Climate change drivers for a single and smart EU grid

Smart and Secure Transmission Grids to Realise US and EU Renewable Energy Potentials

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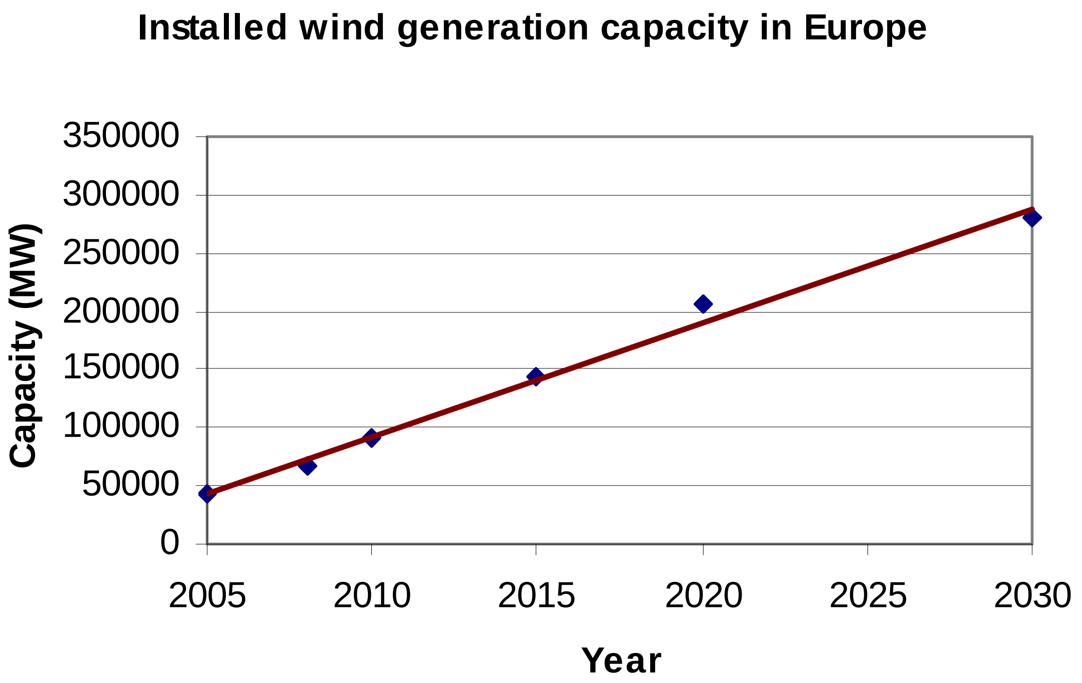
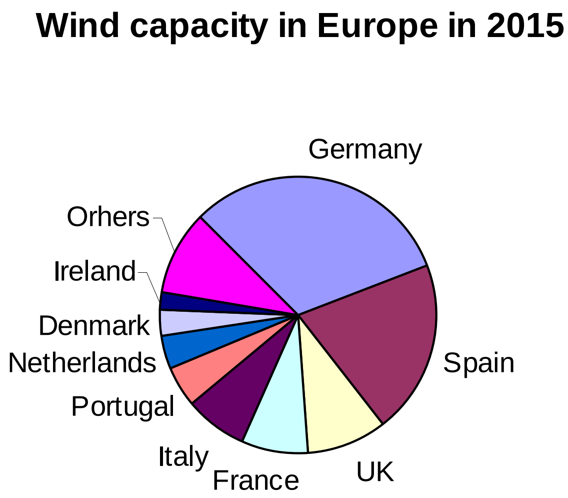
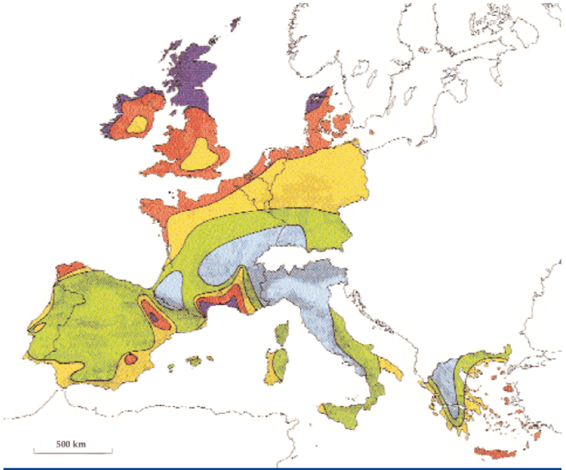
Expected growth in wind power





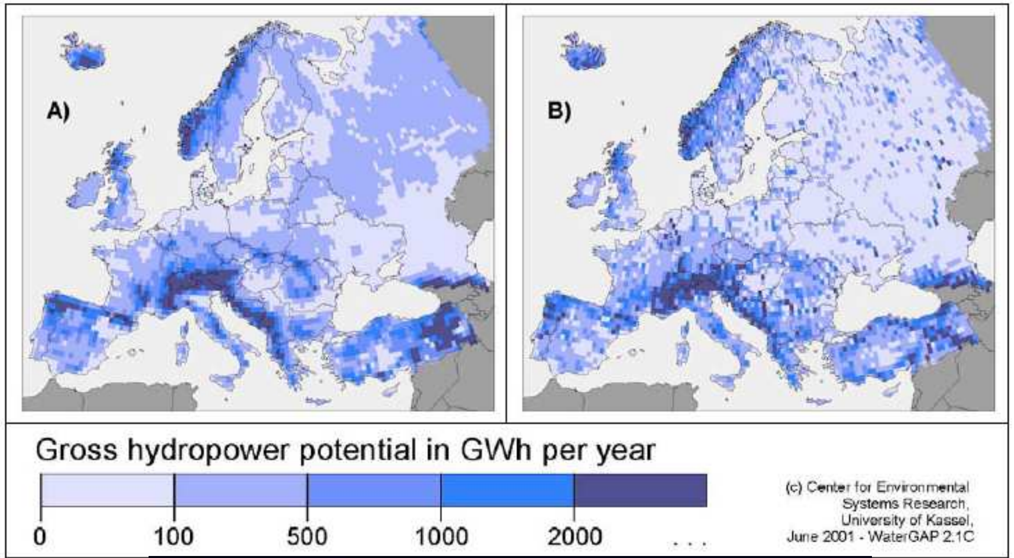
Data source: European Wind Integration Study

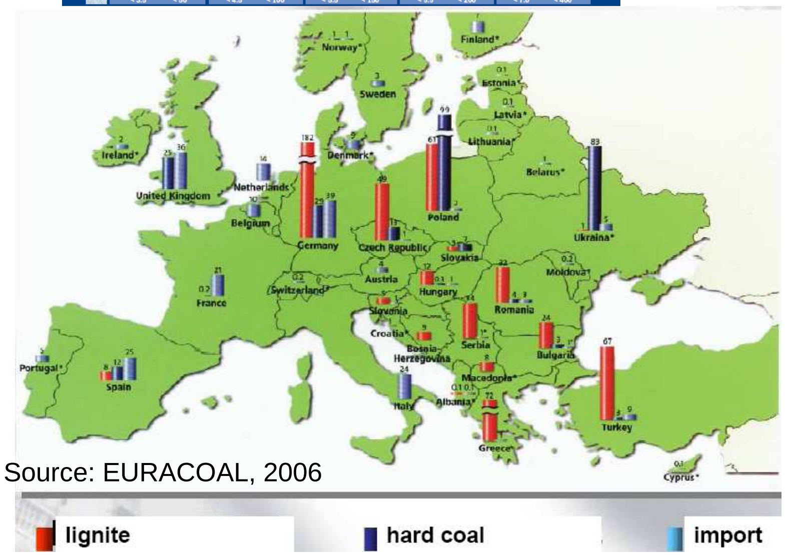
Resource and demand in Europe



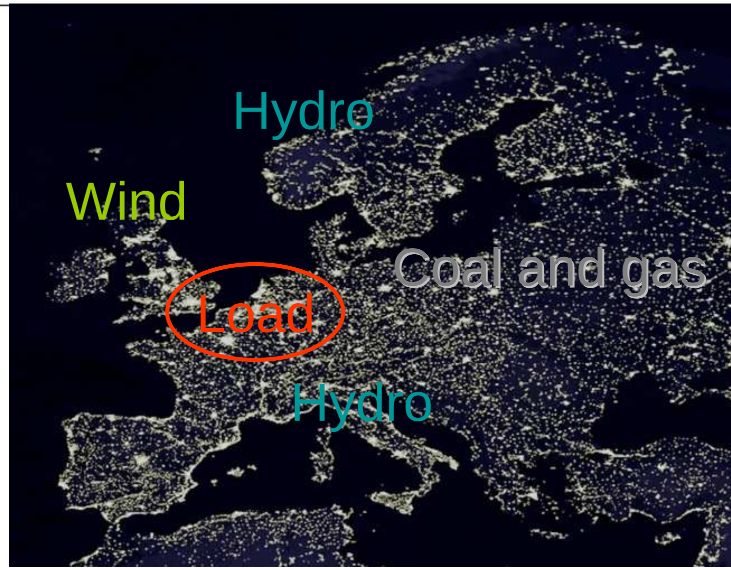
Wind resources at 50 metres above ground level for five different topographic conditions

