This paper is based on a presentation by Dr Mike Hall to the January 2005 conference of VIEWS OF SCOTLAND. Fellow of the Royal Society of Chemistry and the Institute of Biology, Dr. Hall is also a founder-director of the Renewable Energy Foundation and is active in Friends of Eden, Lakeland and Luneside Scenery (FELLS). The conference organisers thank him for his collaboration in the preparation of this material for wider distribution.

The picture shows a Feathered Thorn Moth photographed on Whinash Ridge within the footprint of proposed turbine #3. There is beauty to be destroyed underfoot as well as in the landscape.

Outline

1. Where did we come from?
2. Where are we now?
3. Where are we going?
4. Can renewables help?

Where are we coming from ...

1964	2004
Central planning by CEGB	No central planning
Government funded	Equity and debt funded
Public-sector monopoly	Fragmented industry
Prices and incomes policy	Asset-sweating regulation
Fuel self-sufficiency	UK import-dependent
Climate change not an issue	Climate change happening

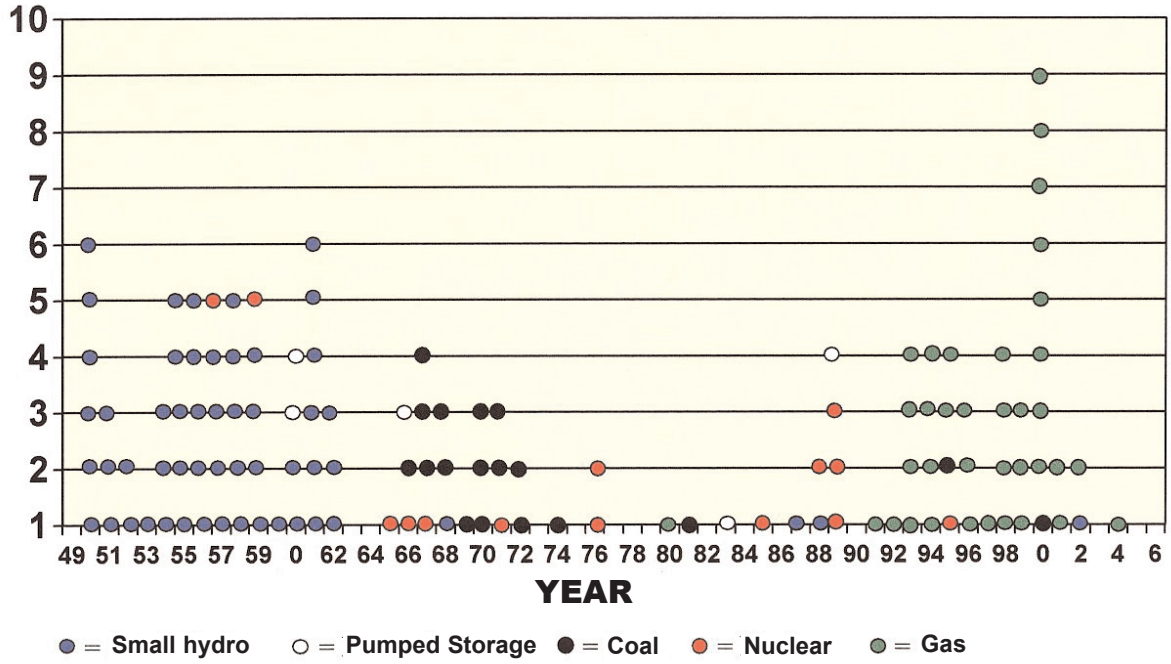
The political, industrial and ecological picture has changed dramatically over the past 40 years from a state-controlled, centrally-planned monopoly to an uncoordinated, fragmented, privatised, equity-driven industry.

… and where are we now ?
What is driving current thinking ?

- **Ageing generators and an ageing GRID system**
- **UK natural fuels (coal, oil and gas) are running out**
- **Kyoto and global warming**

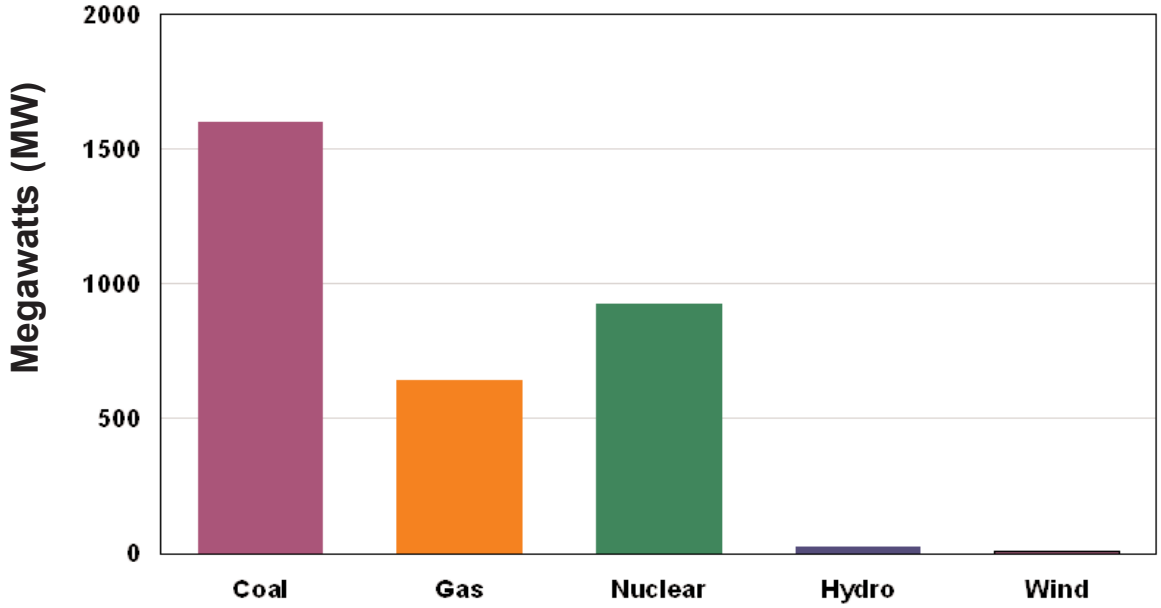
Current thinking seems to be dominated by our ageing power stations and grid system (with no significant new investment for 15 years), by the final consumption of our own oil, coal and gas reserves and by political issues such as the Kyoto Protocol.

