

Evaluating the Cost and Benefits of Wind

What sort of contribution can it make toward
UK energy supply and climate stability?

Personal Background

Energy Developer & Consultant

- Civil engineer, Imperial College, graduating 1962
- Oil related and other offshore construction, from 1963 to mid-1970s
- Founder of the UK's first renewable energy company, CTT. A failure, 1976
- Area Representative, power station sales in Caribbean and South America, 1977 – 1986
- Founded Incoteco (Denmark), in 1986

**Activities include power station clean up, renewables, hydrogen and CO₂ for EOR
Emphatically not `anti-wind`**

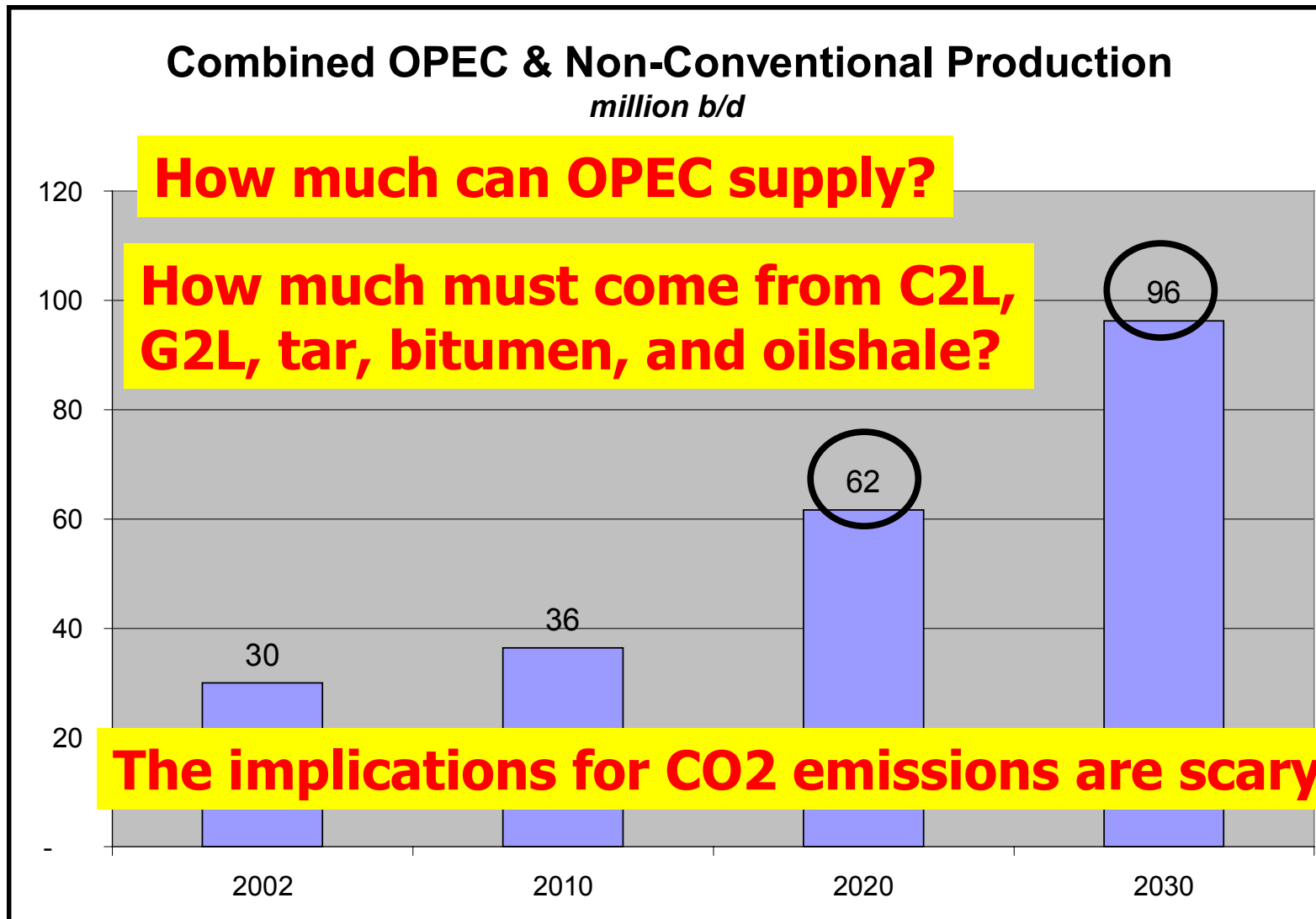
Hydrocarbons are wonderful!

Low cost hydrocarbons have given us more benefits than we can even bear to realise

- Amazing industrial productivity
- Astonishing mobility
- Previously unthinkable land productivity
- Sanitary living space
- Thousands of beneficial chemicals & materials
- Comfortable habitations
- etc., etc.

incoteco

...but low cost, environmentally benign
HCs cannot meet World demand



incoteco

Can't Wind Hydrogen Fill the Gap?

NOT REALLY!!

- UK uses about 50 million t/y transport hydrocarbons,
- Generating ~ 155 million t CO₂
- To replace this alone would require 18 million t of hydrogen
- Manufactured from approximately
 - 110,000
 - 3 MW wind turbines

A Single Line 55,000 km long

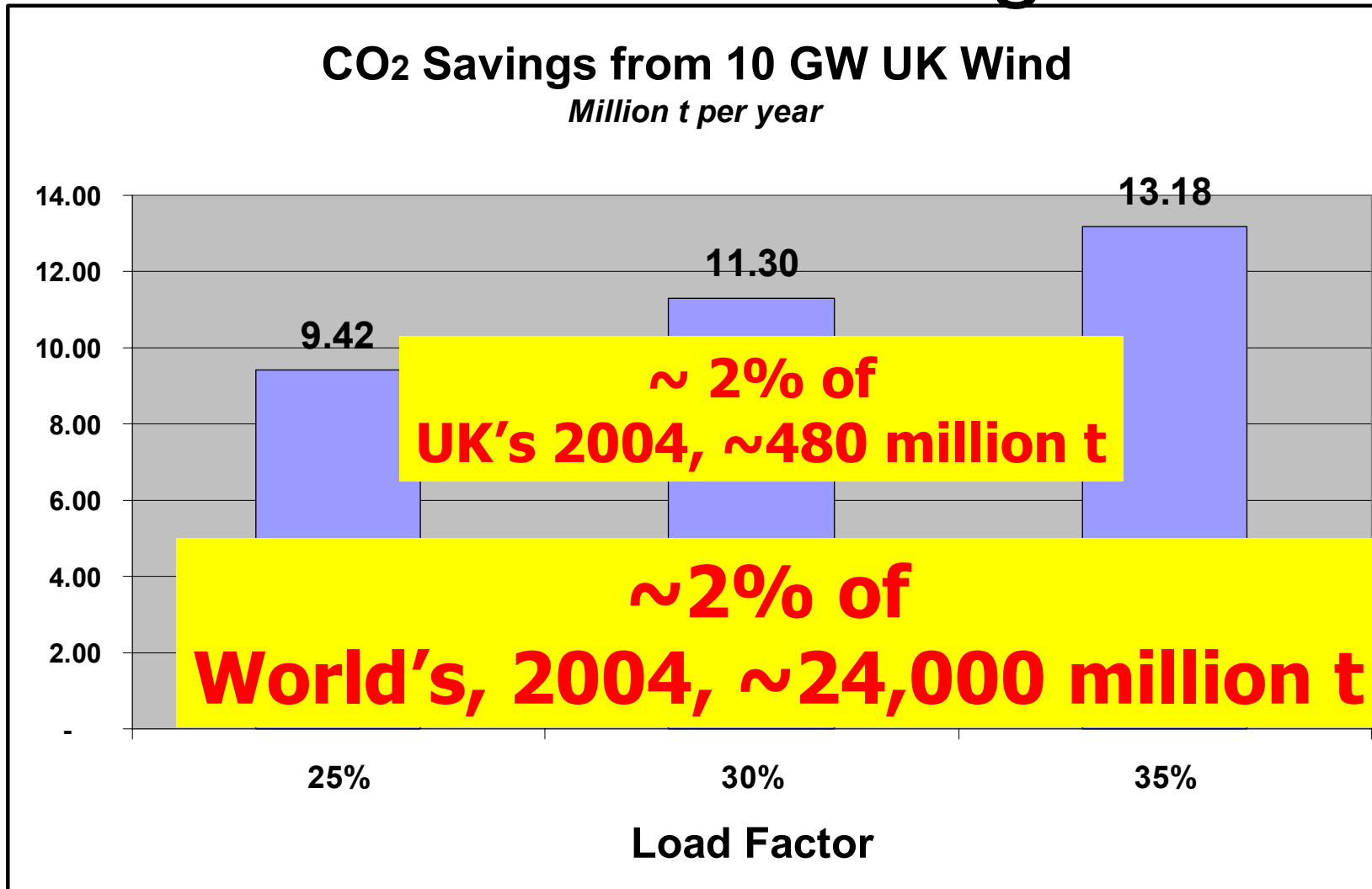
Costing £330 thousand million

Can't wind power generation help?