	Sheltered terrain		Open plain		At sea coast		Open sea		Hills and ridges	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0 - 6.0	150 - 250	6.5 - 7.5	300 - 500	7.0 - 8.5	400 - 700	8.0 - 9.0	600 - 800	10.0 - 11.5	1200 - 1800
	4.5 - 5.0	100 - 150	5.5 - 6.5	200 - 300	6.5 - 7.0	250 - 400	7.0 - 8.0	400 - 600	8.5 - 10.0	700 - 1200
	3.5 - 4.5	50 - 100	4.5 - 5.5	100 - 200	5.5 - 6.5	150 - 250	5.5 - 7.0	200 - 400	7.0 - 8.5	400 - 700
	< 3.5	< 50	< 4.5	< 100	< 5.5	< 150	< 5.5	< 200	< 7.0	< 400





Source: EURACOAL, 2006



Drivers for an interconnected transmission system: demand security

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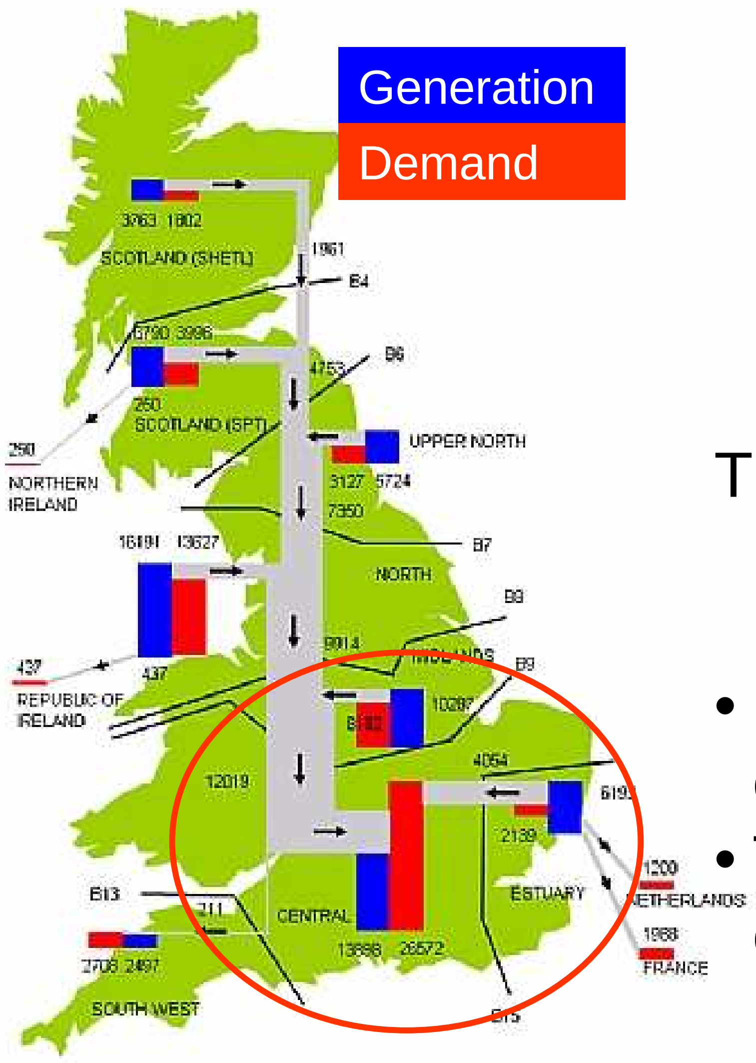
Figure 7.4 - ACS Power Flow Pattern for 2015/16

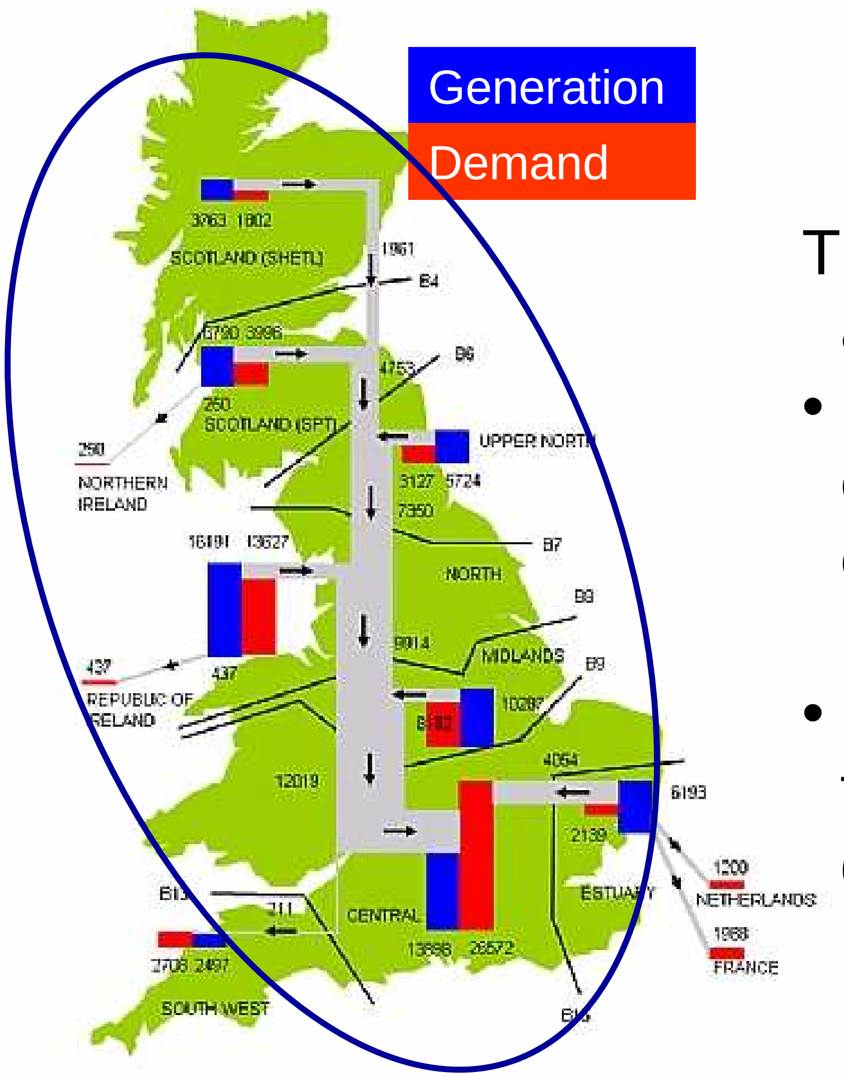


The available local generation is insufficient to support demand in the area

- Reliability of supply depends on access to remote generation
- The grid acts as a reserve source of power

