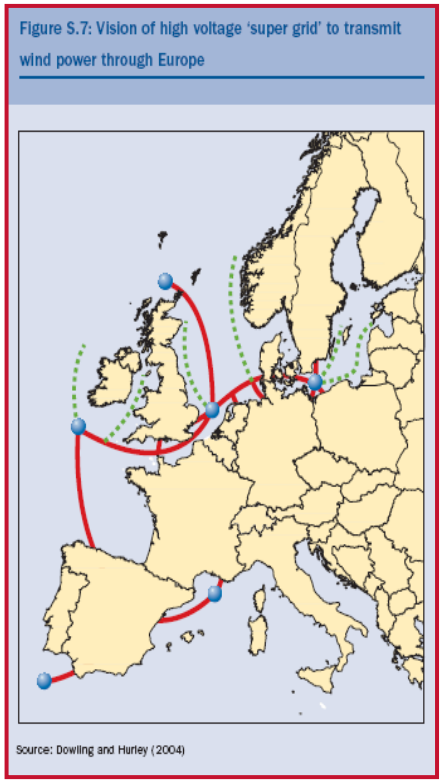
Robin Rigg/UK

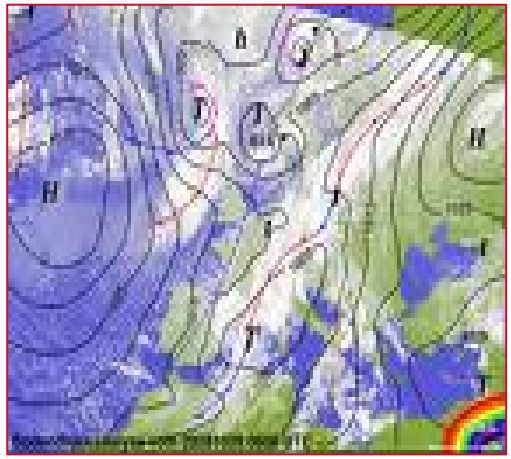
Studland Bay, Tasmania/AUS

- More wind
- Less visual impact

- Accessibility
- Network connection
- Costs

Challenges





..the high pressure area will move from the Azores to the North Sea...

- Bring the energy to the consumer
- Respect grid codes
- Real time network mgt
- Forecasting
- Generation mix mgt
- Reserve mgt
- All hardware
  - Turbines
  - Platforms
  - Electrical equipment etc.

Source: EWEA, Wind Energy –The Facts March 2009 (left)

Robin Rigg UK (Irish Sea)

- **Commissioned: 07.2009**
- **Power: 60 x 3 MW = 180 MW**
- **AC connection**
- **Cable length: 12 km (9 km submarine cable)**
- **Water depth: about 30 m**

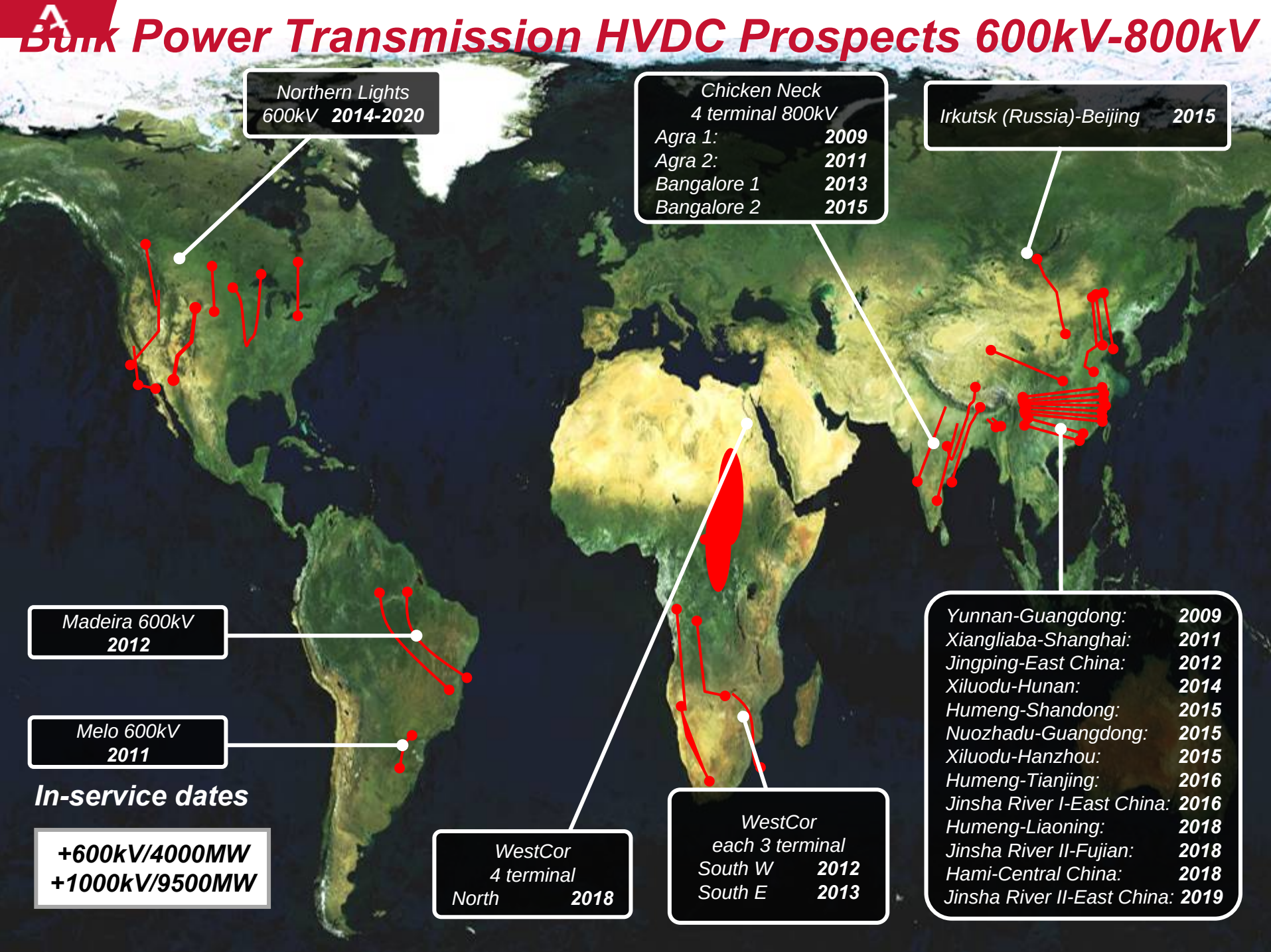
Alpha Ventus GER (North Sea)