- A little....
- Up to ~ 10 GW, in UK, can be built offshore...
- ...each MWh generated "saves" about 0.43 t CO₂ (DEFRA, DTI)
- ...and some fossil fuel
- Over 10 GW, without energy storage, these fuel & emission savings are rapidly diminished by the requirement to run fossil plant, sub-optimally, to balance load

Storage is nowhere in the UK budget

How Much? How Significant?



Cost to reduce 0.04% World CO₂ Emissions?

- Wind power costs £190 per t CO₂ saved, based on...
 - 0.43 t/MWh avoided (DTI – DEFRA Guidelines)
 - £ 24/MWh electricity wholesale price
 - £ 48/MWh ROC
 - £10/MWh infrastructural costs due to wind (estimate)
 - £ 82/MWh all told
- European Emission Trading System currently values one tonne traded CO₂ at **€7 or ~ £5**

Is this good value for money?

incoteco

But wind does not just save
emissions...

...it also supplies electricity?

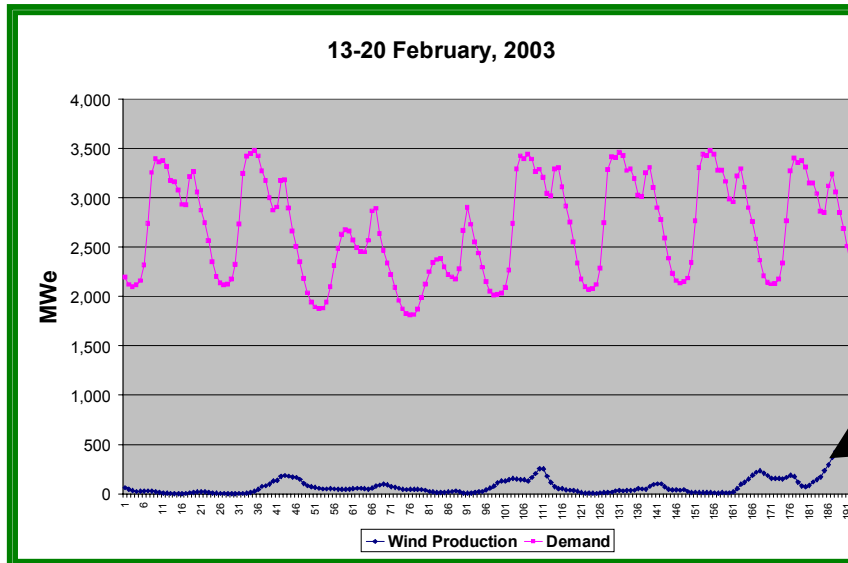
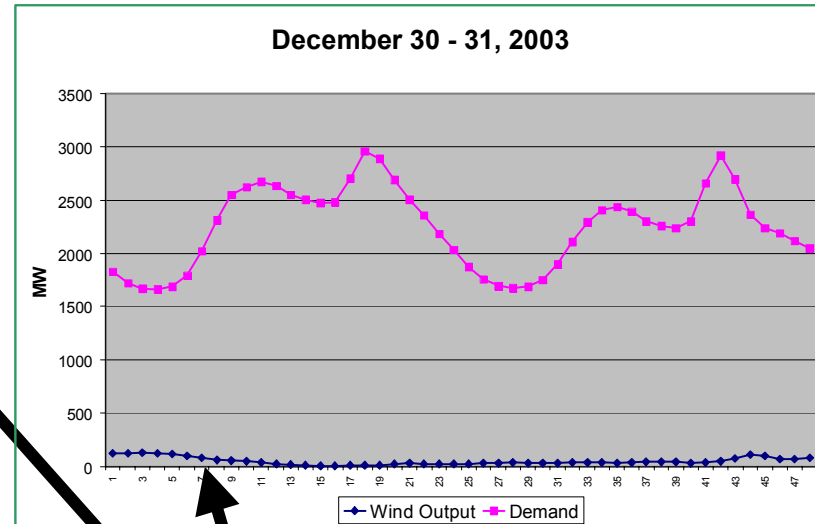
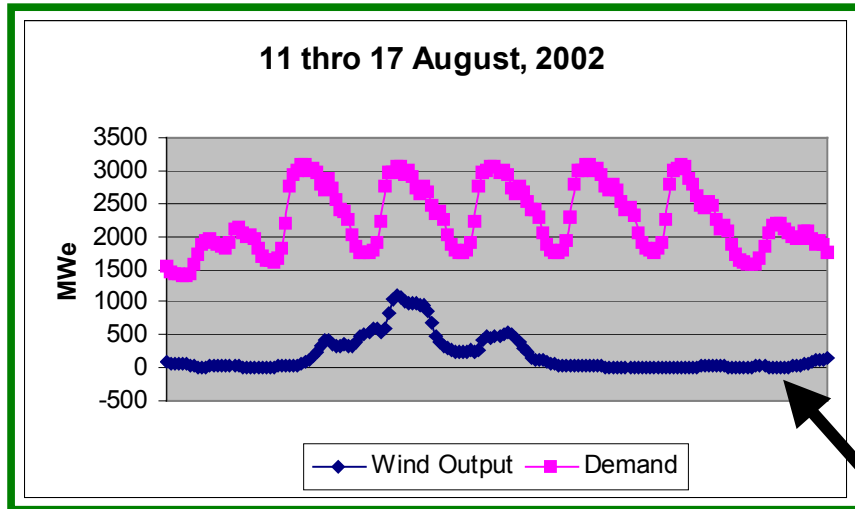
....and saves fuel?