Drivers for an interconnected transmission system: economics

Figure 7.4 - ACS Power Flow Pattern for 2015/16



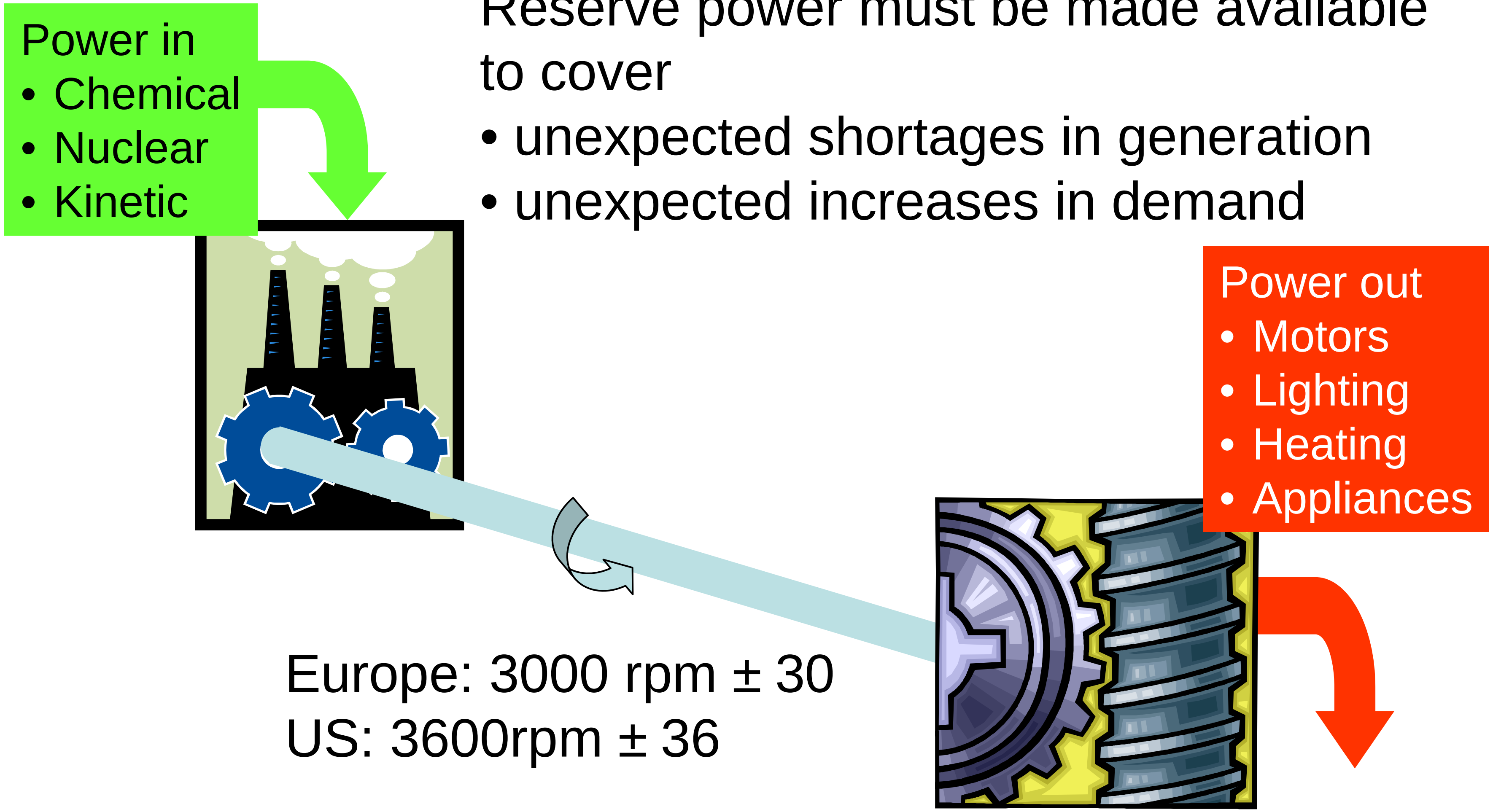
The grid facilitates competition among generators

- Enables use of most economically and environmentally efficient resources
- Is the cost of the grid less than the benefit of access to different resources?

Generation must match demand minute by minute

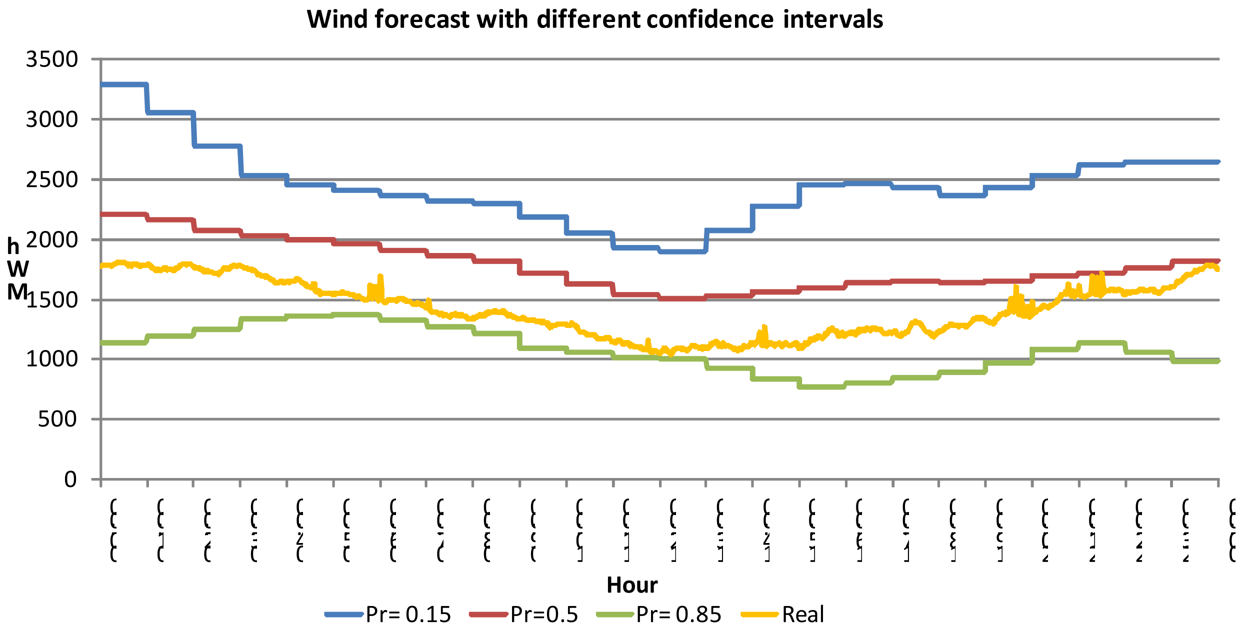
Electrical energy cannot be stored economically on any large scale

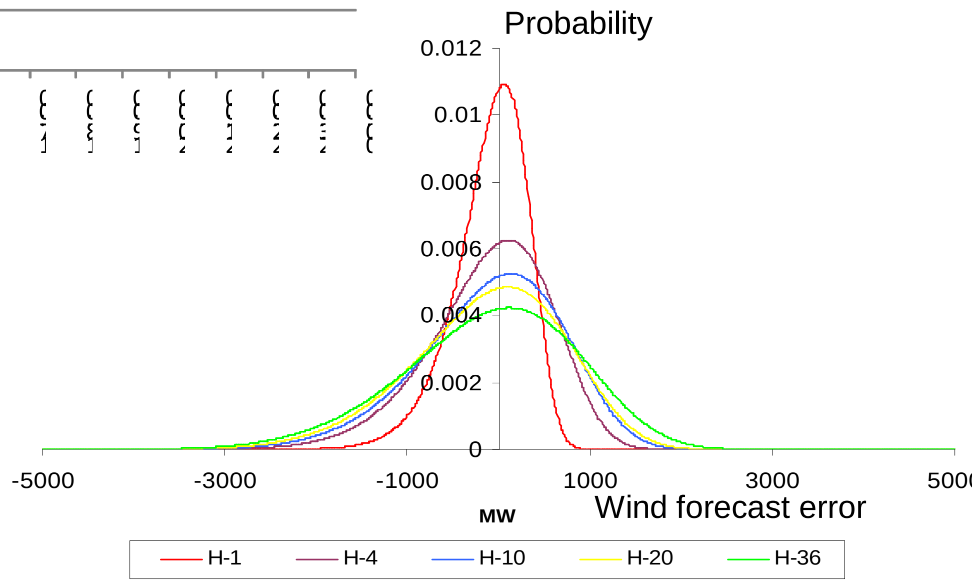
Reserve power must be made available to cover
- unexpected shortages in generation
- unexpected increases in demand