Build-date for current UK power stations



Most of our hydro-power stations were built in the 1950s and 60s, coal stations in the 60s and early 70s and nuclear from 1956 to 1995. While the mad Dash-for-Gas of the 1990s is ongoing, most oil-fired power stations have been phased out.

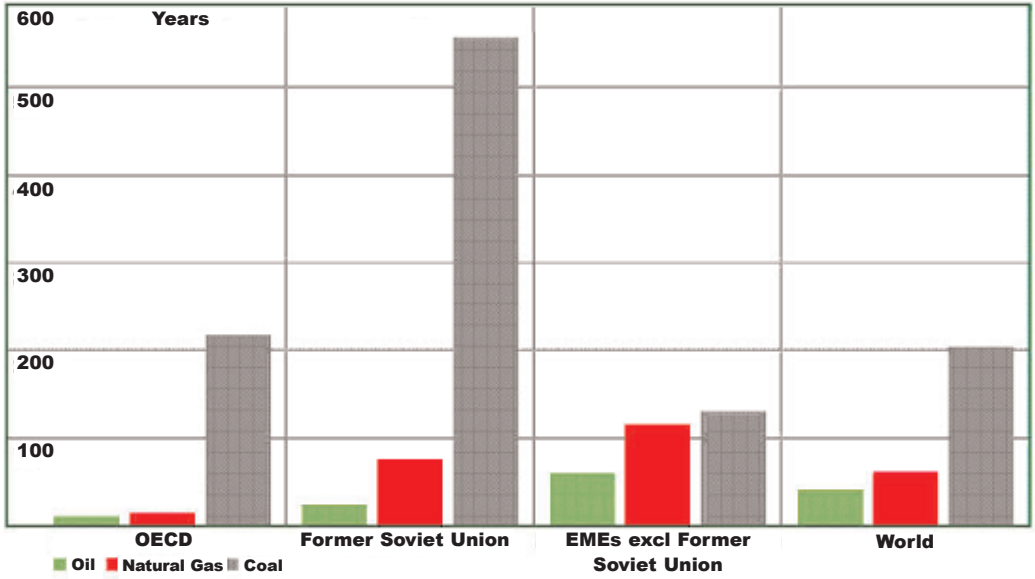
Average UK Installed Capacity by mode



In May 2004, Britain had 18 coal-fired, 36 gas-fired and 13 nuclear power stations with an average installed capacity of about 1,600, 650 and 950 MW respectively – compared with less than 20 MW for hydro and 8 MW for wind.

Note: Hydro includes four pumped storage plants; wind is as of November 2004; CHP, electricity imports and burned material are omitted.

Fossil fuel Reserves-to-Production ratios, 2002



Fossil fuels have a limited lifetime. British Petroleum's *Statistical Review of World Energy 2003* suggests that we have about 50 years of oil reserves left, 75 of gas and perhaps 200 of coal. Even if new deposits are found, our fossil reserves are being consumed at an accelerating rate, especially in India and China …

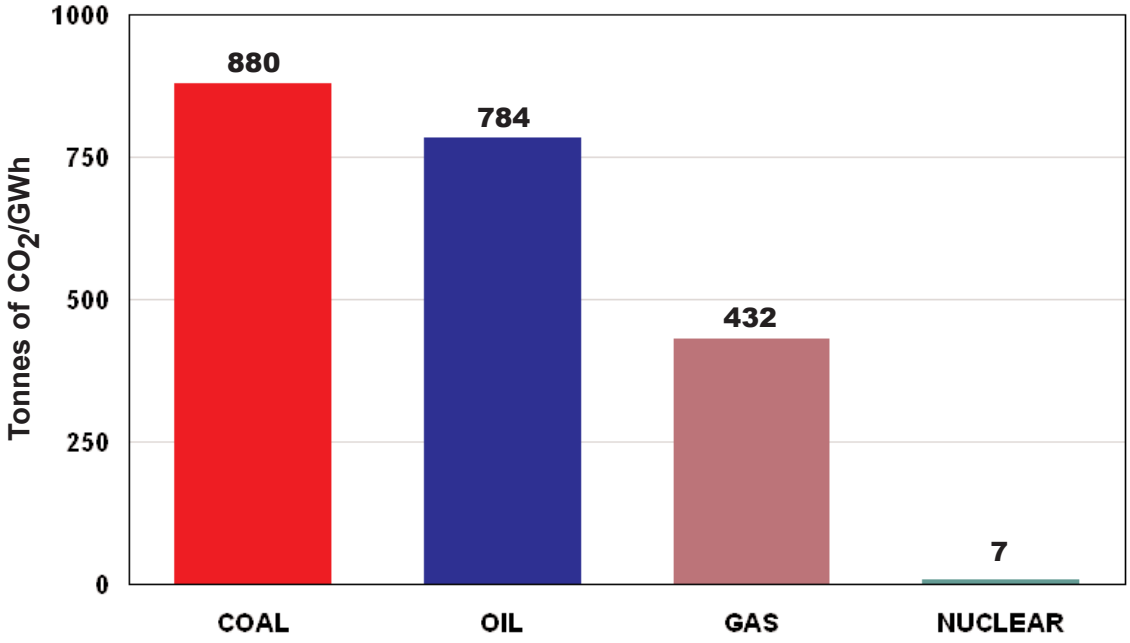
Note: The world's Reserves-to-Production ratio for coal is around five times that for oil and more than three times that for natural gas. Coal's dominance in R/P terms is particularly pronounced in the OECD and the former Soviet Union.