£10 –15 per MWh

And must always be shadowed by
firm capacity

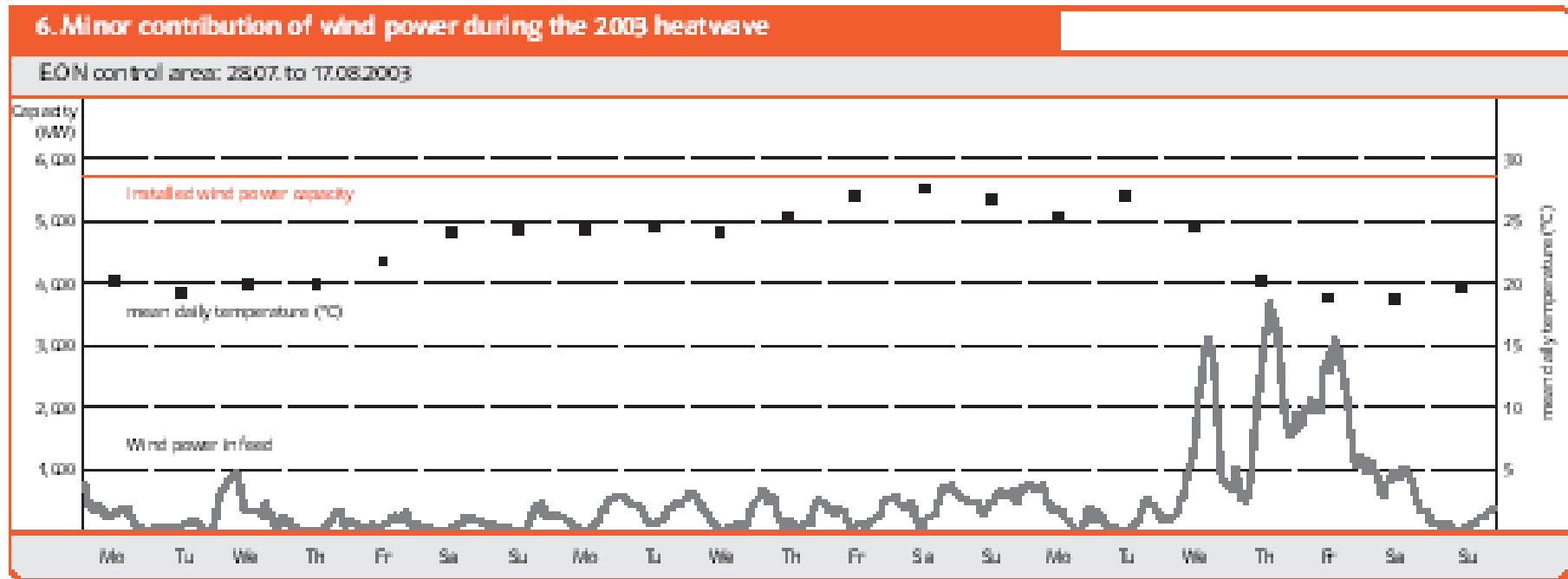
incoteco

It provides no firm capacity in Denmark



Wind Output
West Denmark

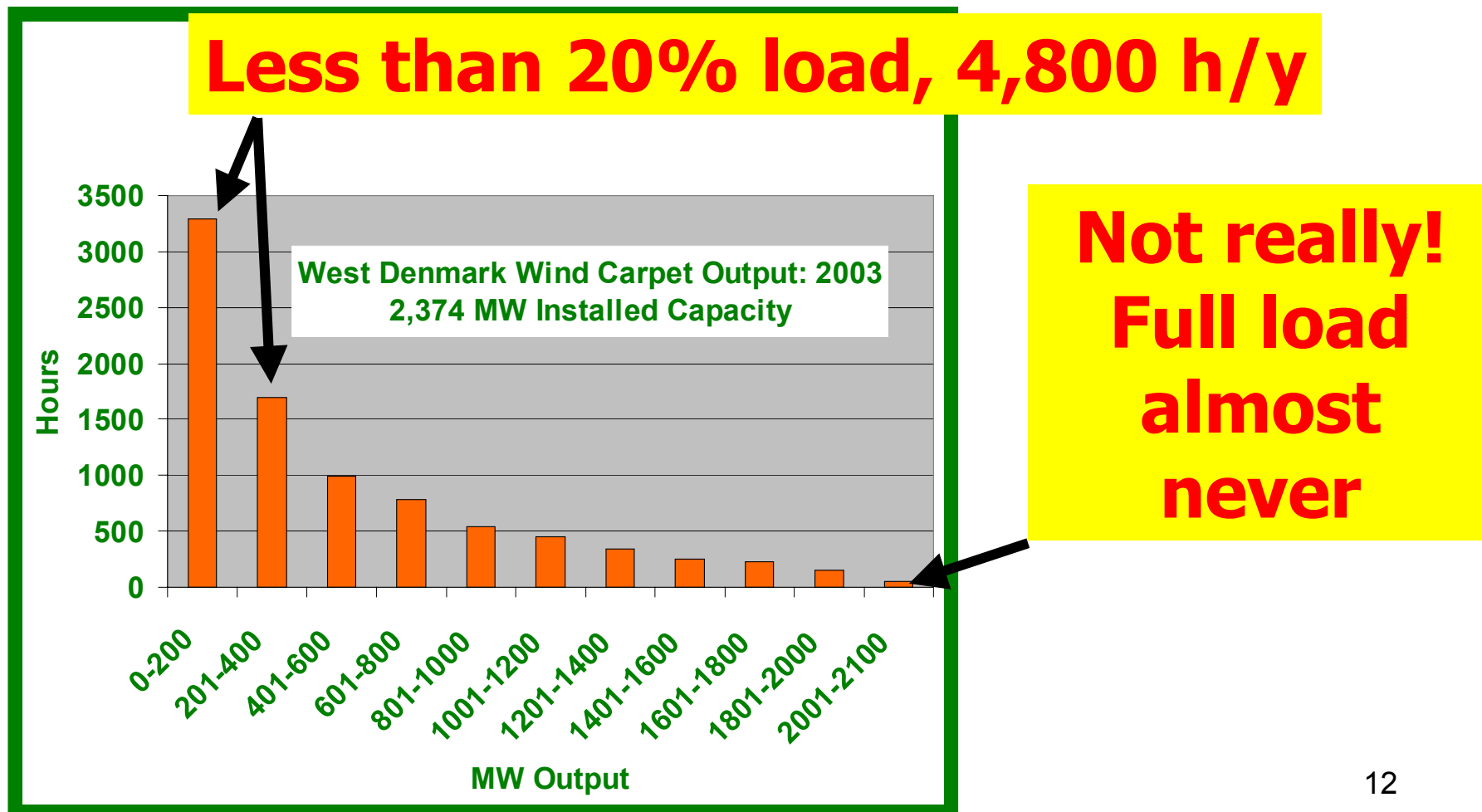
Nor in Germany



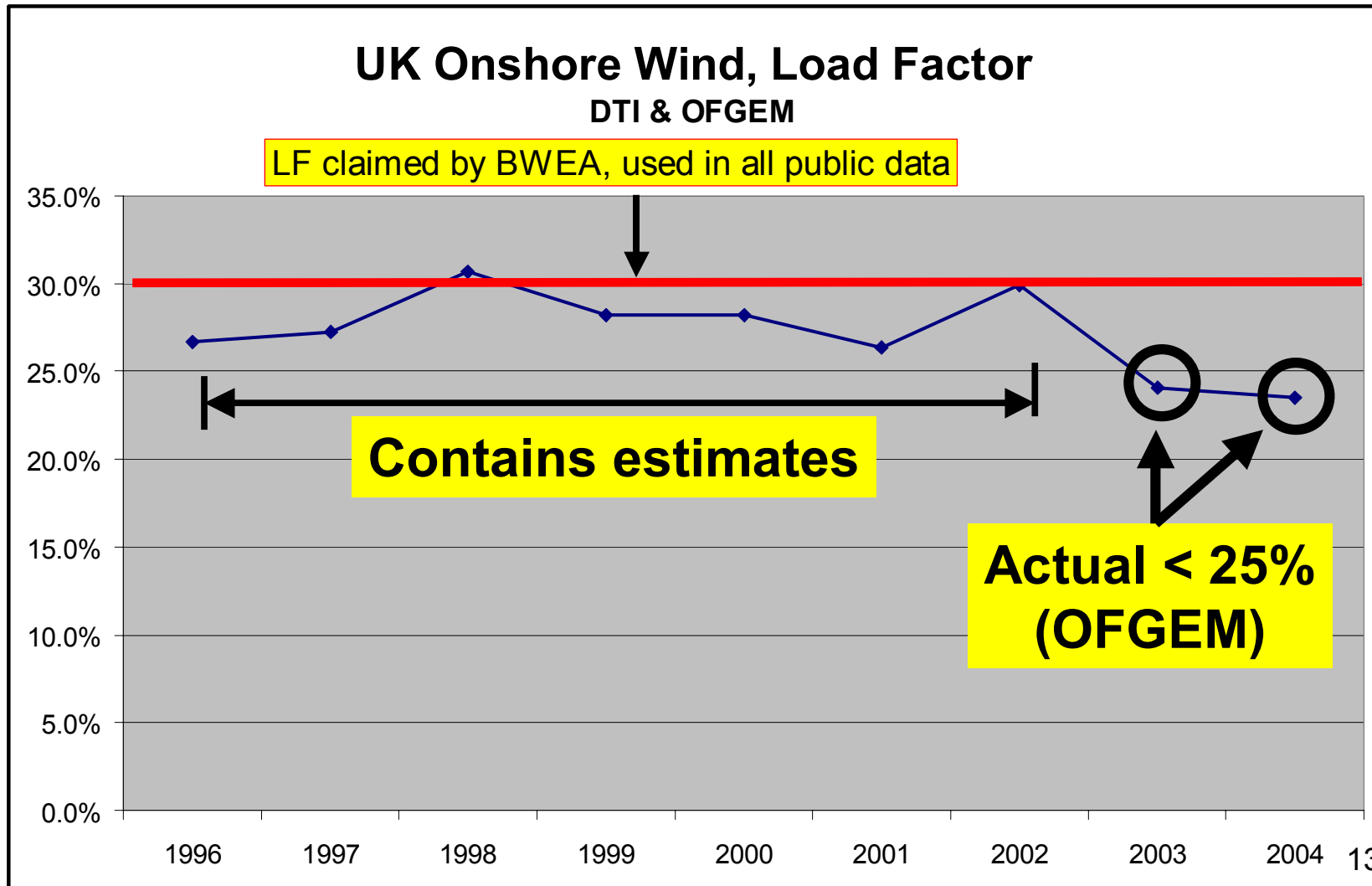
**EON Netz
Heat wave, 2003**

incoteco

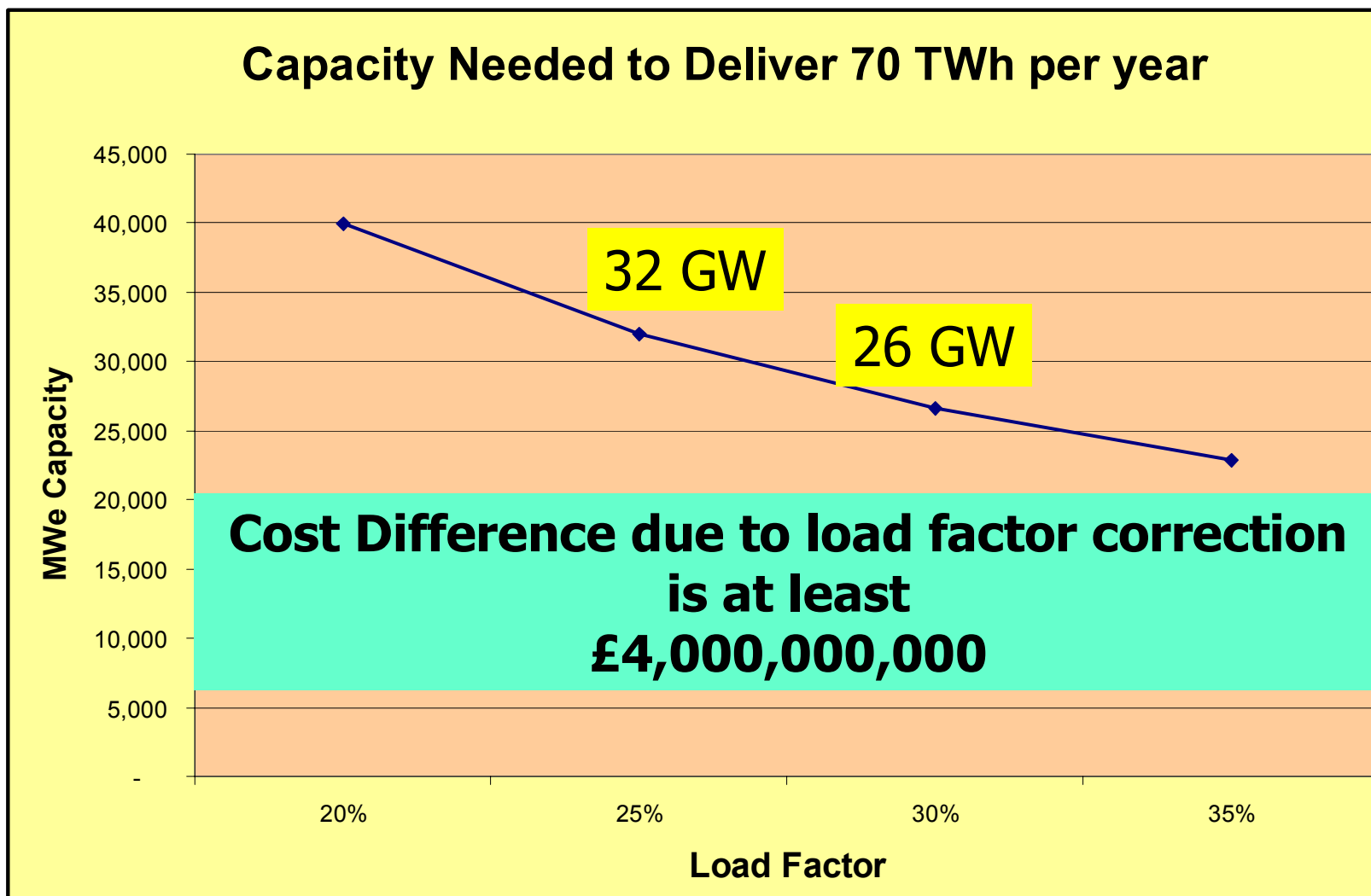
But does it not produce lots of energy?



LOAD FACTOR, Claimed and Actual



The Effect of Load Factor



Consequences arising from lowered load factor