- Commissioned: 2009
- Power: 12 x 5 MW = 60 MW
- AC connection
- Cable length: 45 km
- Water depth: about 40 m

Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

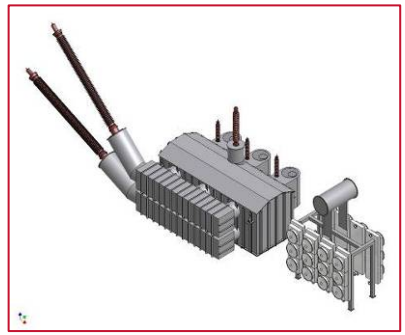
Bulk Power Transmission HVDC Prospects 600kV-800kV



Challenge: UHVDC Products 800 kV 6400 MW

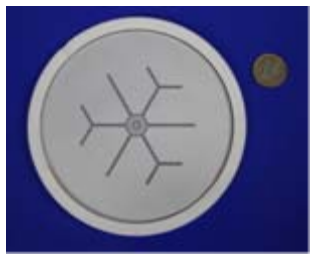
- **Products**
  - Valve
  - Converter transformer
  - Bushings
    - Transformer
    - Wall bushing
  - u-i measurement
  - By-pass switch
  - Controls

By-pass switch



Converter transformer

Bushings

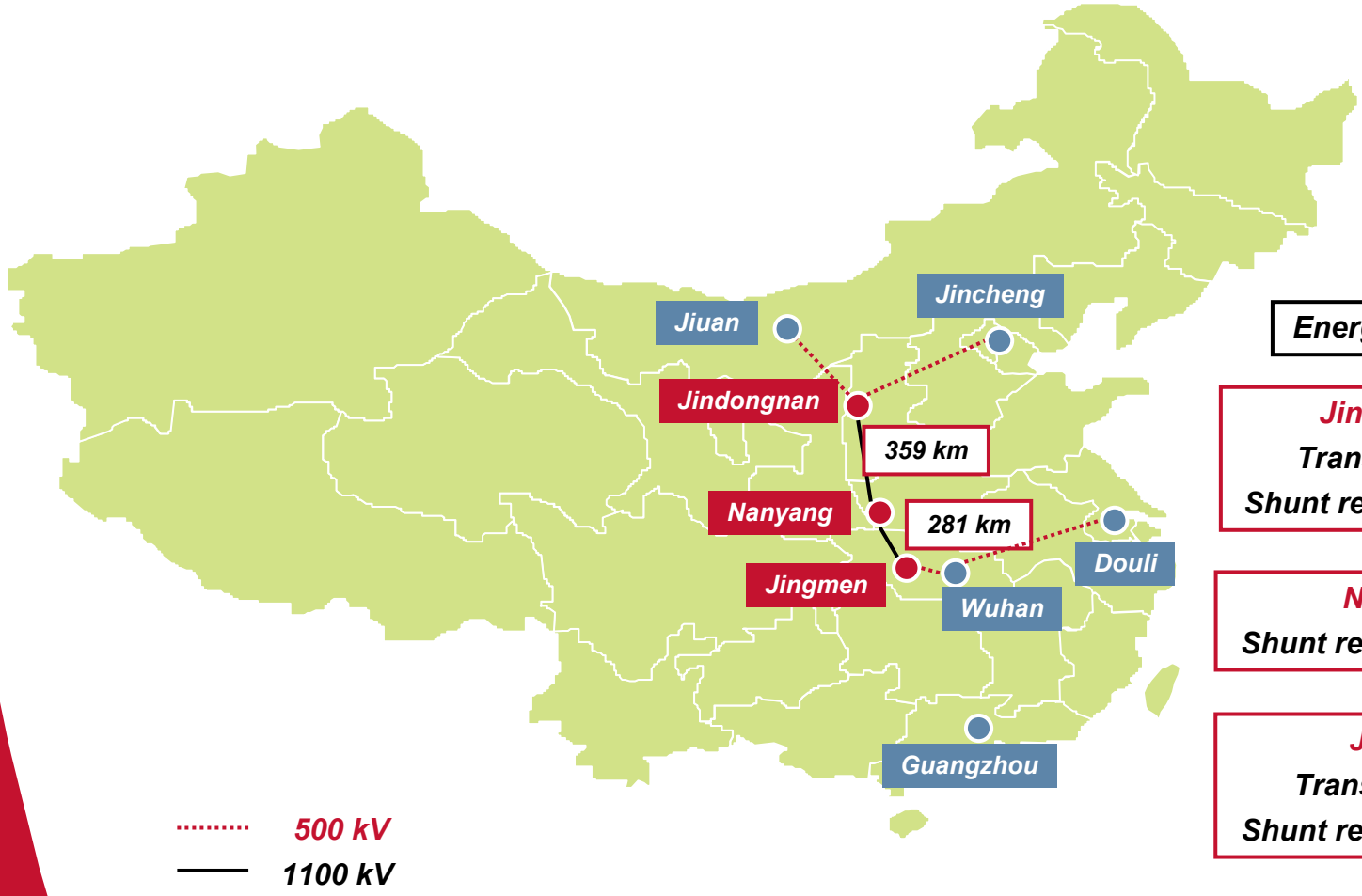


6“ Thyristors

Valve

Massive R&D investment

Bulk power transmission 1100 kV AC in China



Energized in 01/2009

Jindongnan S/s
Transfo: 3000 MVA
Shunt reactor: 3x320 Mvar

Nanyang S/s
Shunt reactor: 3 x240 Mvar

Jinmen S/s
Transfo: 3000 MVA