The UK's Kyoto Commitments

- **Reduce basket of six GHGs by 12.5% of 1990 levels by 2008-12**
  (CO_2, methane, N_2O and three man-made)
- **National goal to cut CO_2 levels by 20 per cent by 2010**
- **Aspiration to move towards 60 per cent reduction from current levels by 2050 (RCEP)**
- **Aim to supply 10 per cent of electricity from renewables by installing 10GW of new renewables capacity**

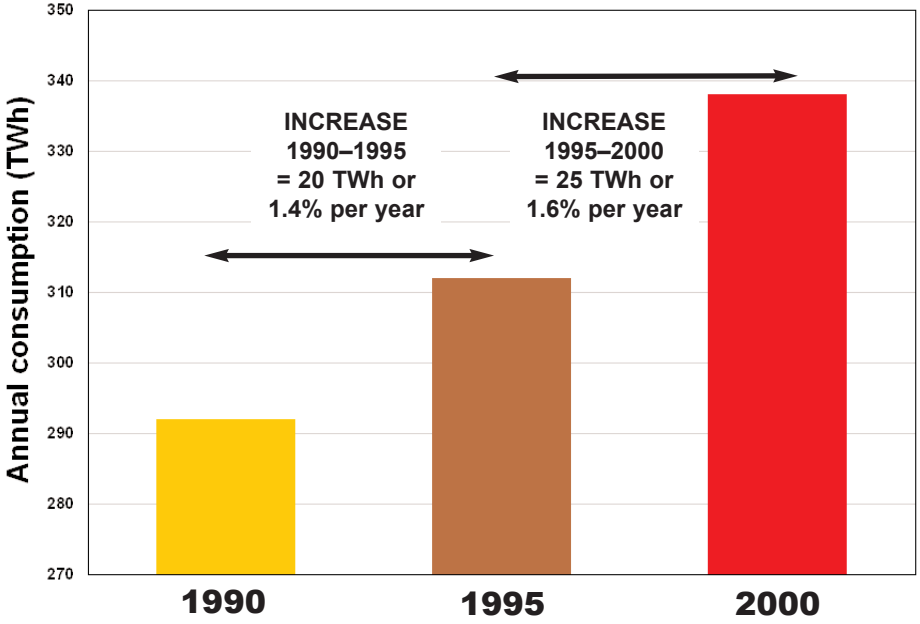
... and this has to be set against swingeing government targets under Kyoto and in response to the Royal Commission on Environmental Protection.

Emission of CO_2 in electricity generation



In the light of these targets, oil and coal have fallen from grace in terms of their large CO_2 output. Gas produces only half as much CO_2 and new designs of turbine may reduce this further. By far the cleanest in CO_2 terms are the nuclear stations – though they have their own, quite different problems. (Data from British Energy.)

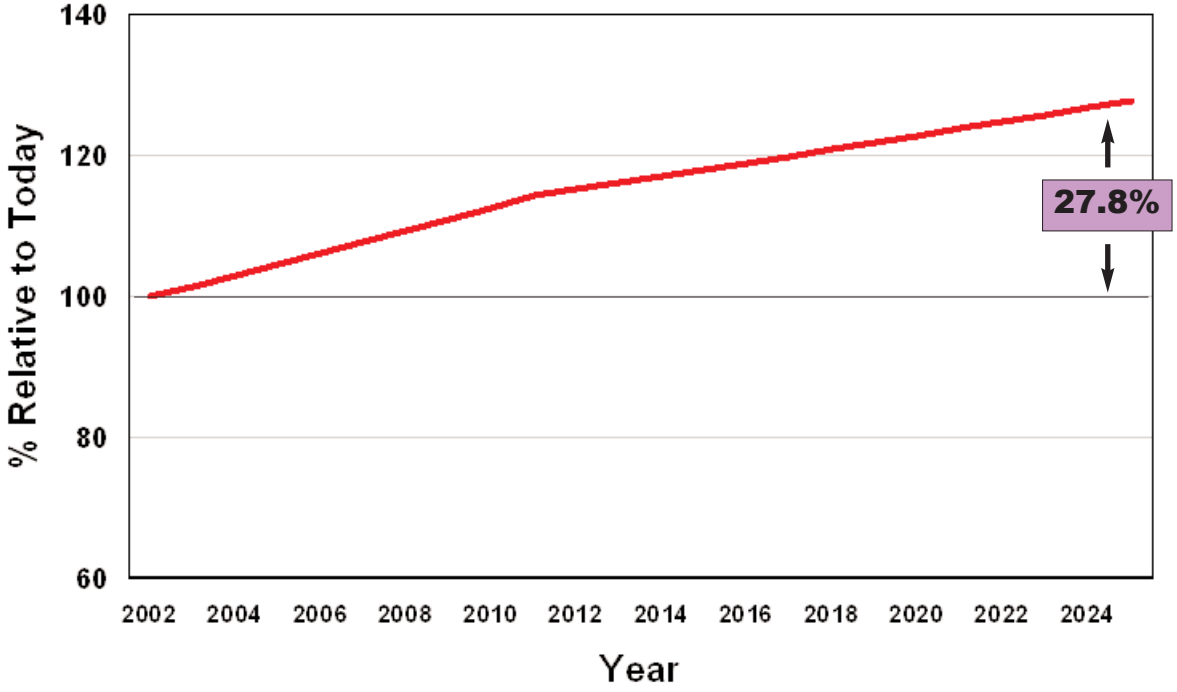
Where are we going?