- Reduced expected output for each qualified generator is off-set by...
- ...increased ROC value because...
 - RO “kitty” grows annually
 - ..shared between under-performing generators
- Consumer will bear the whole cost of under-performance

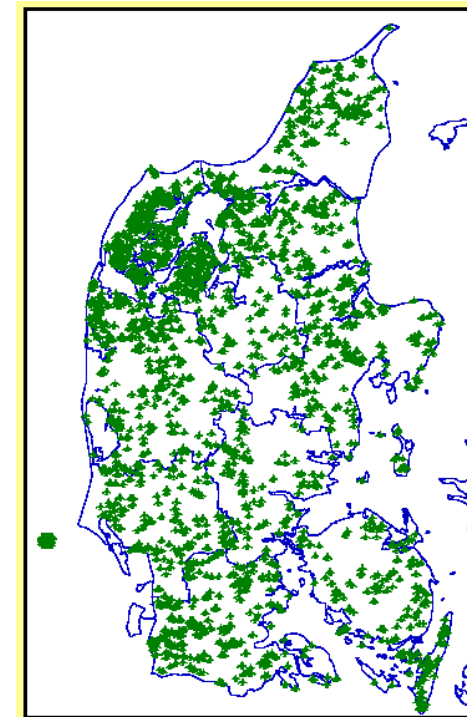
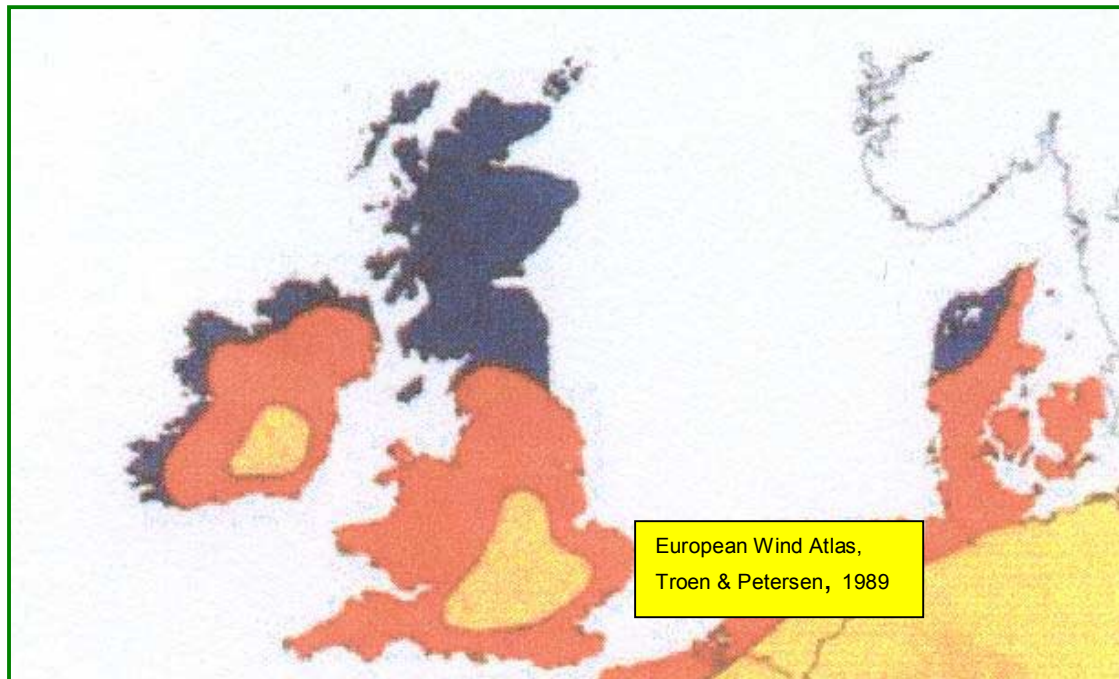
Wind industry promises 24 TWh from 8000 MW wind by 2010, Gov't expects 25 TWh

Unlikely to deliver more than 20 TWh, even if the capacity get built

incoteco

What can we learn from Denmark?