Shunt reactor: 3x320 Mvar

GIS and H-GIS Technology are in use

Source: Y.Shu Electra Nr. 242 February 2009

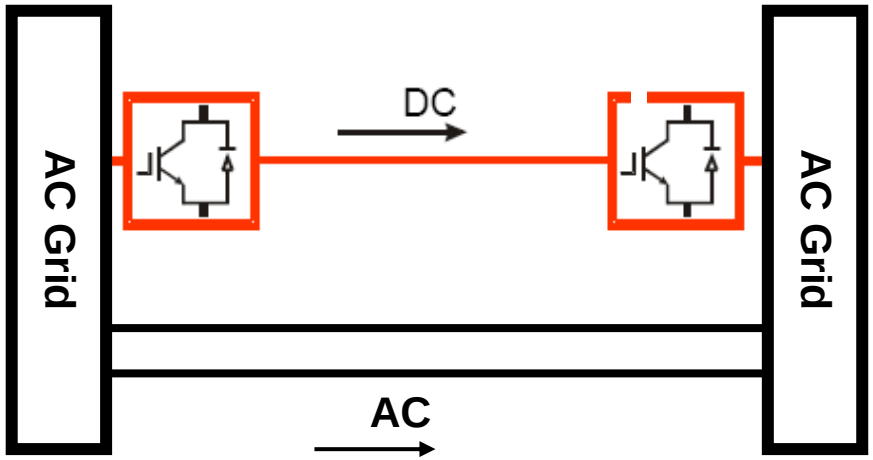
国家电网
STATE GRID
中国电力科学研究院
CHINA ELECTRIC POWER RESEARCH INSTITUTE

IEC meeting 2009/02/ New Del

Airscape of Jingmen Substation

009/1/23 Dr. Jianbin Fan 4

DC systems embedded in AC networks (Supergrids)



AC

DC

- **Reactive power compensation on both ends**
- **More transmission capacity via the AC line**

Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

More utilization of FACTS devices

- Dynamic control of voltage, impedance and phase angle of high voltage AC transmission lines.
- Better utilization of existing and new oh-lines
- Increase power quality
- Improved dynamic stability

SVC St.Johns Wood UK

STATCOM Glenbrook USA

Stability, Energy efficiency

SVC (UK network)