Rise in Electricity Consumption in the UK during the 1990s (DTI data)

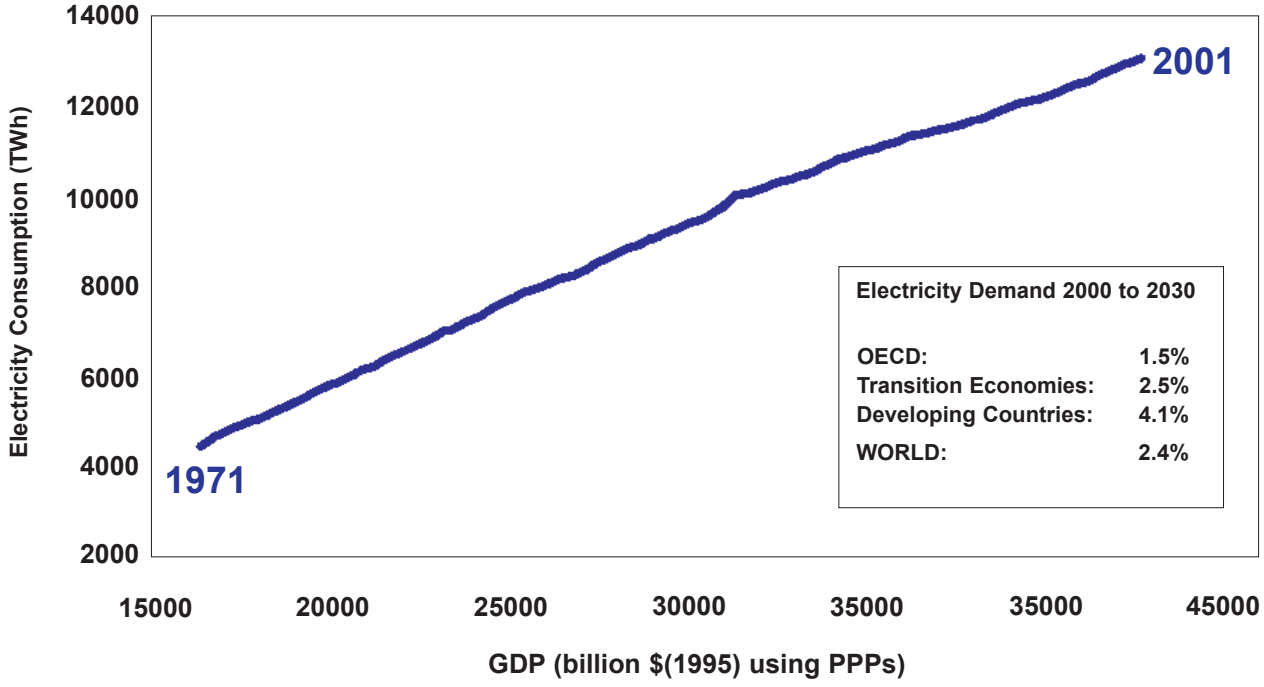
DTI data show that electricity demand rose each year on average by 1.4 per cent from 1990 to 1995 and by 1.6 per cent from 1996 to 2000 – or by 20 and 25 Terawatt hours per year in the two five-year periods respectively.

Rise in electricity demand – 2002-2025



DTI projections suggest that this rise will continue at a similar rate until about 2012/13 and will then slow to about 0.8 to 1 per cent per year until 2025. By 2025 we will need 28 per cent more electricity than we were using in 2002.

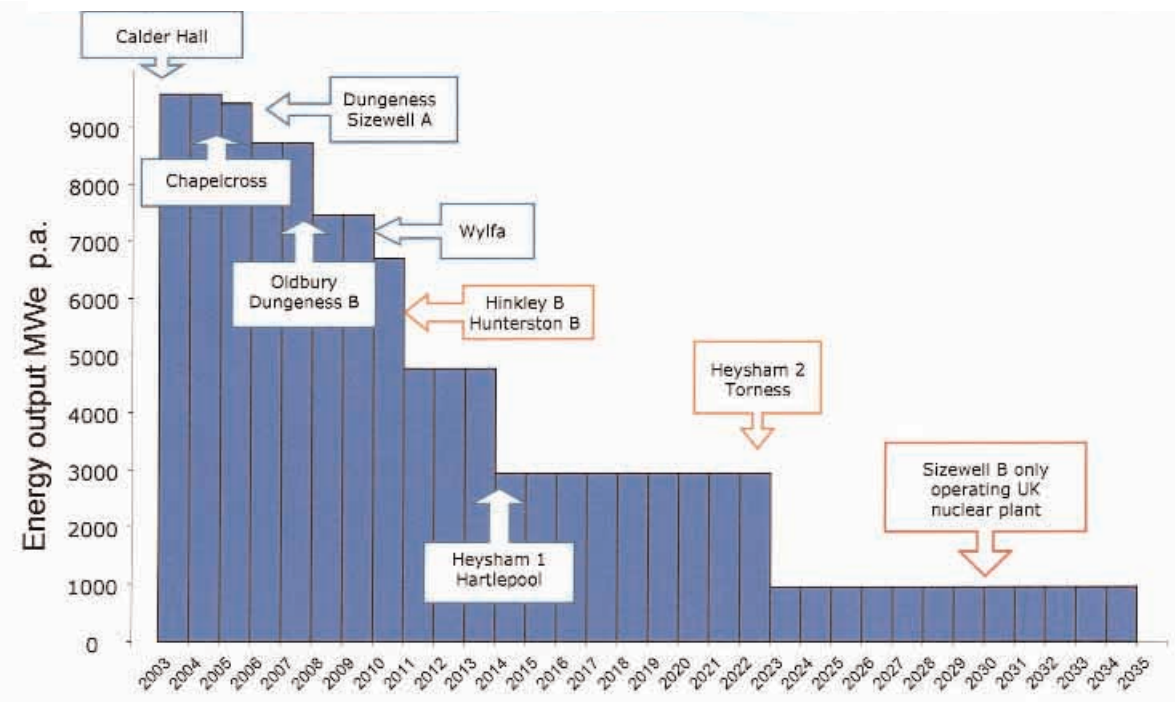
World demand is set to increase rapidly ...