Latitude Sunderland to Moray Firth
Scale similar to Scotland
Disposition of Windcarpet similar to Future UK



Expect UK wind carpet will behave like the Danish one

incoteco

Denmark believes in wind

the most wind intensive nation on Earth



2,315 MW of wind capacity generates the equivalent of ~ 20% power consumed in West Denmark
More is coming

incoteco

...but it is not so simple

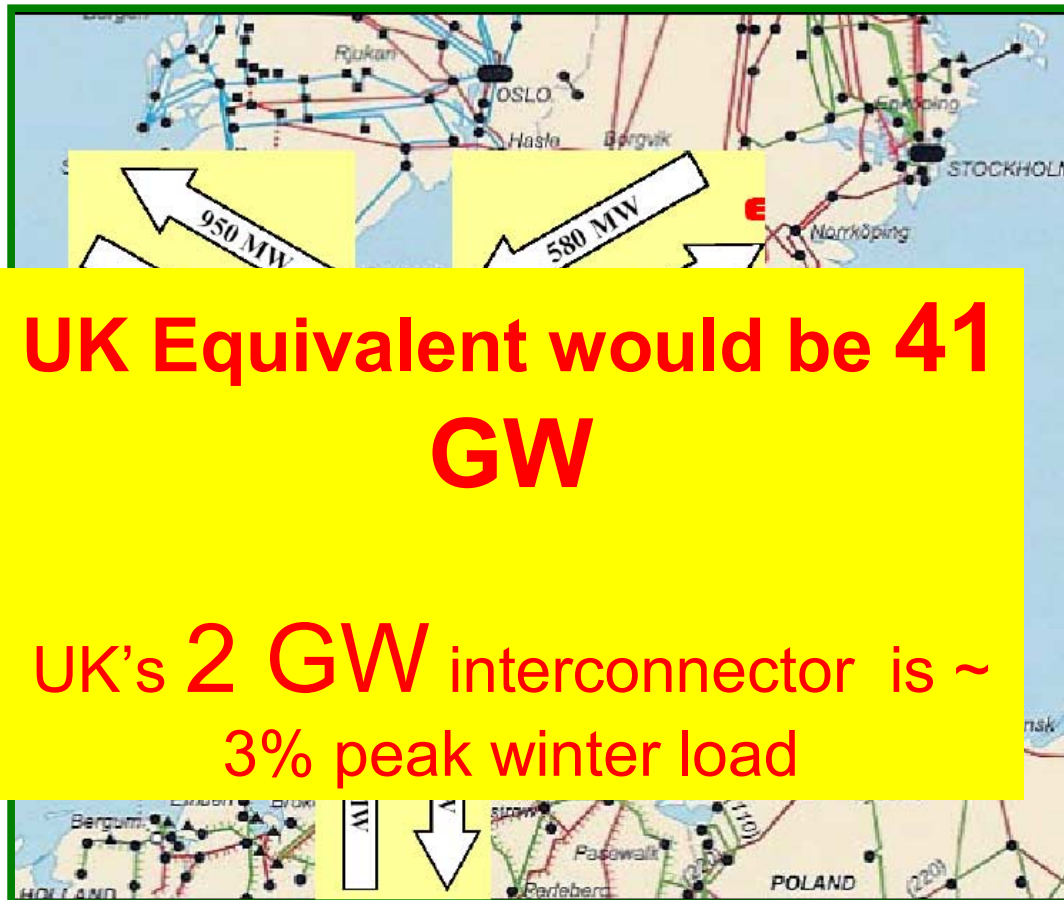
Power exports often mirror
wind production

**In 2003, most Danish wind power
was produced when exports were
high**

**So Denmark does not
consume 20% wind energy**

incoteco

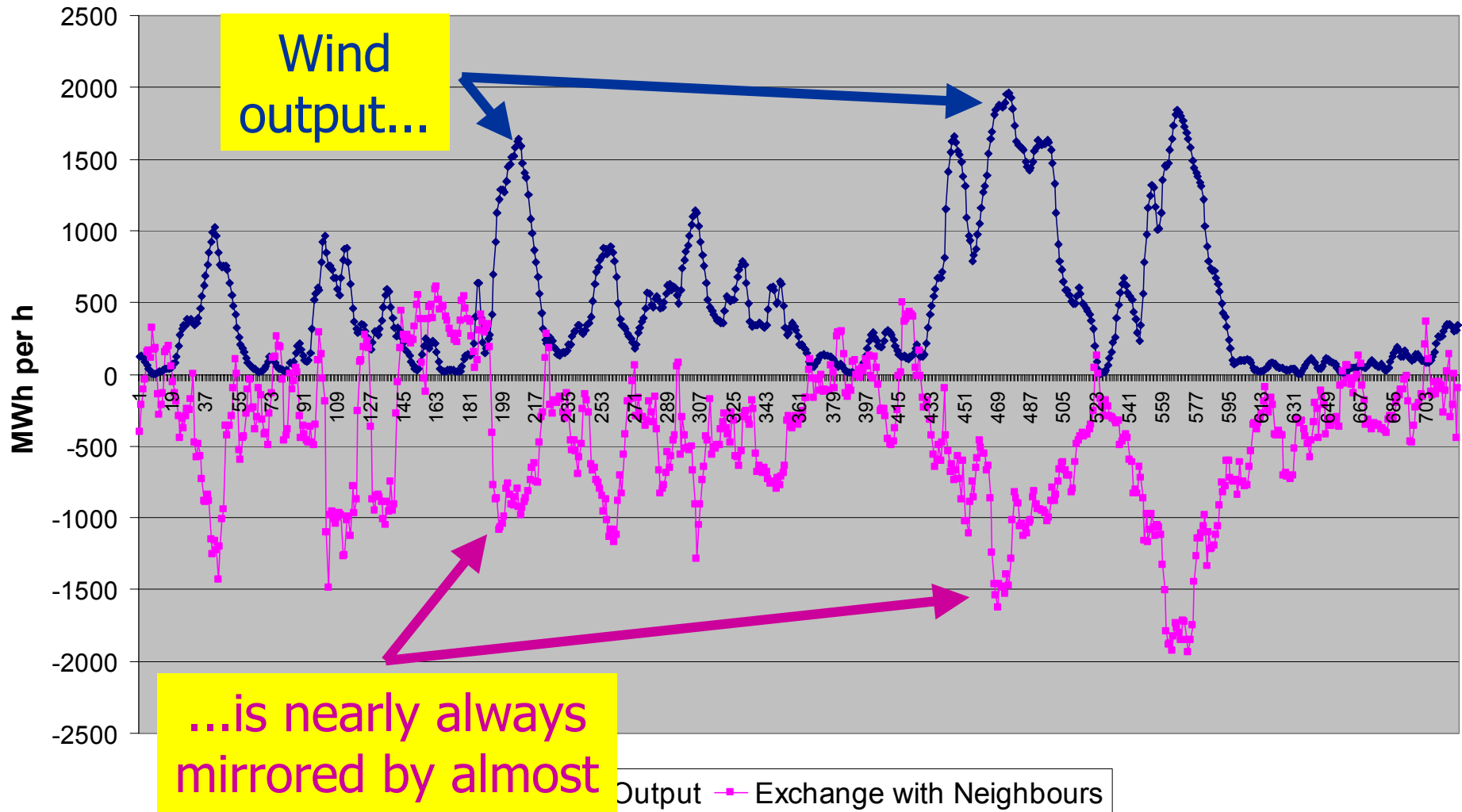
West Denmark can only balance wind because of its giant interconnectors



2,760 MWe export Capacity & 2,380 MW import capacity with neighbours.