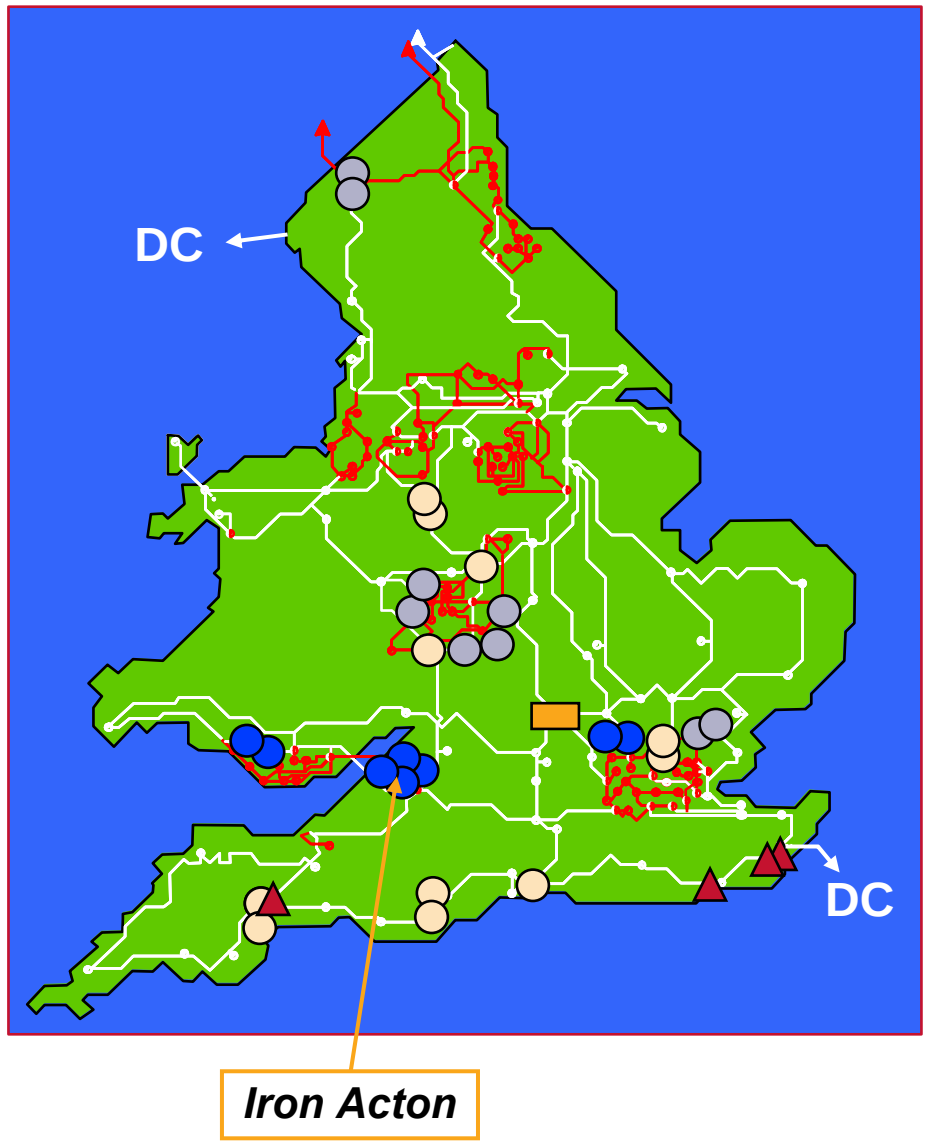
Total SVC Rating
5.6 GVar (2008)

AREVA T&D Installations:

- Saturated Reactor (SR)
- Thyristor Controlled Reactor (TCR)
- Thyristor Switched Capacitors (TSC)
- Relocatable Static Var Compensation (RSVC)
- STATCOM

Installations by competitors:

- Thyristor Controlled Reactor (TCR)
- Thyristor Switched Capacitors (TSC)



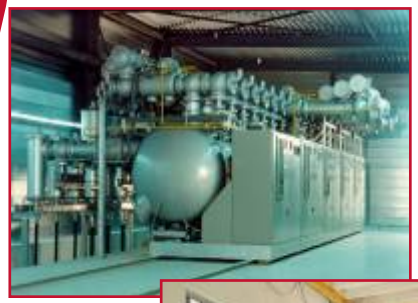
Iron Acton RSVCs

Iron Acton RSVCs

Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

Reduction in footprint 245 kV GIS



1973 100 %

1985 26 %

1999 17 %

2005 16 %,
but for 300 kV

Reduction of losses by bringing the highest possible voltage close to the consumer

Volume reduction by a factor of 6 in 32 years

Low loss transformers

- **Transformers**
  - **Low-loss transformers**
    - **Amorphous core materials**
    - **Design modifications**
      - **high quality GOS**
      - **copper wires**
      - **lower magnetic induction**
  - **The efficiency is 97.5% to 99.4 % at 40% to 50% loading. The transformer is not always operated at maximum efficiency, therefore the overall efficiency is about 90 %.**
  - **Use of amorphous steel instead of GOS reduces the no-load losses by 70 - 80 %.**

Distribution transformer

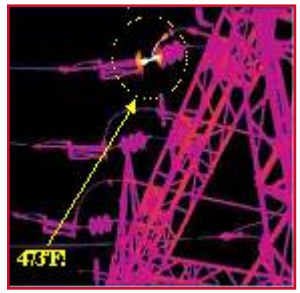
Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