Short-term reliability with wind

It is essential to have a good forecast of the available power in order to schedule the right amount of reserve





Figures: REE

Effect of wind power diversity

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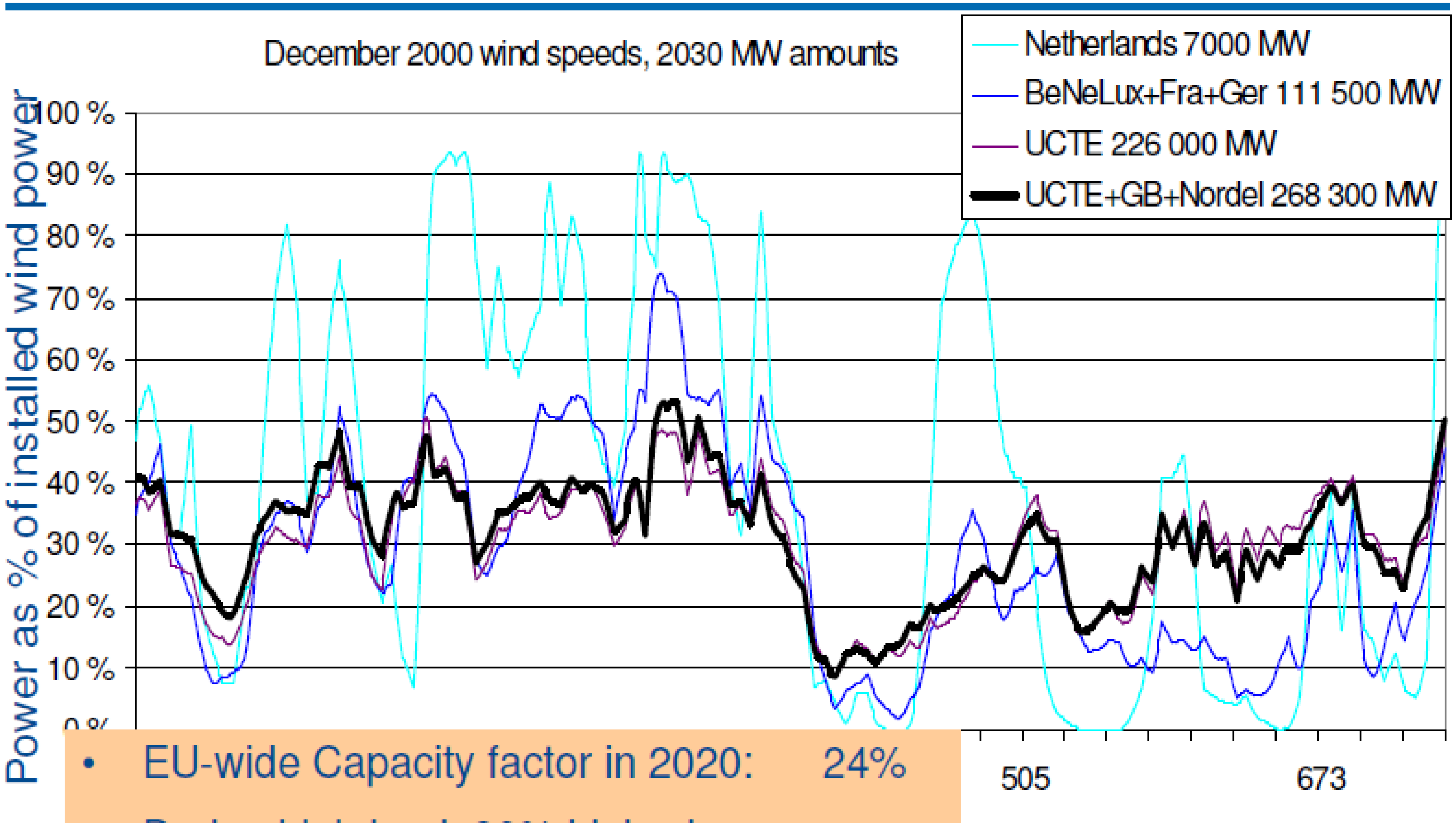
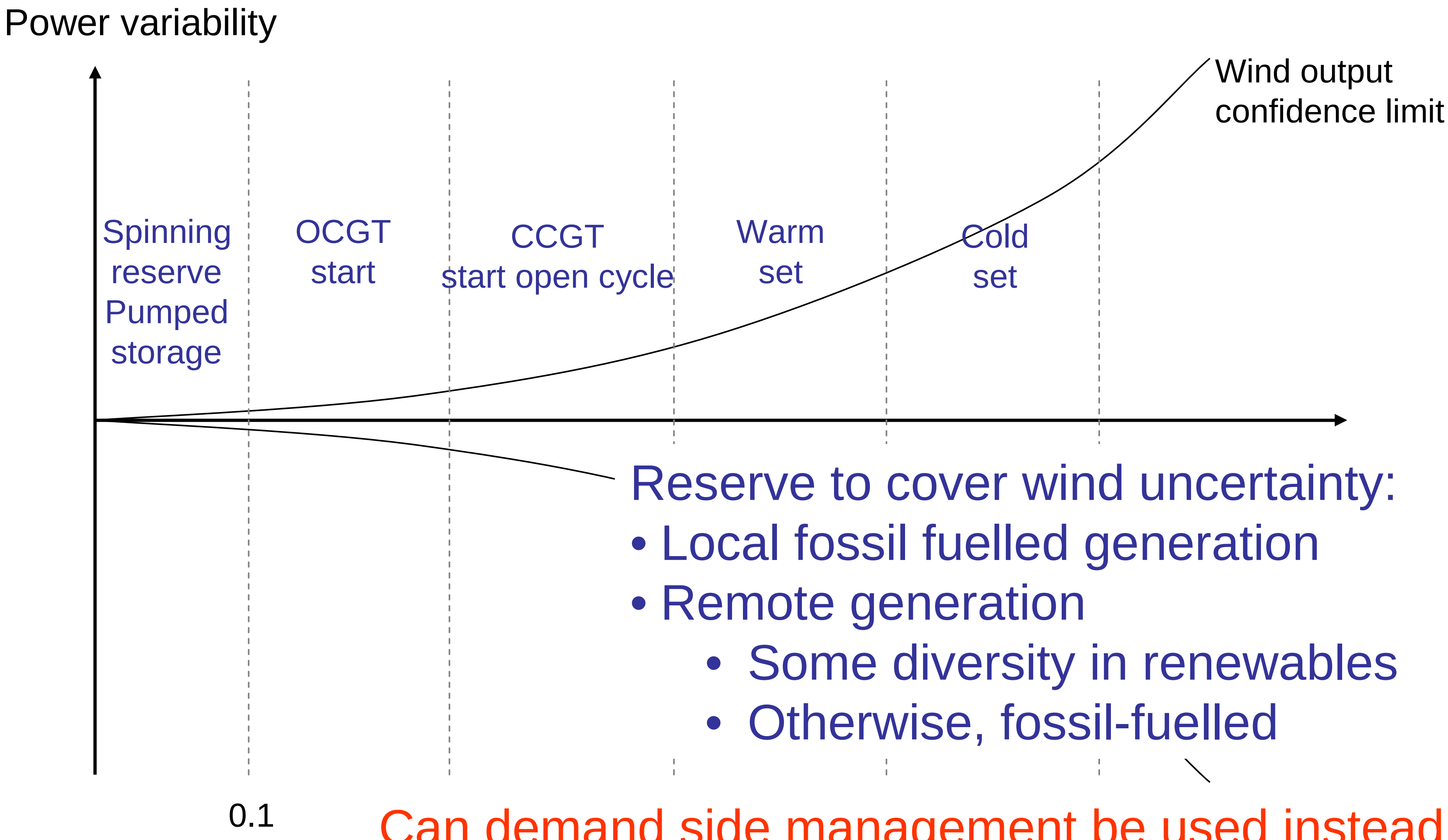


- EU-wide Capacity factor in 2020: 24%
- During high load: 20% higher!

Source: Tradewind

What provides reserve?