This is ~ 70% of actual winter peak load

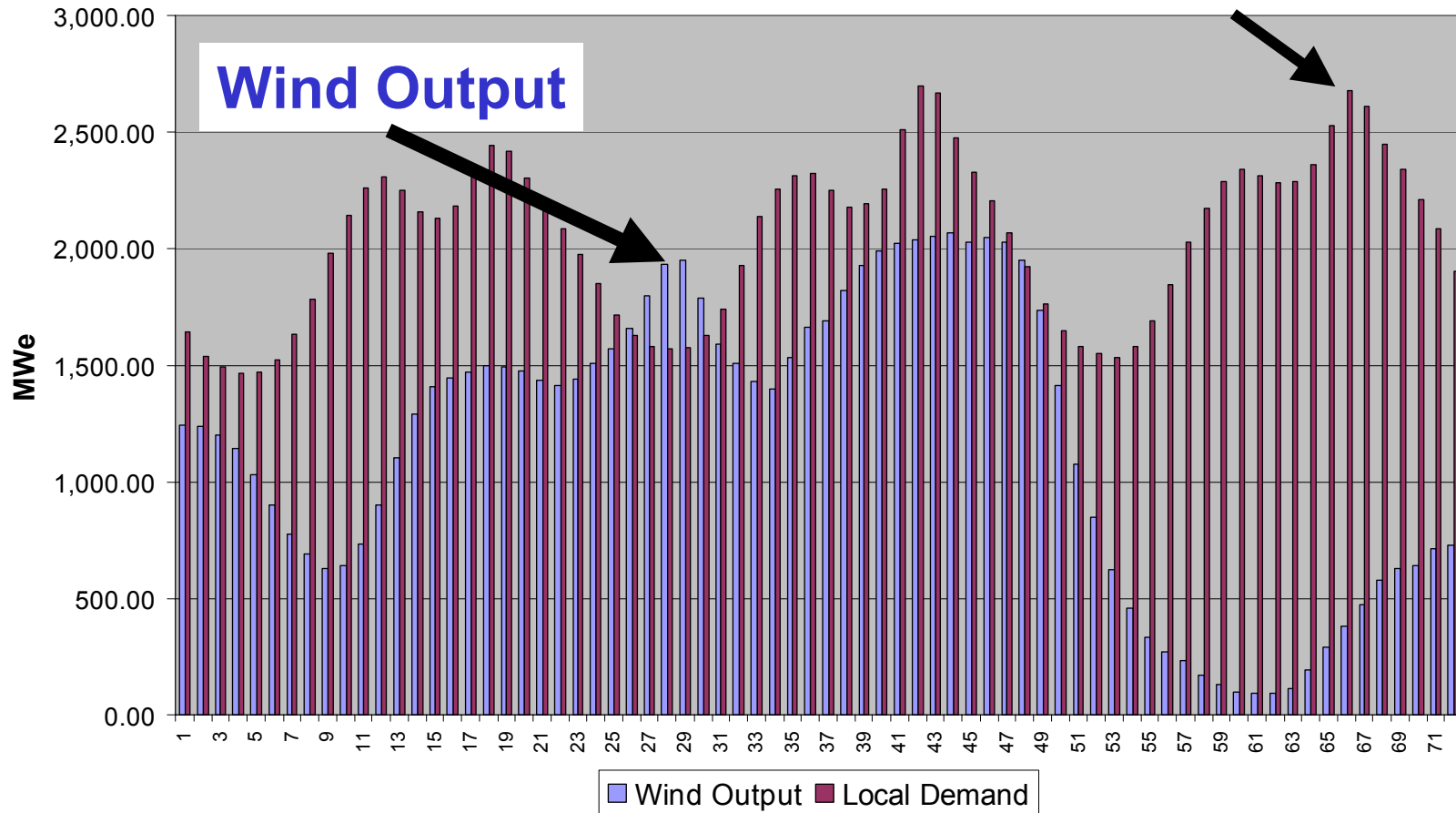
Wind Output & Net Exchange, June, 2003



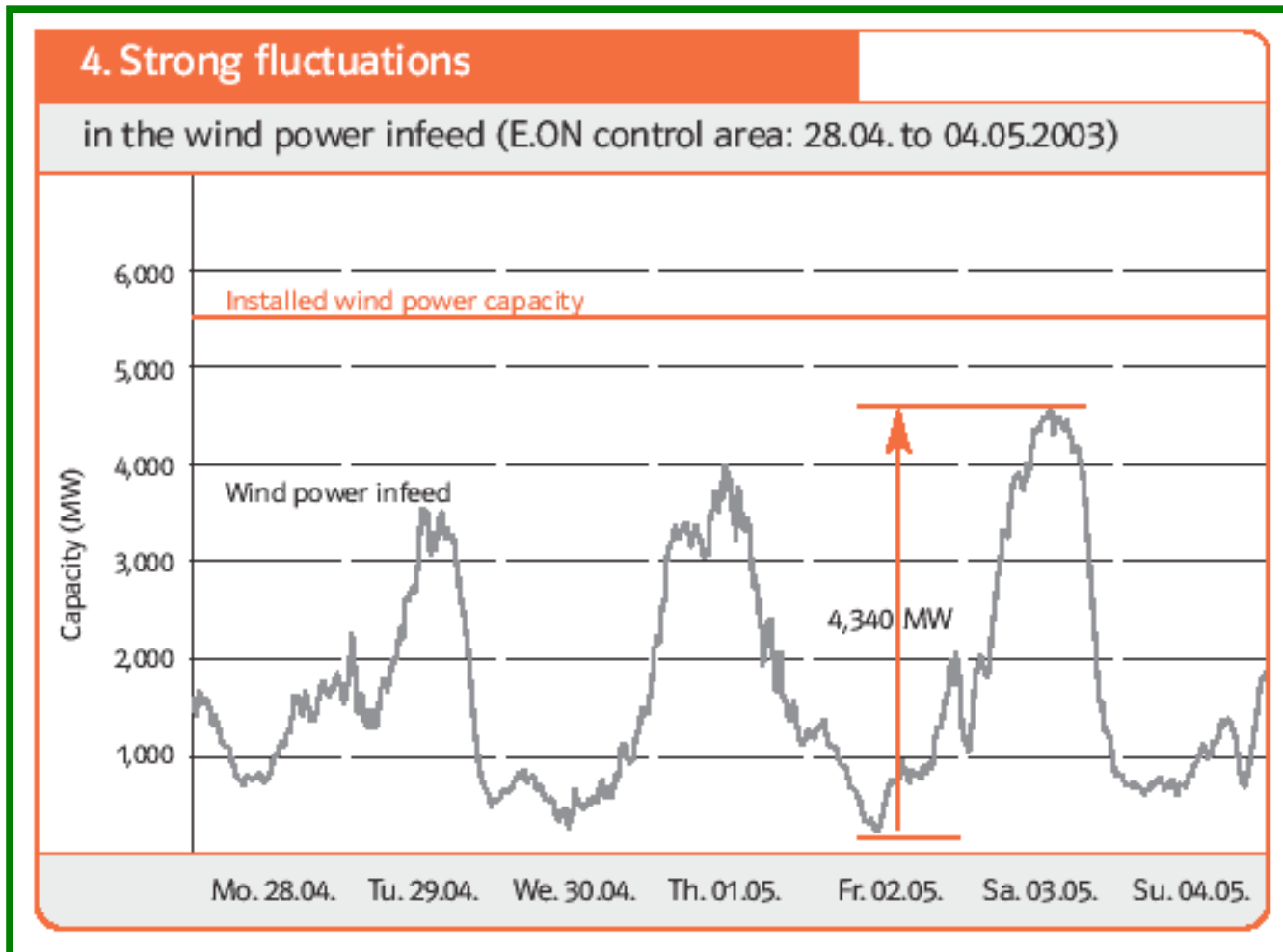
Necessary because wind power is generated out of phase with demand