Source – IEA Investment Outlook 2004

The European Commission shows world demand rising even faster at 2.4 per cent per annum from 1971 to 2001.

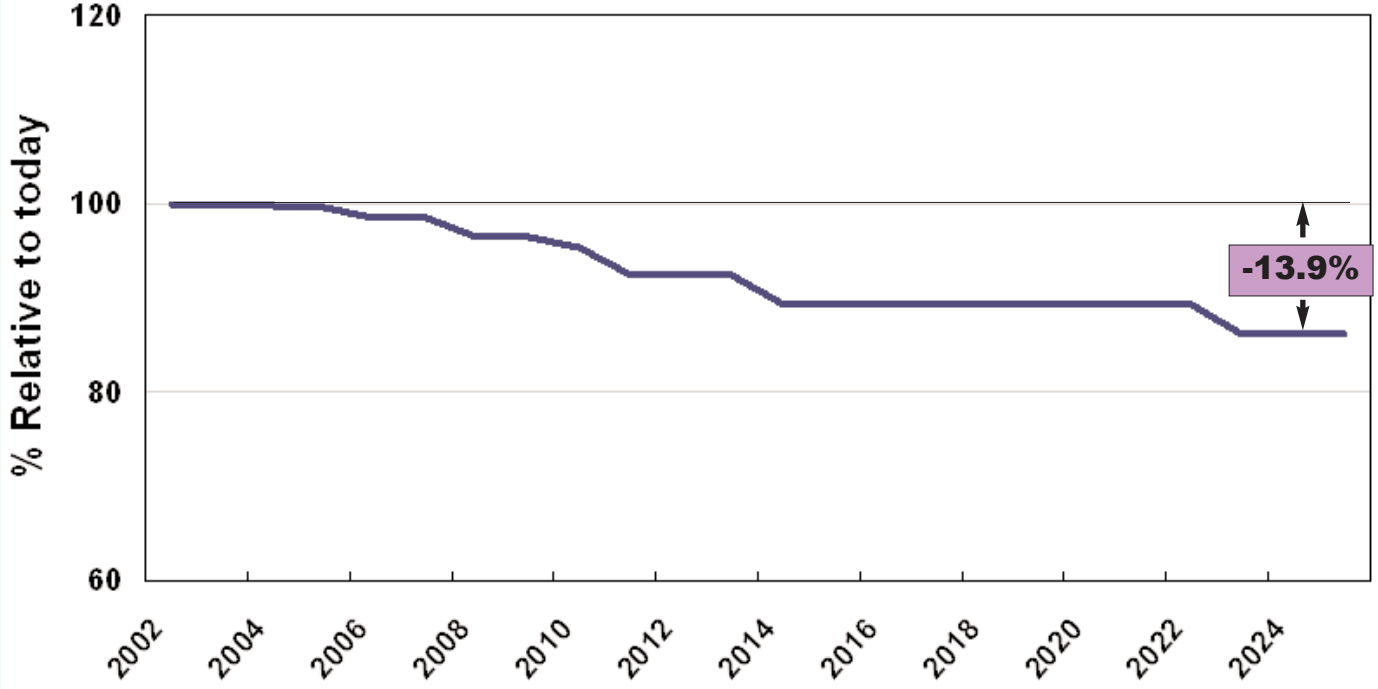
A projected rundown in nuclear Installed Capacity ...



Meanwhile, except for Sizewell B, all the UK's nuclear power stations, currently producing 22 per cent of our electricity with no CO_2 emissions, are scheduled to close by 2023. This shows the anticipated closure timetable.

Data from BNFL, January 2005.

means losing 14% of overall capacity by 2025



Total UK Installed Capacity as of May 2004 is from the DTI's *Digest of UK Energy Statistics* (DUKES).