Reserve to cover wind uncertainty:

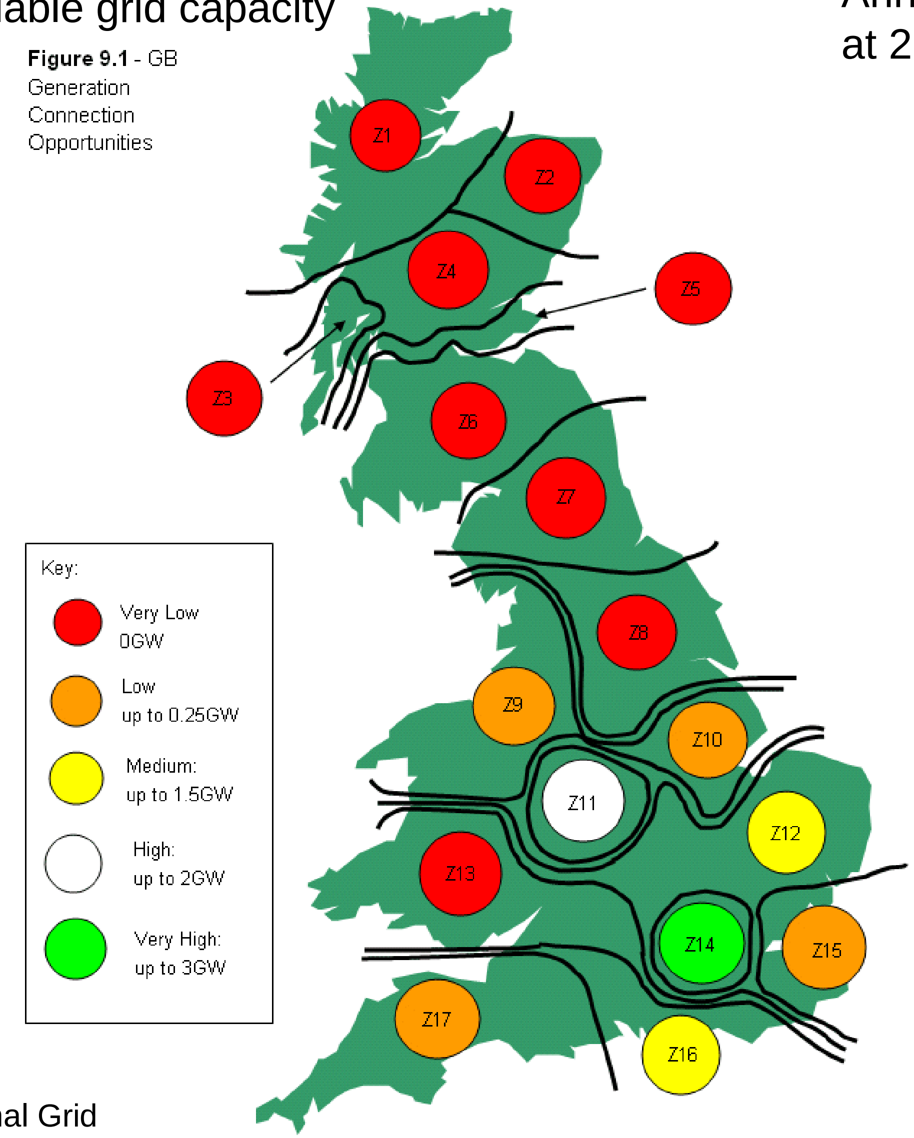
- Local fossil fuelled generation
- Remote generation
    - Some diversity in renewables
    - Otherwise, fossil-fuelled

Figure: CIGRE

Can demand side management be used instead of fossil-fuelled generation or interconnection?

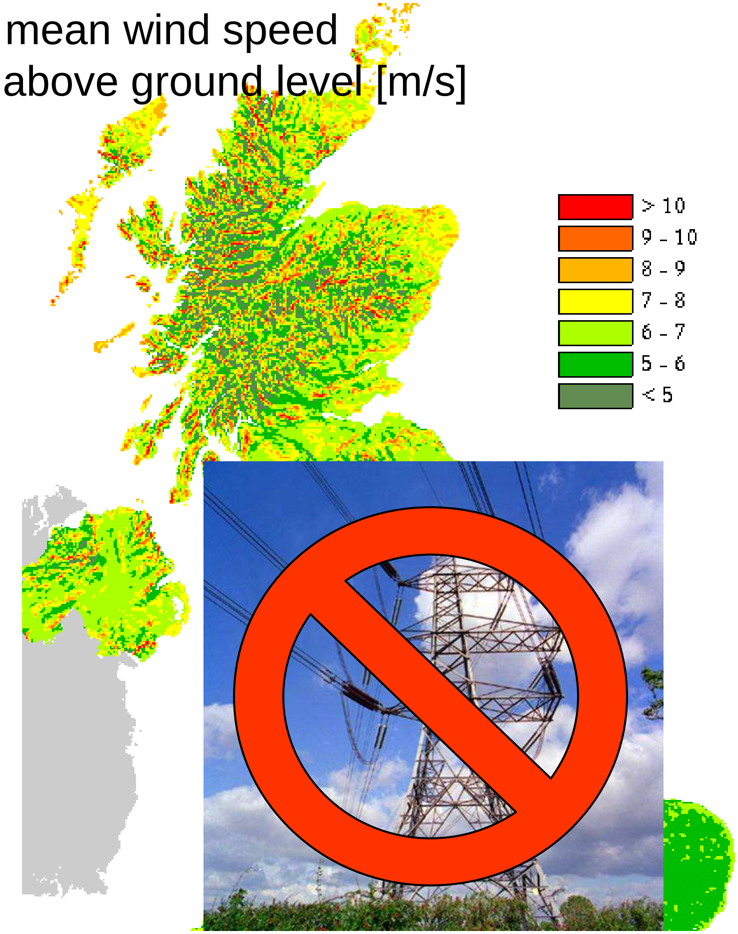
Wind is in the 'wrong' place!

Available grid capacity



National Grid
Seven Year Statement

Annual mean wind speed
at 25m above ground level [m/s]



No-one wants you to build conventional overhead lines any more!

New technology options

- 'Dynamic ratings' of overhead lines
  - Monitor temperature of conductors
  - When windy
    - need more transmission capacity
    - but cooling effect greater
- Better utilisation of thermal capacity of lines
  - Use series control to optimise power between lines
- Bypass AC grid with HVDC
- Wider exploitation of 'corrective' actions
  - Need for
    - good wide-area monitoring and control
    - accurate and reliable decision support

What if we get it wrong?

- Energy not supplied is due to
  - (most frequently) faults on distribution system
    - lose small amounts of load
  - (less frequently) faults near the interface of transmission and distribution
    - lose bigger amounts of load
  - (rarely) faults within the interconnected transmission system
    - lose lots of load

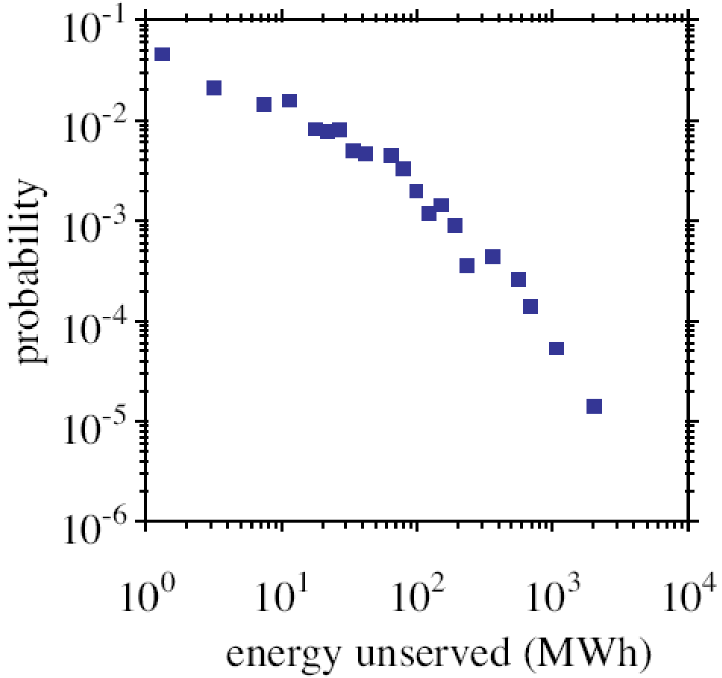


Fig: Dobson, Carreras, Lynch, Newman

Some major loss of supply incidents

- 2003
  - 14 August - North-Eastern US
  - 28 August – London (UK)
  - 5 September – Birmingham (UK)
  - 23 September - Scandinavia
  - 28 September – Italy
- 2006
  - 4 November – Western Europe
- 2008
  - May 27 – Great Britain
- 2009
  - Brazil

What happened in Europe in 2006?