Dynamic loading/monitoring

Dynamic loading/monitoring

- Increase utilisation of existing transmission capacity through real-time information



Overhead line

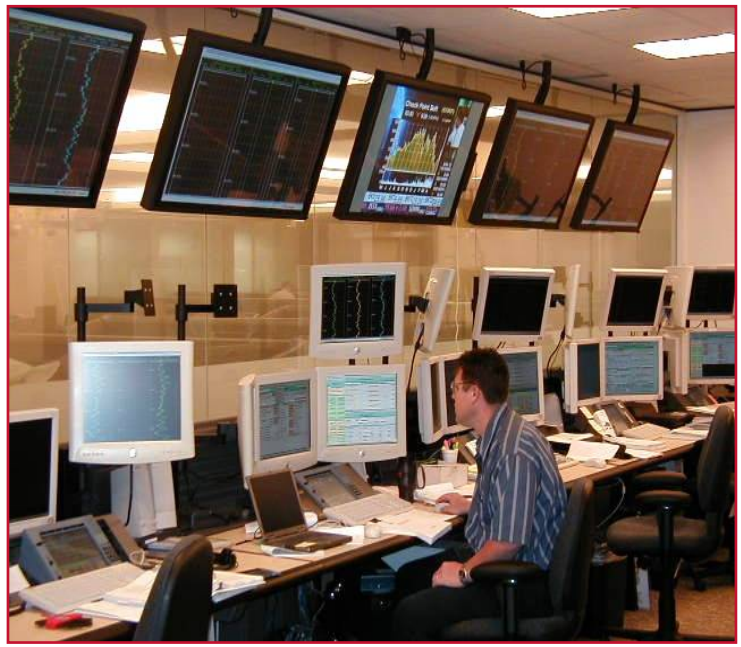
- Monitoring systems to deliver exact statements of operating conditions of assets

Power transformer

Monitoring system

More intelligent networks

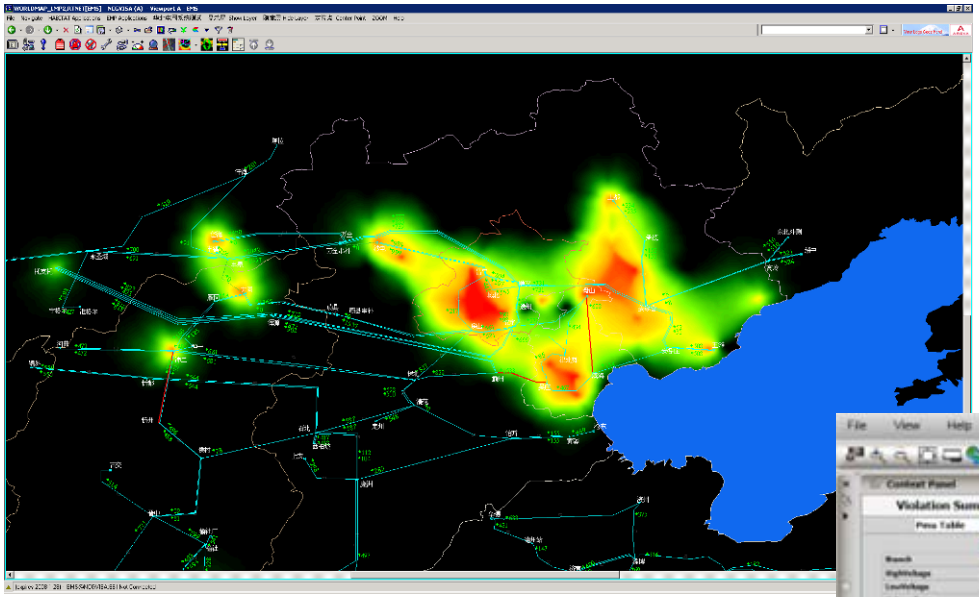
- **Network management solutions**
  - **Decentralised generation issues (millions of sources)**
    - **Fast changing generation and load profiles**
    - **Reversal of power flow**
    - **Forecasting, risk assessment**
  - **Real-time data management and visualisation**
  - **Demand side management**
    - **Smart metering**
      - **Transparent information to customer (tariffs etc.)**
  - **Congestion management**