The Large Combustion Plants Directive

The LCPD integrates pollution control and national emissions ceilings

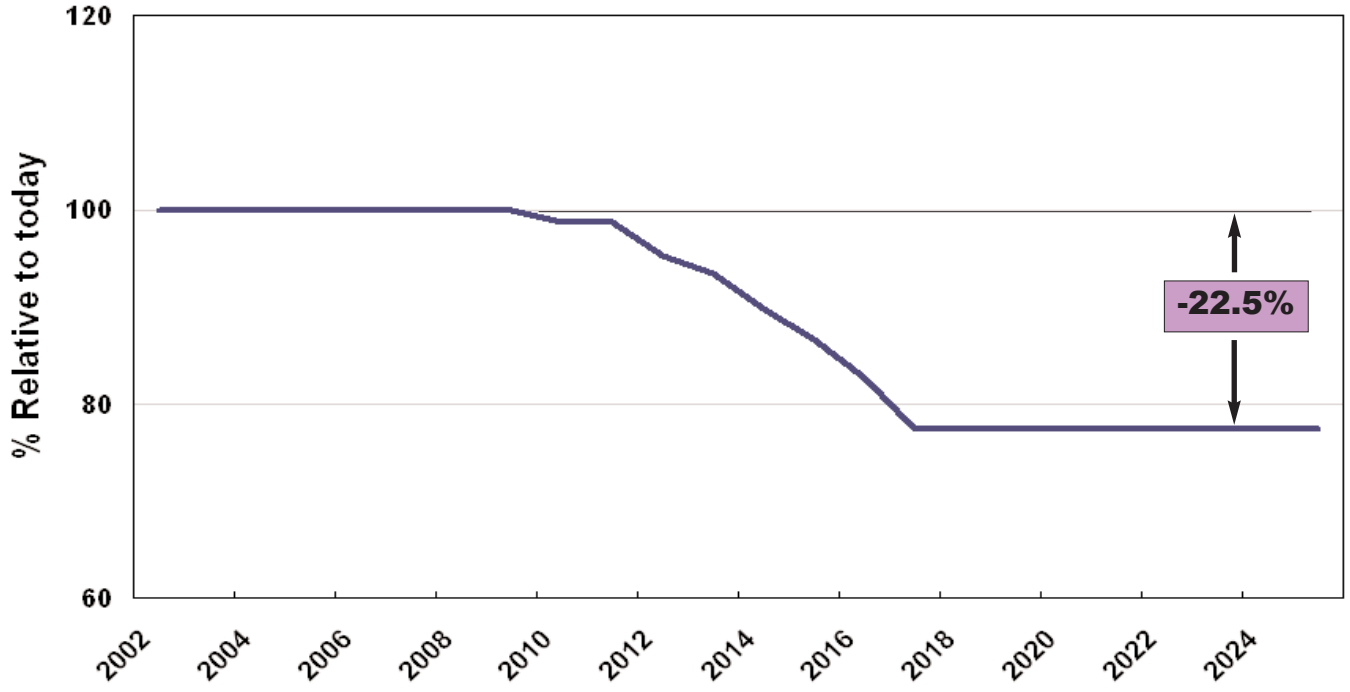
For coal power stations, there are two options:

1. **Opt-in:** – **fit FGD at £2-300 million/plant**
2. **Opt-out:** – **20,000 hours operation from 2008 and closure by 2015**

The EU Carbon trading scheme will also greatly increase costs to coal-fired power stations

Coal will fare no better as it emits Sulphur Dioxide, the cause of acid rain. The EC's LCPD stipulates that if coal plants do not fit Flue Gas Desulphurisation (FGD) equipment by 2008 they are limited to a further 20,000 hours (about two and a half years) generating time. By 2015, all non-FGD plants will have to close. Owners will not spend the necessary £250 to £300 million per plant on ageing power stations and most have opted out.

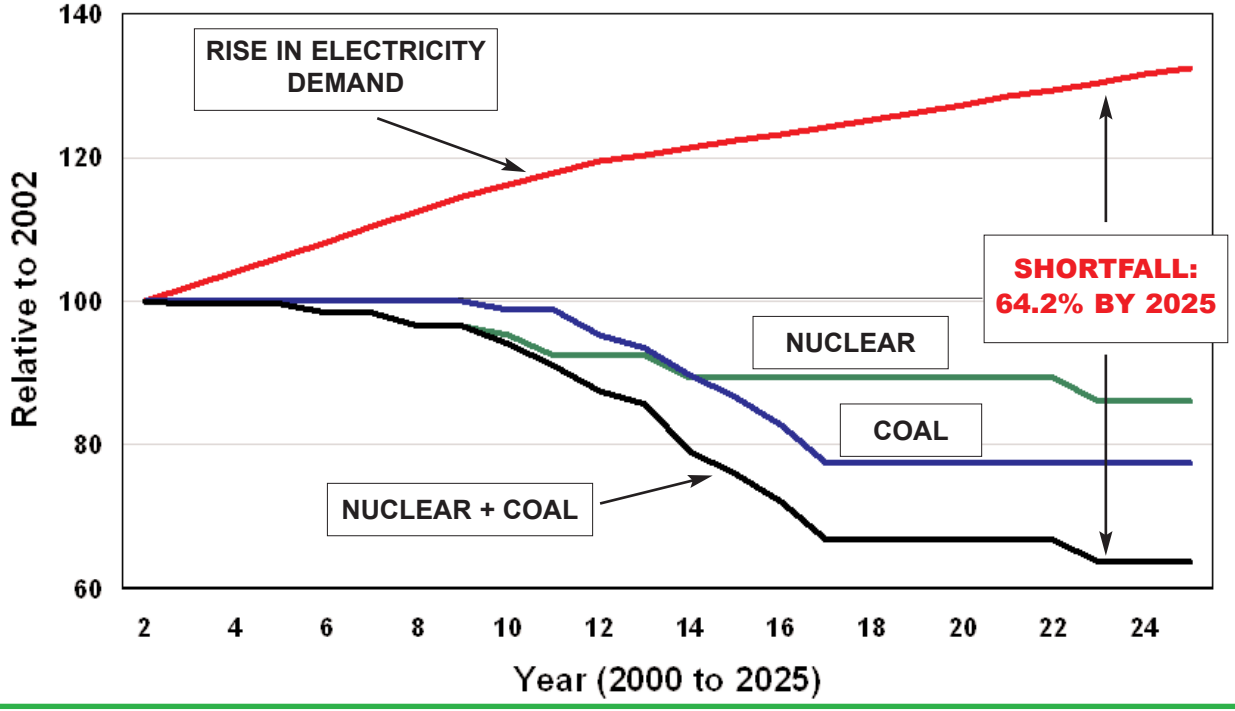
will reduce coal-fired capacity by 2025 and lead to