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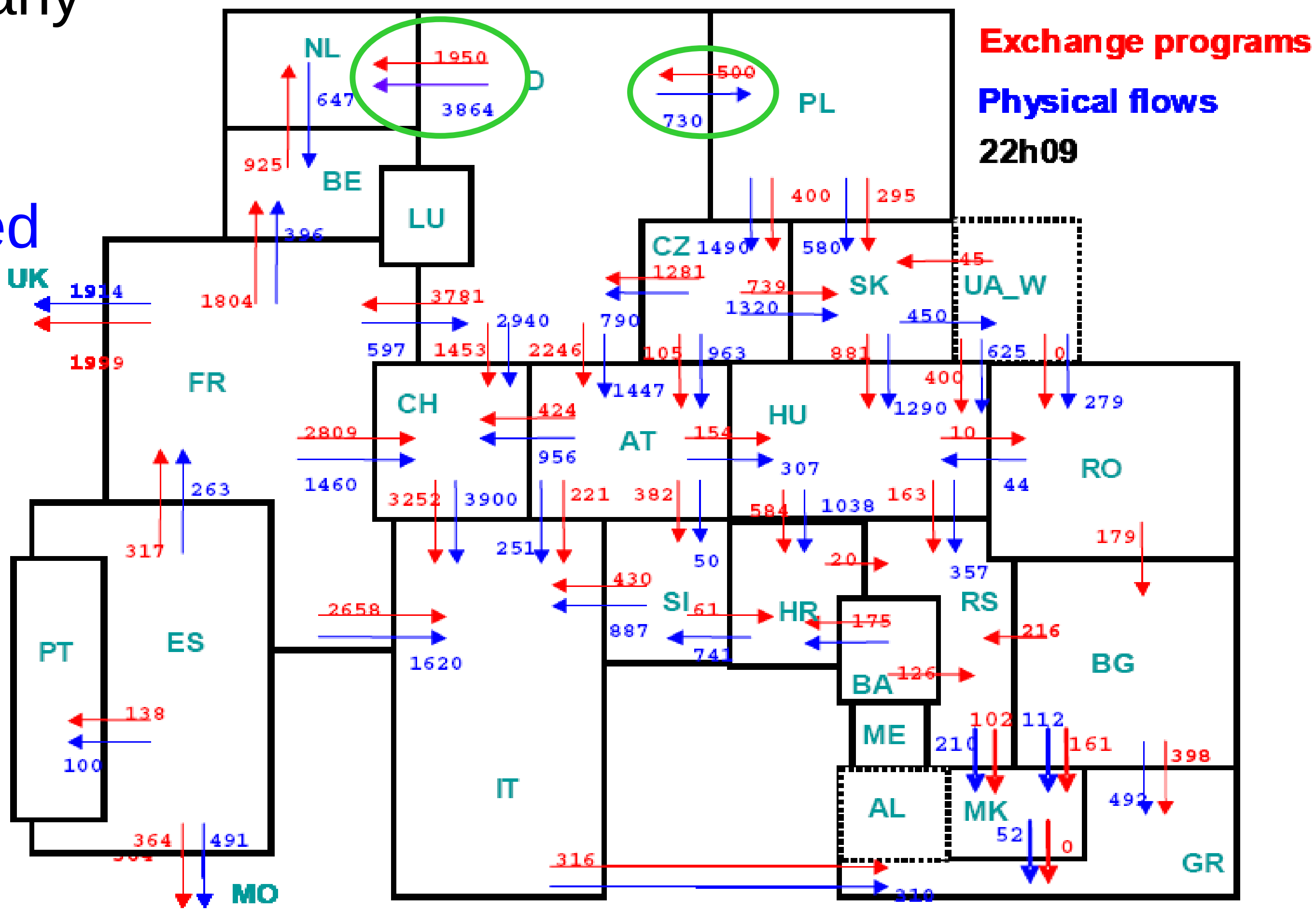
Planned outage of a double circuit

- Let a ship pass down a river

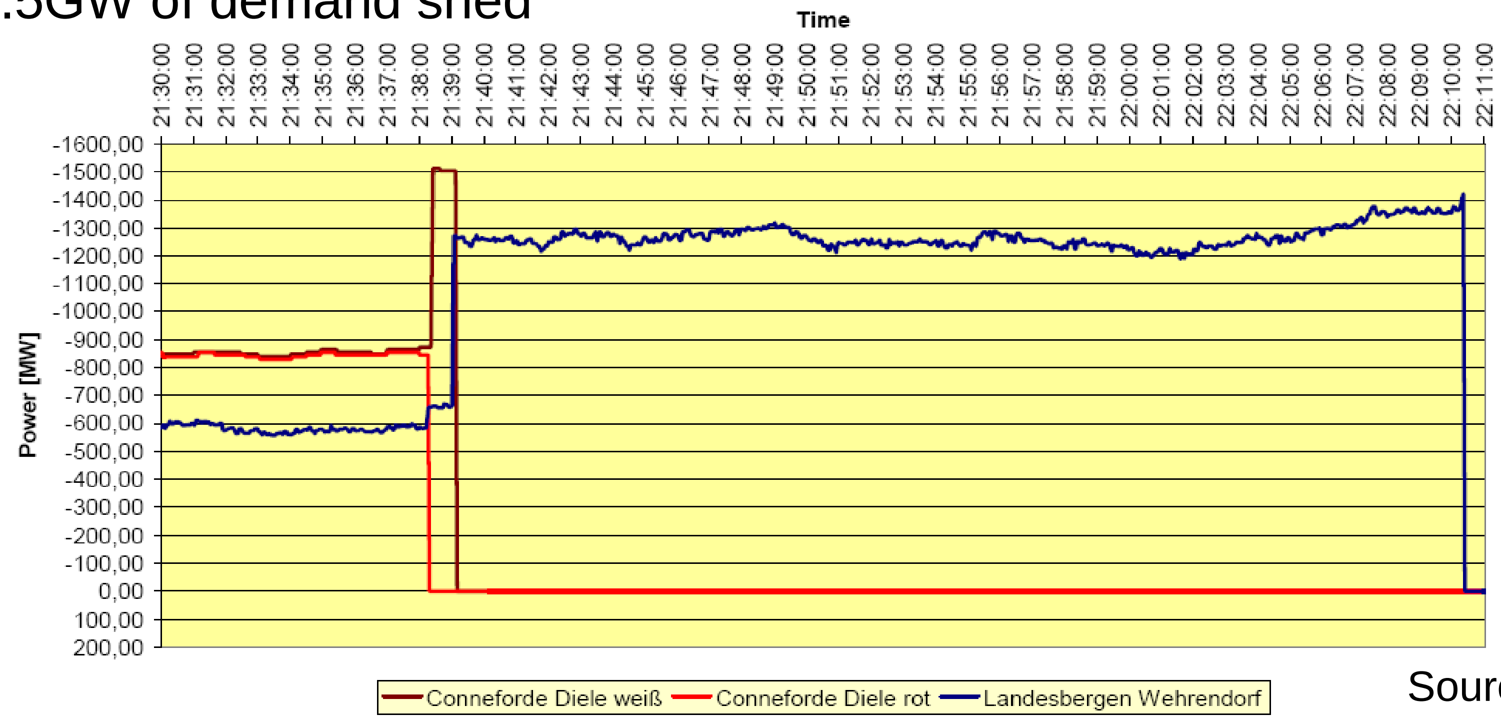
Windier in Germany than expected

- More power actually exported from northern Germany than planned
- Higher east to west flows in Germany than planned