December 26 thro 28, 2003

Demand



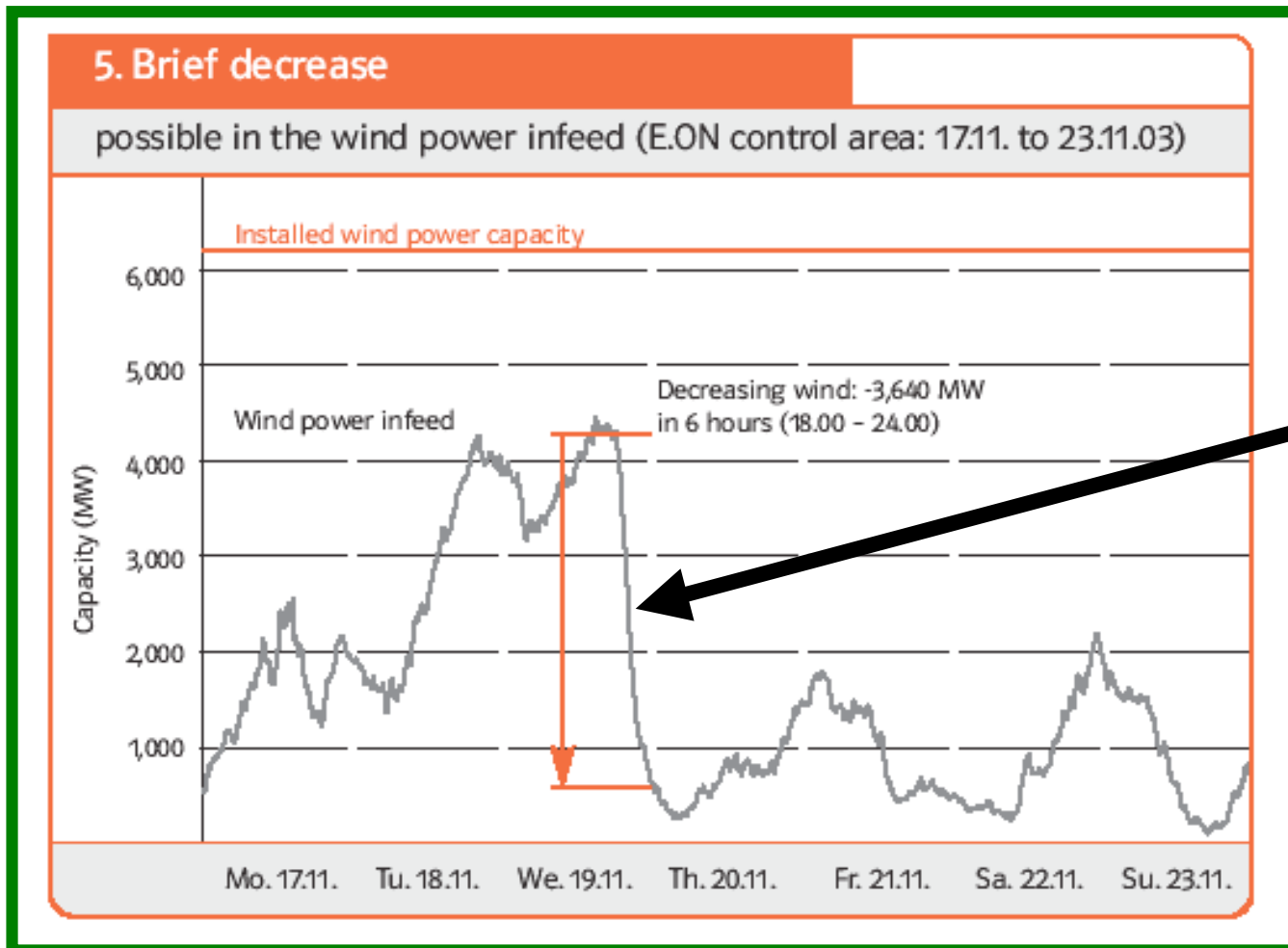
In Germany too...



Eon Netz operates a 20 GW system stressed by 6000 MW of wind power & inter-connections in all directions

Germany - Sudden system shock

EON NETZ

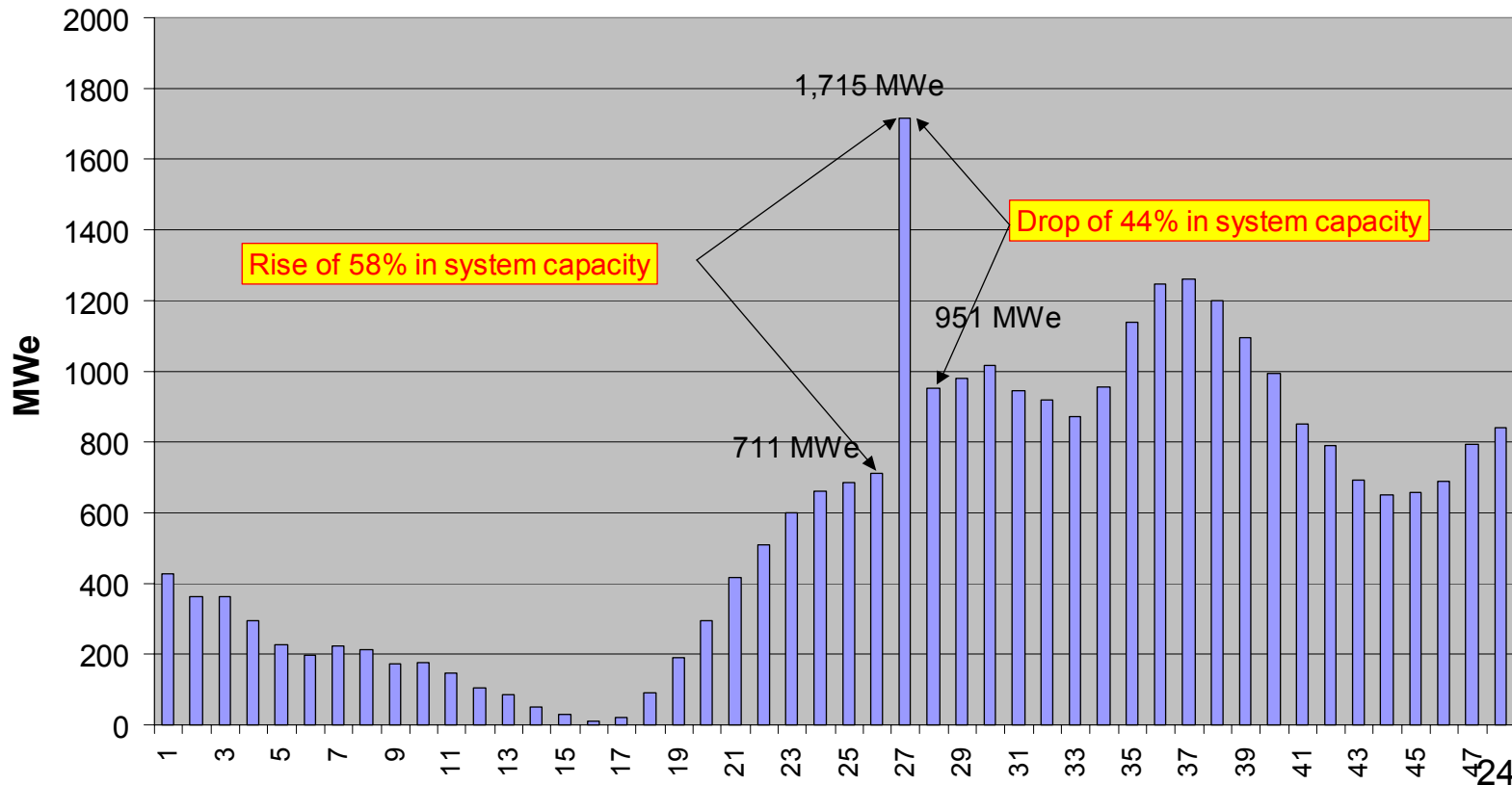


Wind output fell by 600 MW per hour for 6 hours. Balancing thermal power must be found