It means the loss of a further 22 per cent of 2002 generating capacity.

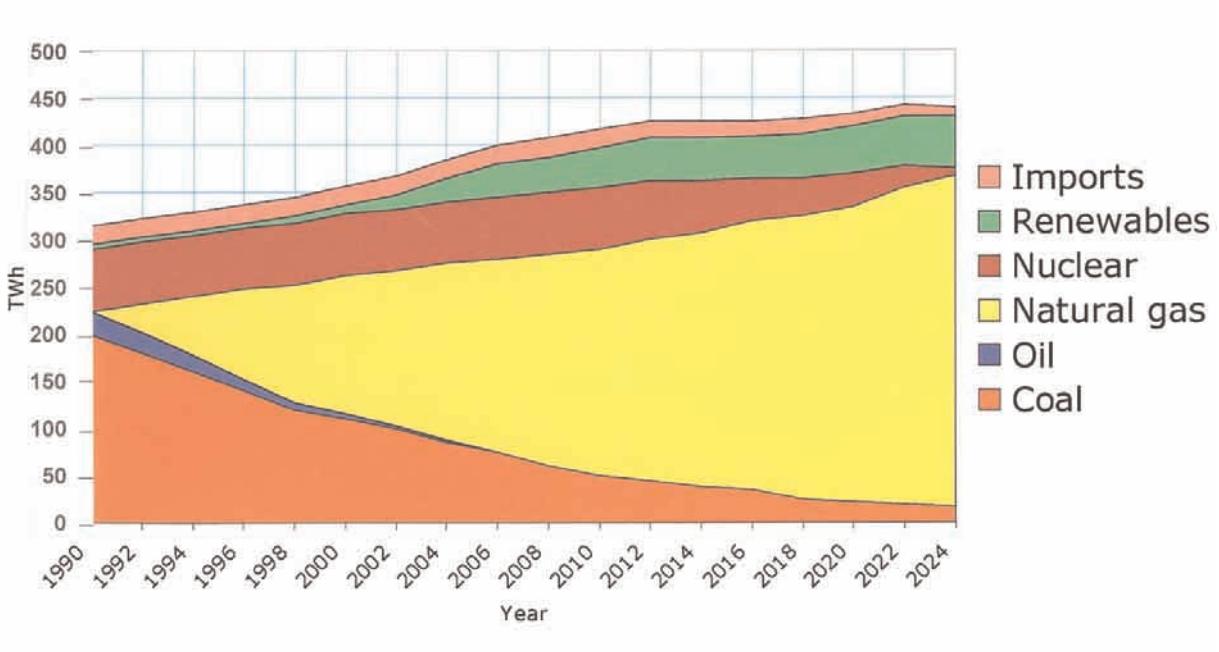
Data for coal-fired plant closures are taken from the final report on the LCPD to the Environmental Agency by Oxford Economic Research Associates.

a 64.2% shortfall in UK capacity by 2025



Add together the growth in demand and the loss of nuclear and coal power stations and we are left with an electricity 'gap' of 65 per cent by 2025.

DTI projections for energy supply



The Government is proposing to plug this gap by importing gas from Russia, the Ukraine, Nigeria and the Middle East, mostly by a trans-continental pipeline. It is making itself a hostage to political, economic, and terrorist fortunes. The UK is at the very end of this supply line! The prime job of any government is security. Do we call this security? Britain's whole future is at risk under this policy.

The DTI predicts growth of 19% by 2020

Source	TWhs in year shown						
	1990	1995	2000	2005	2010	2015	2020
Coal	204	147	106	54	39	30	28
Nuclear	60	81	82	86	66	40	23
Gas	nil	57	133	197	238	280	308
Renewables	4	5	10	21	42	42	44
Imports	14	16	14	12	10	8	8
Totals	282	306	345	370	395	400	411

The DTI predicts that growth from 2000 to 2020 will be 19 per cent.

Can Renewables help?