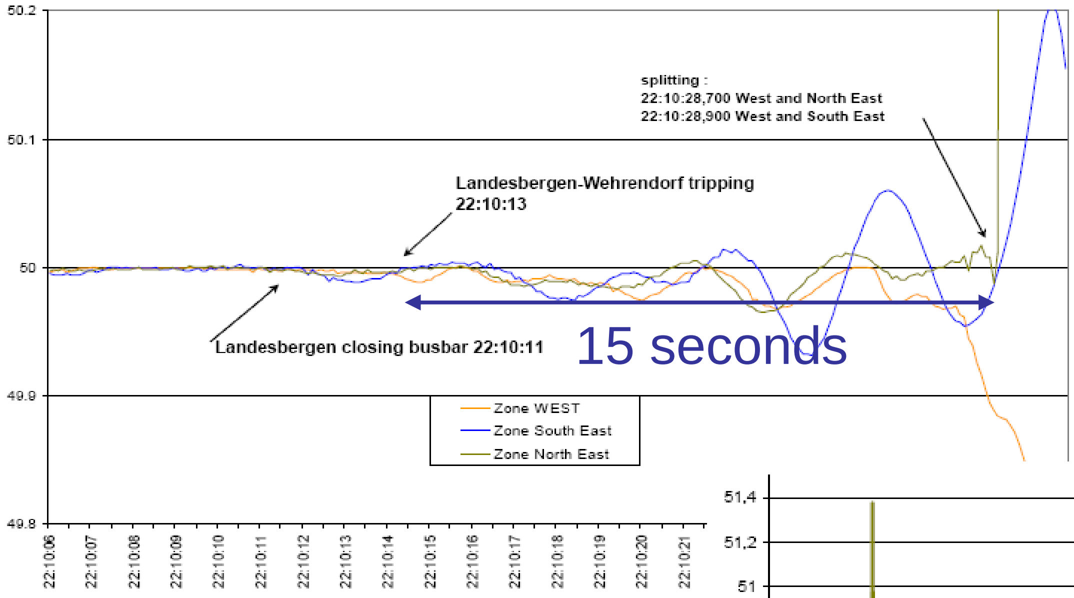
UCTE event, November 4 2006

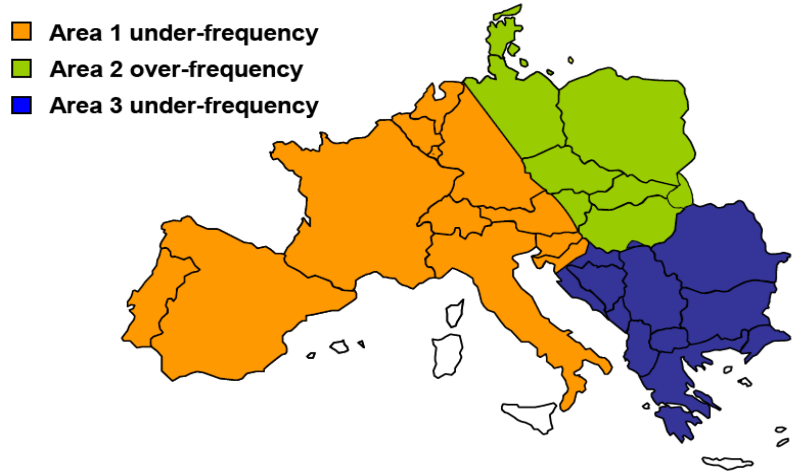
1. Planned outage of 380 kV Conneforde-Diele rot and weiss circuits
2. Warning of high loading on Landesbergen-Wehrendorf circuit
3. Busbars coupled at Landesbergen at 22:10
   - intended to reduce loading on Landesbergen-Wehrendorf line
4. Loading on Landesbergen-Wehrendorf increased
5. Landesbergen-Wehrendorf tripped 2 seconds later
6. Cascade tripping started → split of Europe into 3 islands within 15 secs
7. 14.5GW of demand shed

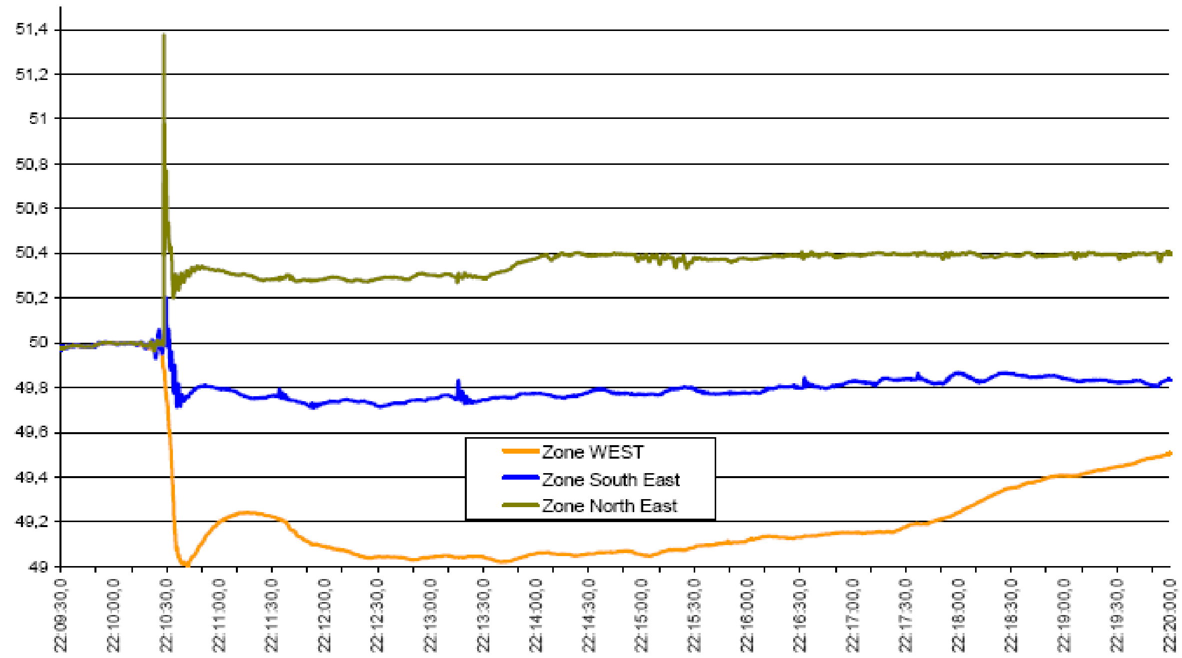


Source: UCTE

UCTE, November 2006: changes in system frequency







Not as bad as it might have been!