Control room

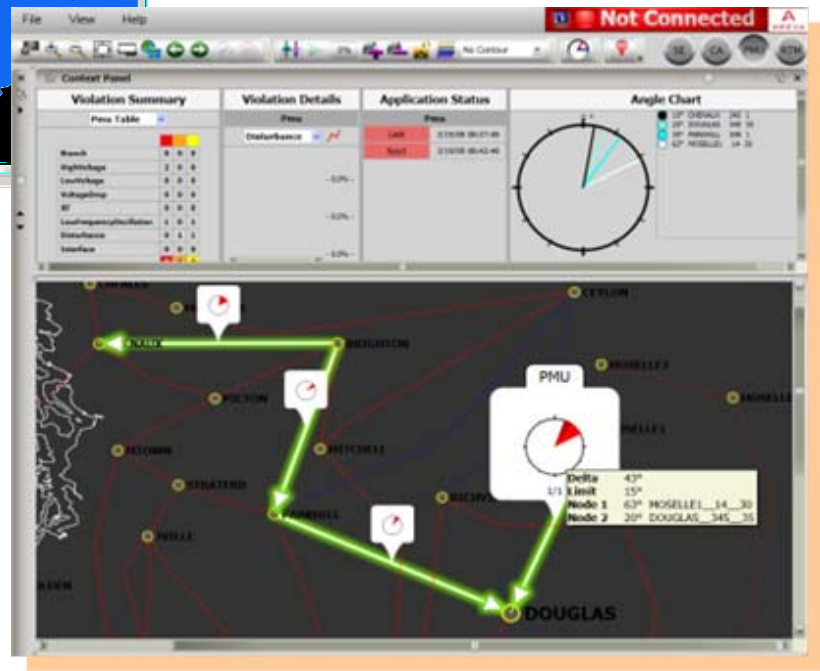
ICT will allow real time management of the full chain

Visualisation and Decision Support



Situation Awareness with WAMS

World map with voltage contour



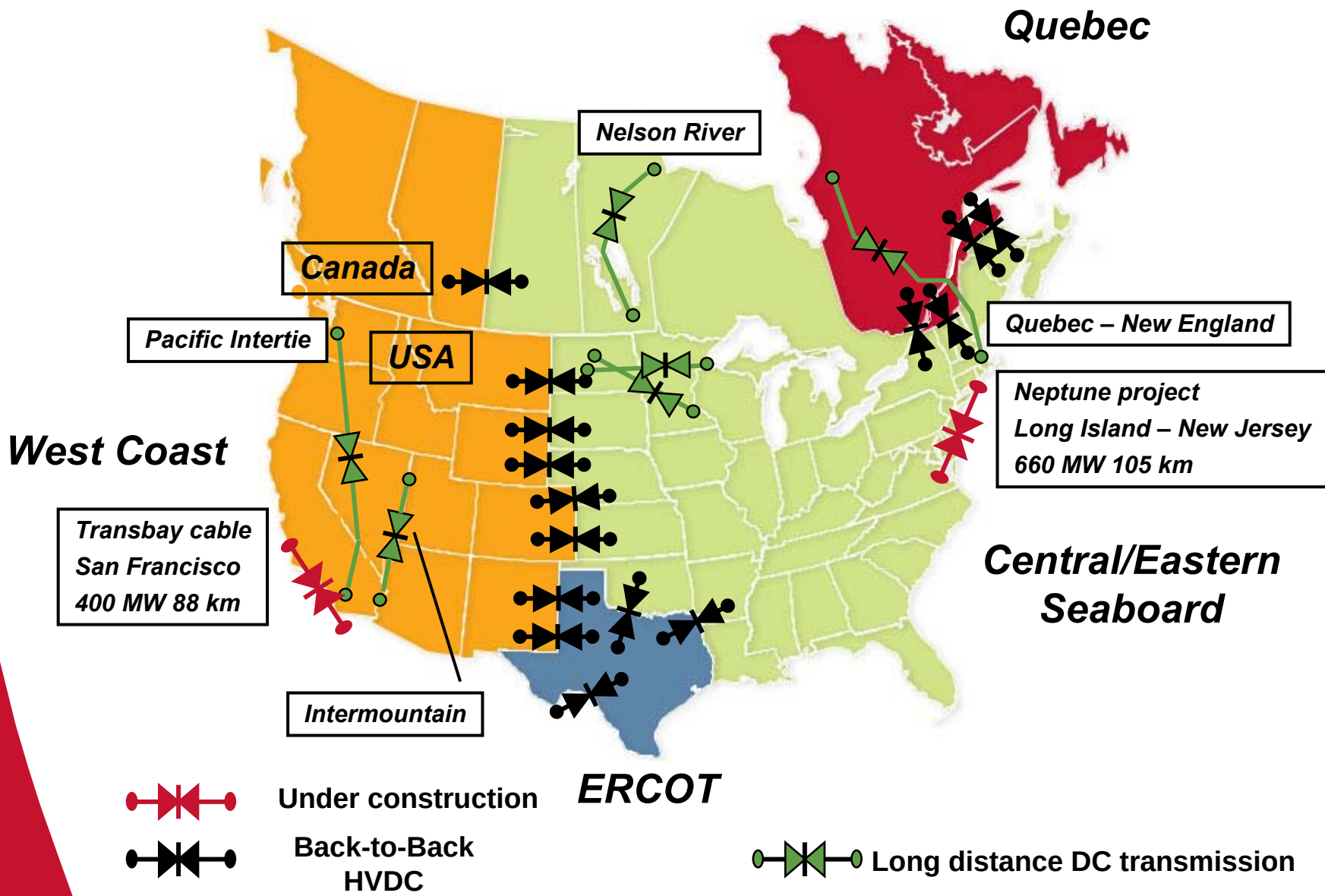
Visualization for Wide Area Security

Guide operator with re-despatching actions

Some technical answers (not exhaustive)