Denmark

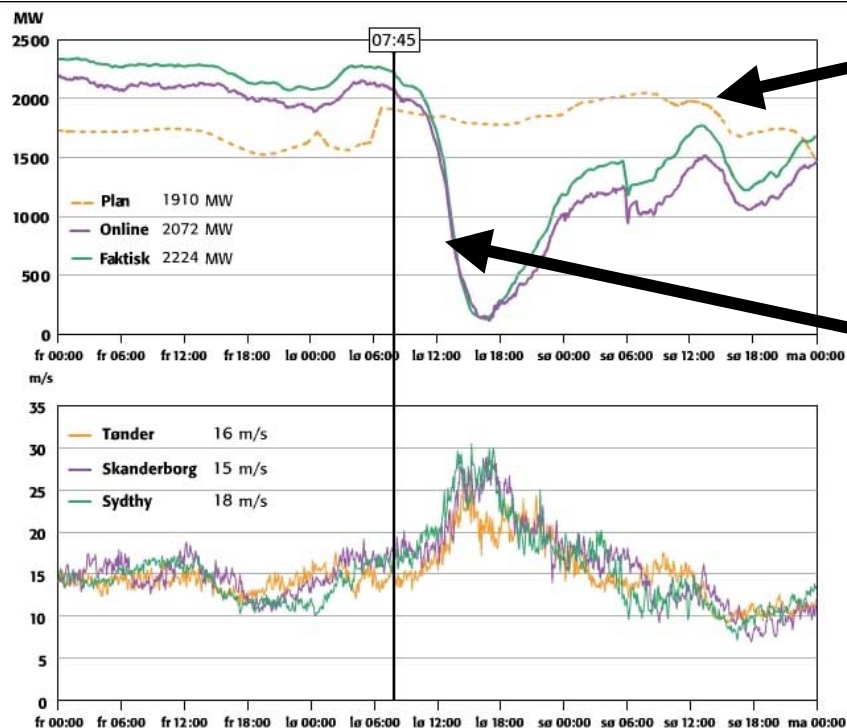
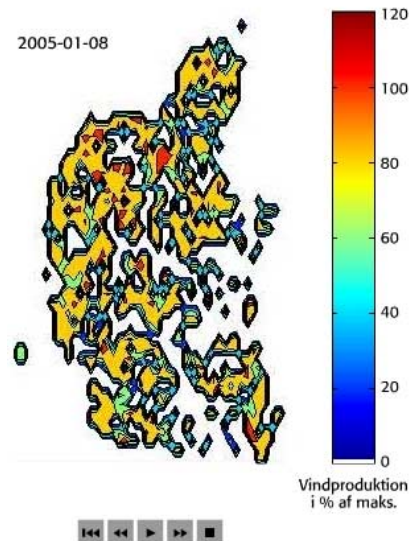
Storm Conditions October, 2000

Wind Output, 28 - 29 October 2000
System Capacity 1,700 MWe



West Denmark 8th January, 2005

Vindproduktion under orkanen
lørdag den 8. januar 2005



Wind output forecasted

Actual wind output

- Bemærkninger
- 2005-01-08 16:44 Bilstrup-Tange-2: Vellykket genindkobling
 - 2005-01-08 16:00 Abildskov-Fynsvet: Udkobling
 - 2005-01-08 15:05 Hatting-Landerupgaard: Vellykket genindkobling
 - 2005-01-08 15:05 Landerupgaard-Sket: Mislykket genindkobling
 - 2005-01-08 14:23 Bilstrup-Struer: Mislykket genindkobling



Storm closed down wind output in a few hours!
Regulating capacity equivalent to more than half system demand was required to balance system

With the large wind carpet foreseen for UK, the sudden loss of so much wind capacity would be hard to cope with – even “only” 10 GW

Storm Events in “windy” UK will be more frequent

Other Energy Options more attention

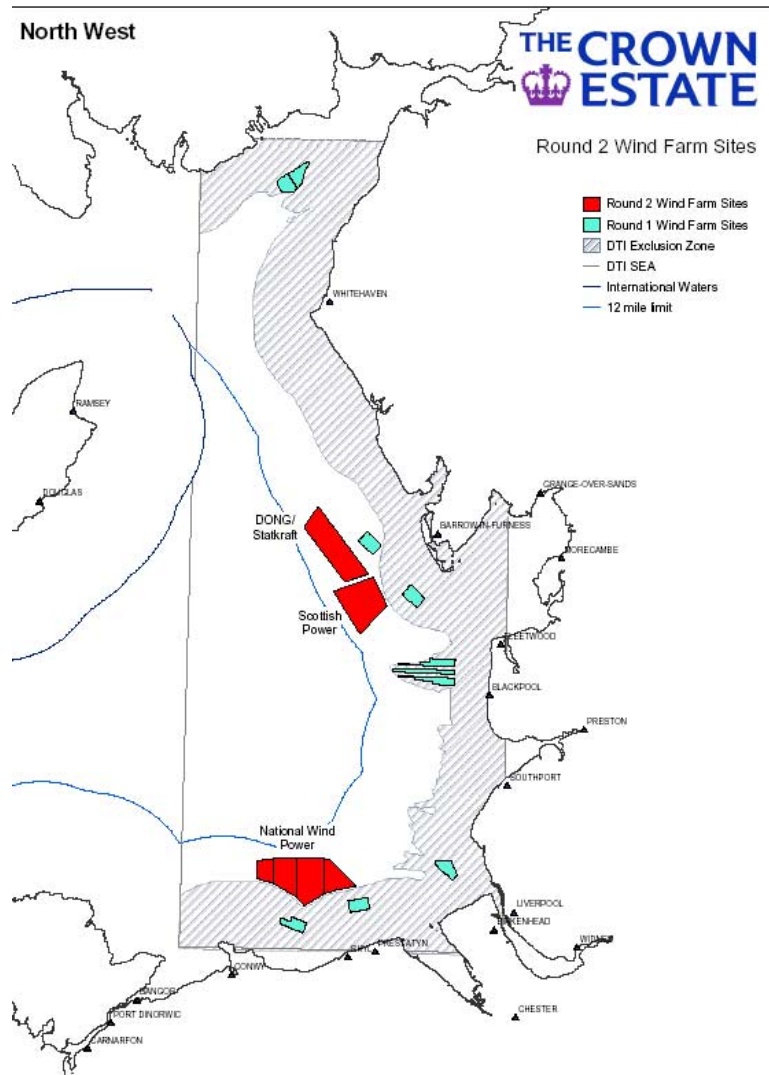
- Unglamorous but most effective, energy conservation reduces demand and consumption, without pain, for example:
 - Hybrid cars can run at 80 mpg
 - Long-life light bulbs are cheap, last longer and give same light at 16% energy cost compared with tungsten carbide bulbs
 - Combined heat and power uses 80 – 93 % energy input
- ...aided by realistic energy pricing & fiscal measures
- ...will avoid need for many thousands of MW, thermal or wind
 - So avoids needless landscape destruction and CO₂ emissions
- Clean coal development with CO₂ sequestration for enhanced oil and gas recovery, extends fossil reserves without CO₂ emissions and buries a billion tons of CO₂ under the North Sea
- Keep the nuclear option open and develop safer, lower cost configurations
- Widen development of other renewables (tide, ocean current, biomass, waste to energy, etc.)

Conclusions

- Up to (say) 10 GW, wind can save some fossil fuel consumption, not cause excessive problems and reduce some emissions but above this (subject to study)...
- ...wind's use will become technically problematic and even more expensive...
- Because, lacking inter-connectors, short term energy storage is needed, more or less MW for MW, thus doubling specific costs
- ...which are already high
- Storage has not been costed into present plans
- ...and must be...

Proposal for 26 GW or more are quite impractical, useless and uneconomic

10 GW can be built offshore



...so the priority for new building should be offshore...

...providing these cause no environmental damage

What next?

- The UK should have a "wind component"
 - mostly built offshore
- But this should only be built after the most thorough assessments of...
- ...its true benefits and
- ...actual costs
- ...properly compared with all the options
- ...in a completely transparent manner

**When the top stops spinning it
falls over**