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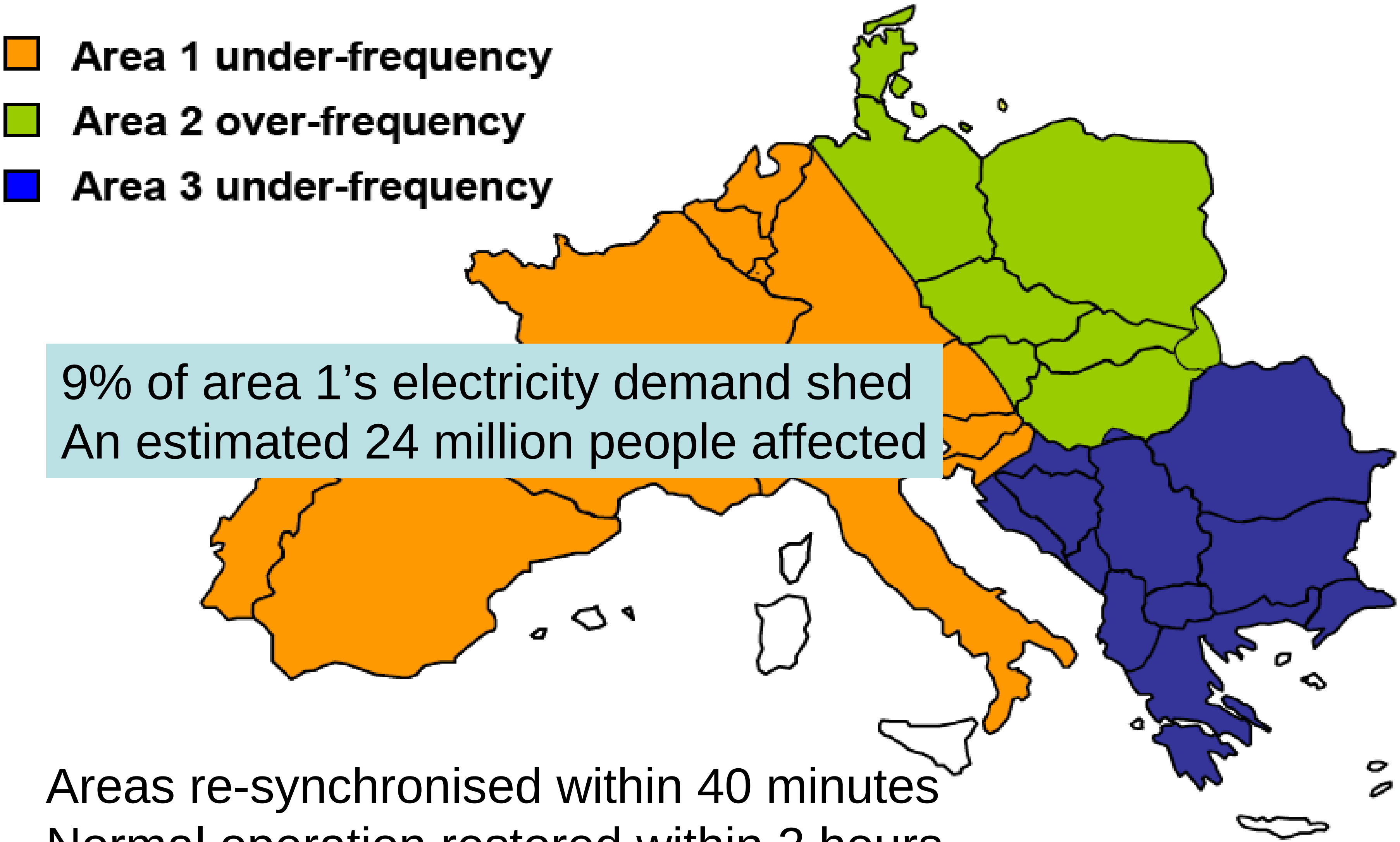


9% of area 1's electricity demand shed
An estimated 24 million people affected

Areas re-synchronised within 40 minutes
Normal operation restored within 2 hours

How to utilise low carbon energy and avoid bad things: ‘smart grids’

What is a ‘smart grid’?

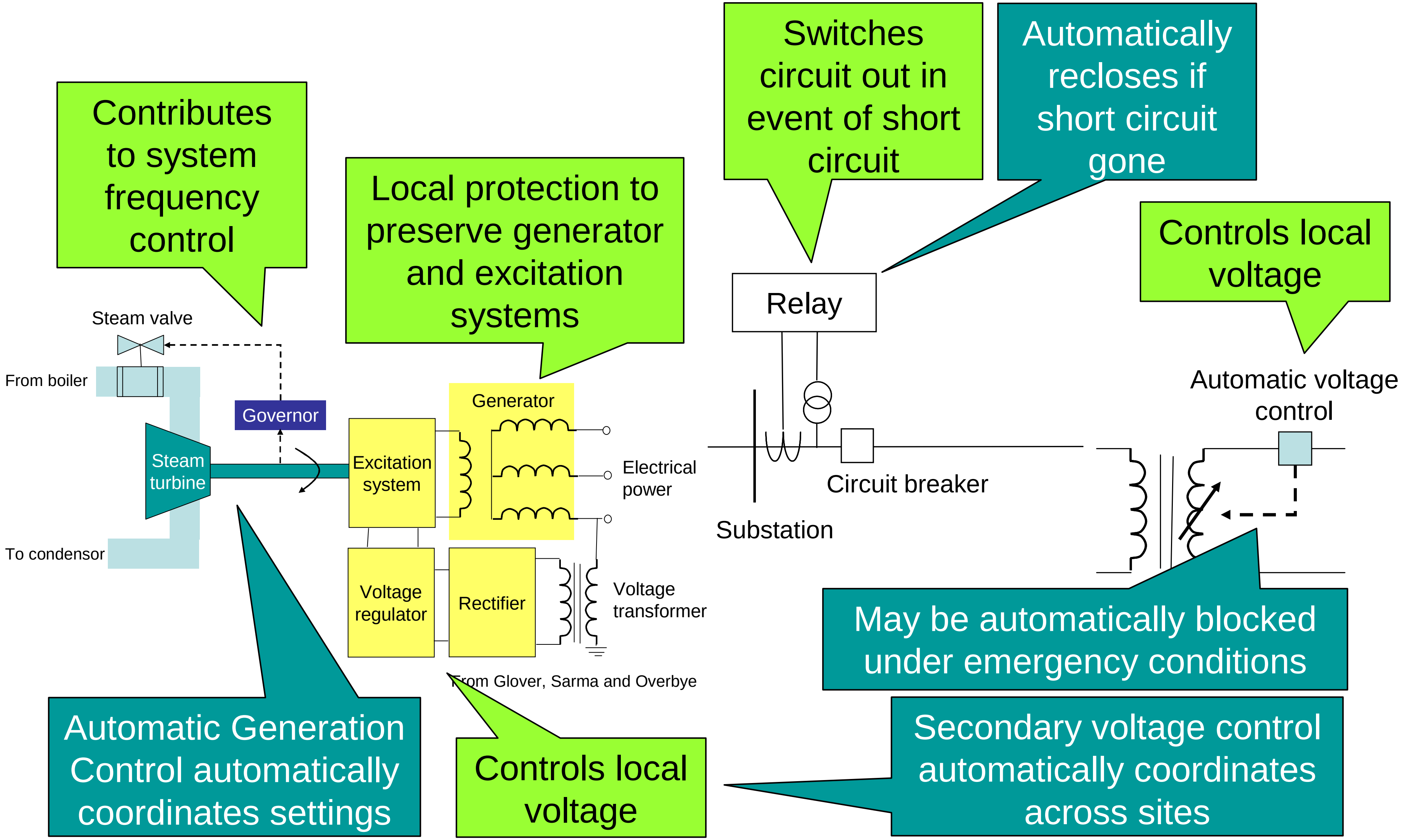
- “Electricity grids of the future are Smart in several ways:
  - they allow the customer to take an active role in the supply of electricity. **Demand management** becomes an indirect source of generation and savings are rewarded.
  - the new system offers greater efficiency as **links are set up across Europe** and beyond to draw on available resources and enable an efficient exchange of energy.
  - environmental concerns will be addressed, thanks to the **exploitation of sustainable energy** sources.”

“European Technology Platform: SmartGrids”, 2006

- “A Smart Grid as part of an electricity power system can intelligently **integrate the actions of all users** connected to it - generators, consumers and those that do both - in order to efficiently deliver **sustainable, economic and secure electricity** supplies.”

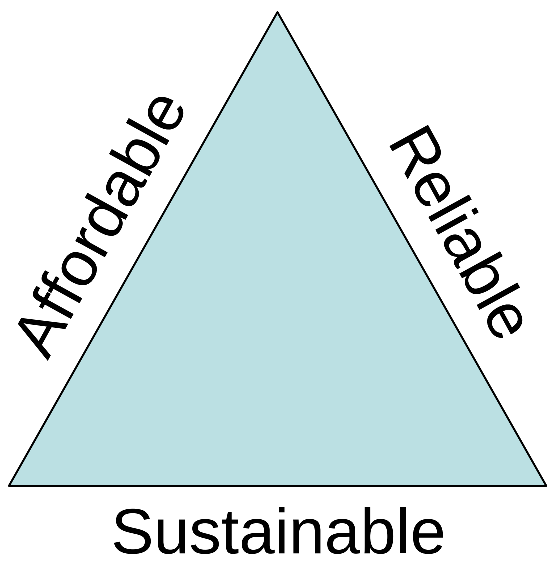
Report to Electricity Networks Strategy Group, UK, November 2009

An already quite smart grid



The future electric power system

- Grids, especially at transmission level, are already ‘smart’.
  – The key to a ‘smarter grid’ is that demand is no longer a constraint but becomes a control variable.
- A ‘smarter grid’ will have to be capable of dealing with many more control variables than present day grids.



The ‘smarter’ grid