- Integration of wind energy
- Bulk power transmission
- Reactive power compensation
- Primary products
  - Substations (smaller footprint)
  - Increase transformer efficiency
- More network intelligence
- Network reinforcement

USA/Canada network structure and b-t-b links



HVDC links in Europe

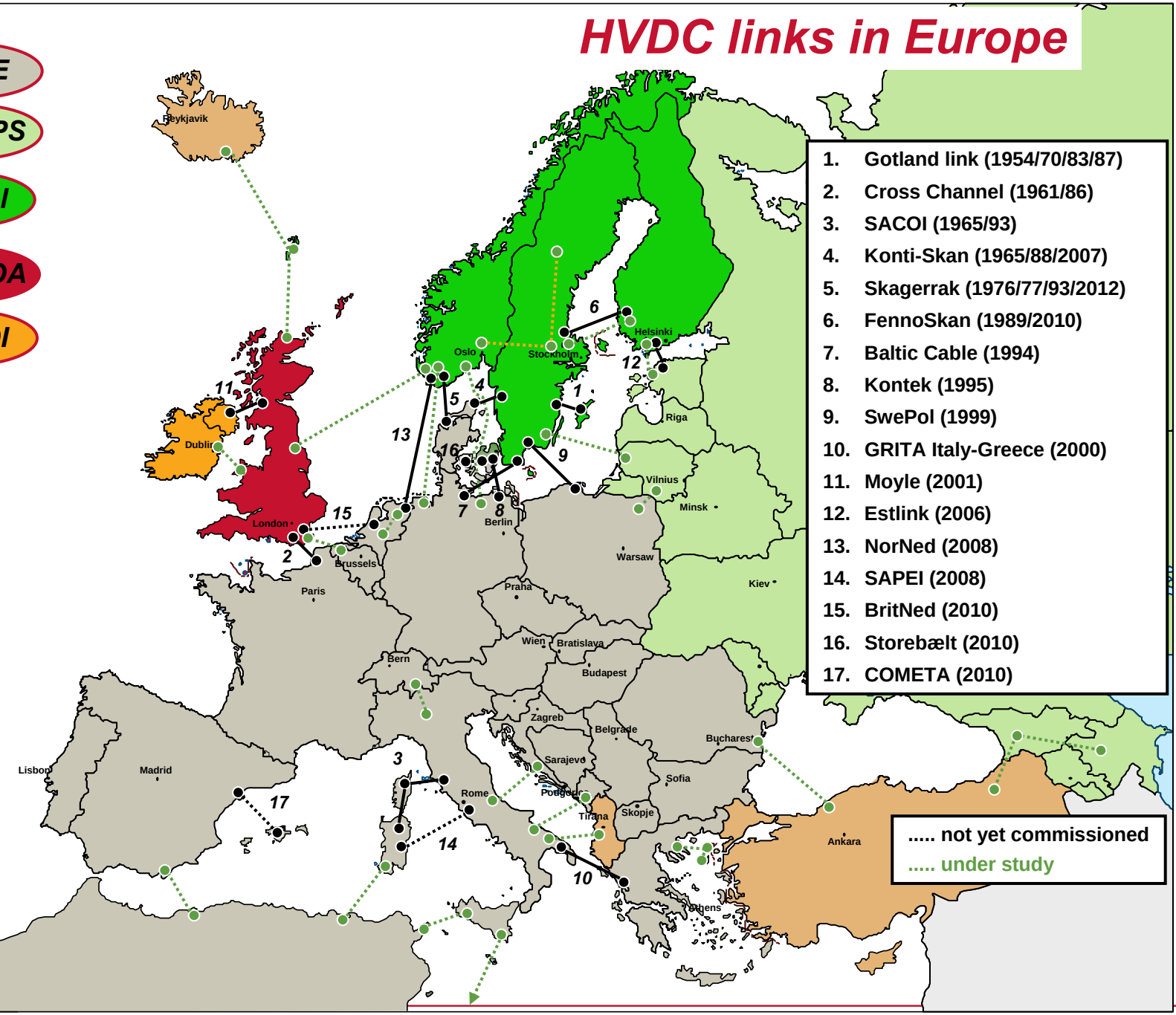
UCTE

IPS/UPS

Nordel

UKTSOA

ATSOI



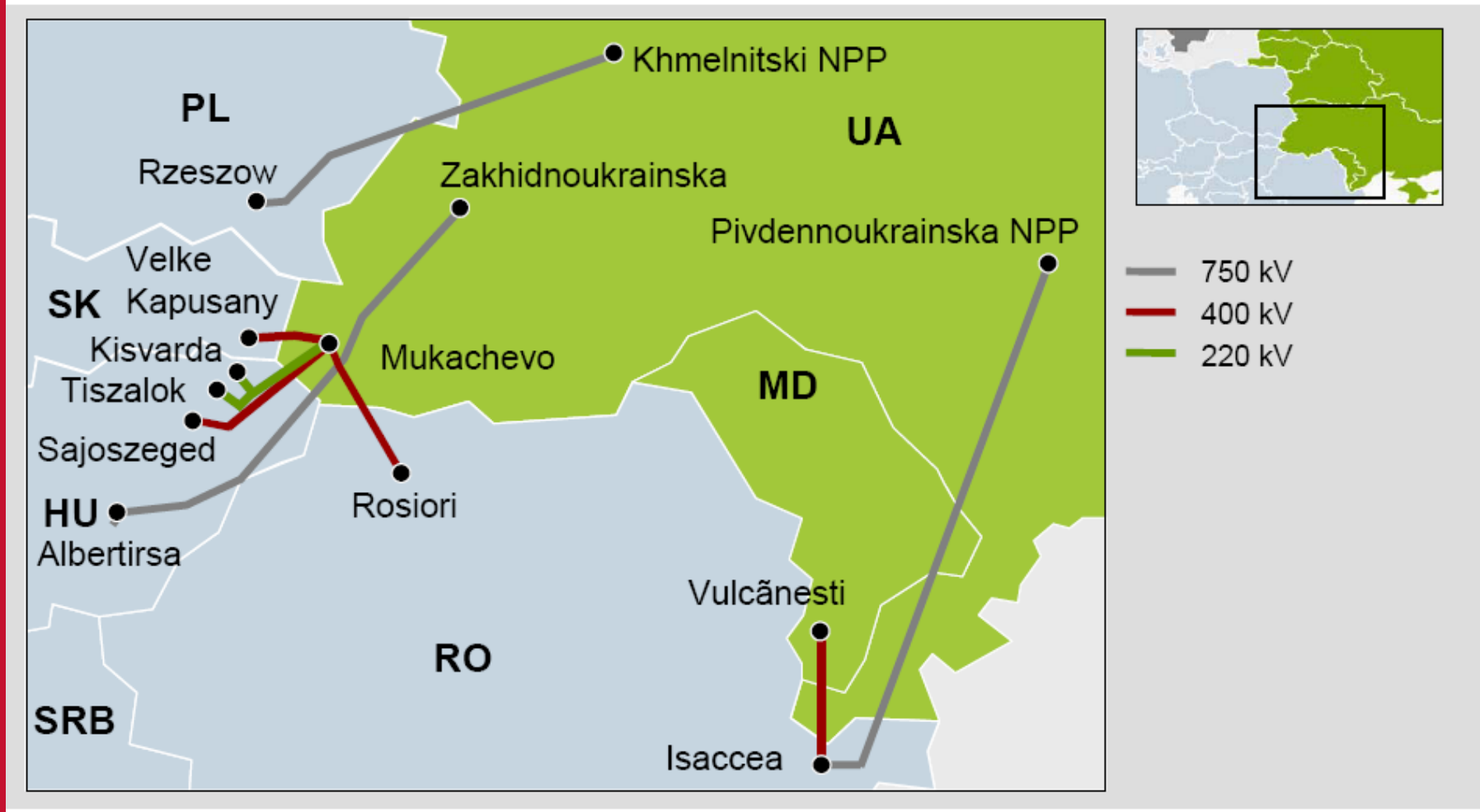
1. Gotland link (1954/70/83/87)
2. Cross Channel (1961/86)
3. SACOI (1965/93)
4. Konti-Skan (1965/88/2007)
5. Skagerrak (1976/77/93/2012)
6. FennoSkan (1989/2010)
7. Baltic Cable (1994)
8. Kontek (1995)
9. SwePol (1999)
10. GRITA Italy-Greece (2000)
11. Moyle (2001)
12. Estlink (2006)
13. NorNed (2008)
14. SAPEI (2008)
15. BritNed (2010)
16. Storebælt (2010)
17. COMETA (2010)

..... not yet commissioned

..... under study

European Priority Projects EL 8

UCTE Central East/IPS_UPS



Nine lines exist, no longer in use

Source: UCTE IPS/UPS Feasibility study November 2008

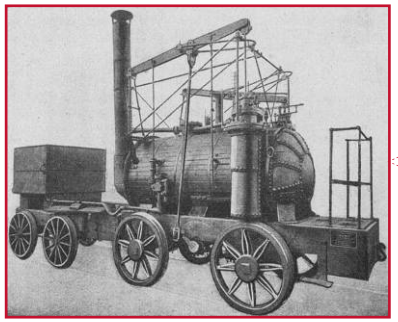
Conclusion

Conclusion

Further improvement of Energy Efficiency at the level of generation, transmission, distribution and also final use of energy will certainly be dependent on technological evolution

Only through joint forces of politics, power sector, industry and the academic world sustainable energy systems can become reality

There is still a lot to do...



Puffing Billy 1825

24 km/h

Maglev 2003

501 km/h

TGV 2007

575 km/h

The limits of technical developments are not predictable

Mulțumesc
Thank you