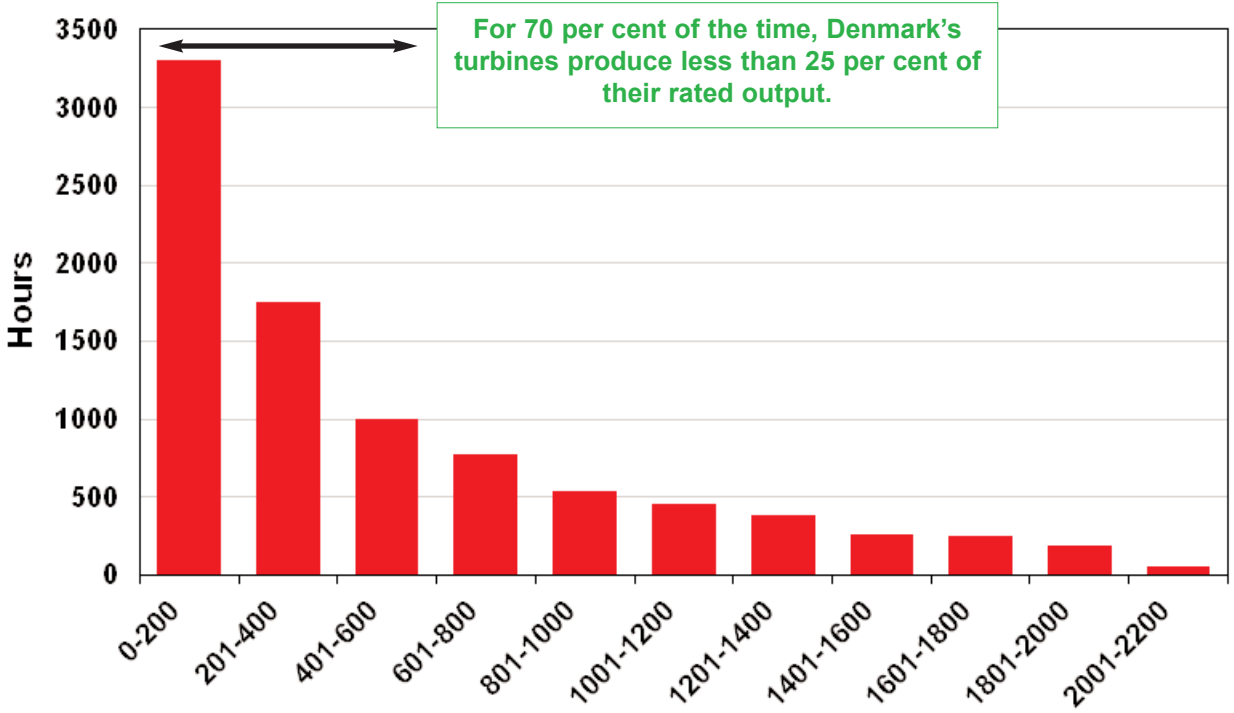
Firm and non-firm fuels for electricity generation

Energy Source	Available	Reliable	Predictable
Conventional *	YES	YES	YES
Biomass/biofuels	YES	YES	YES
Waste Incineration	YES	YES	YES
Landfill Gas	YES	YES	YES
Large Hydro	YES	YES	YES
Small Hydro	YES	FAIRLY	FAIRLY
Tidal	NO	YES	YES
Solar	NO	YES	FAIRLY
Wave	NO	NO	NO
Wind	NO	NO	NO

*Coal, Gas, Nuclear

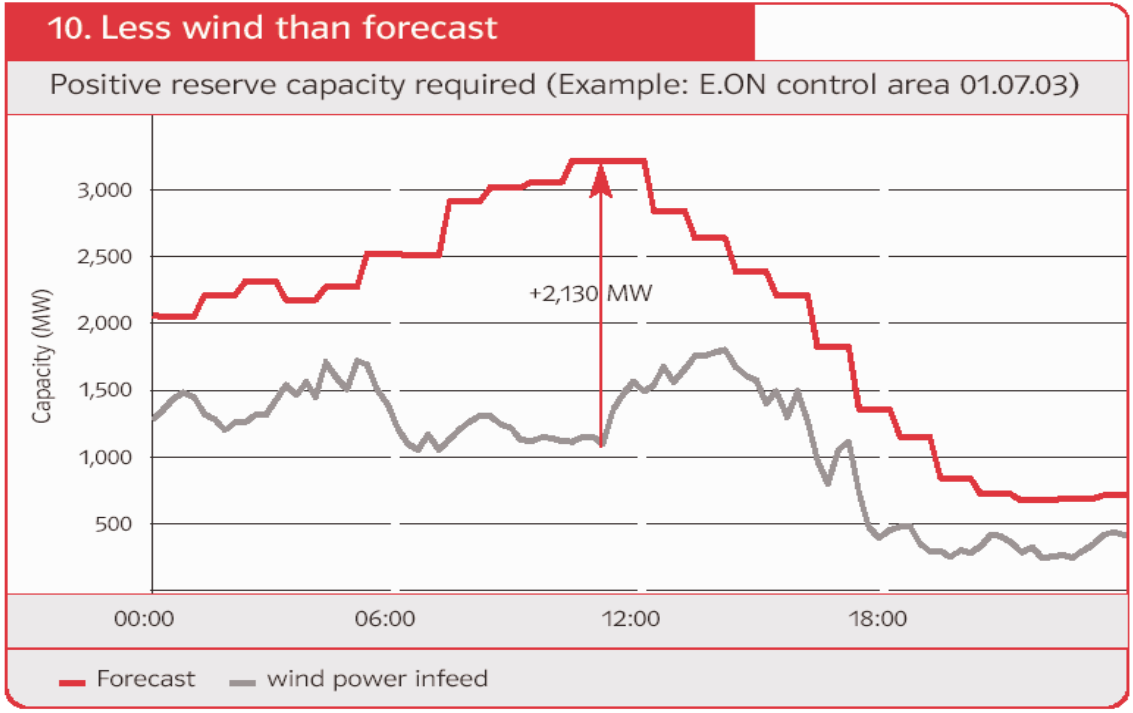
We need to define what we mean by renewables. This table lists the most common in terms of their availability when wanted, their reliability and their predictability. While biomass, biofuels, waste combustion and large hydro score well on all these points, wind and wave power fail on all three.

The turbines turn ... but generate little power



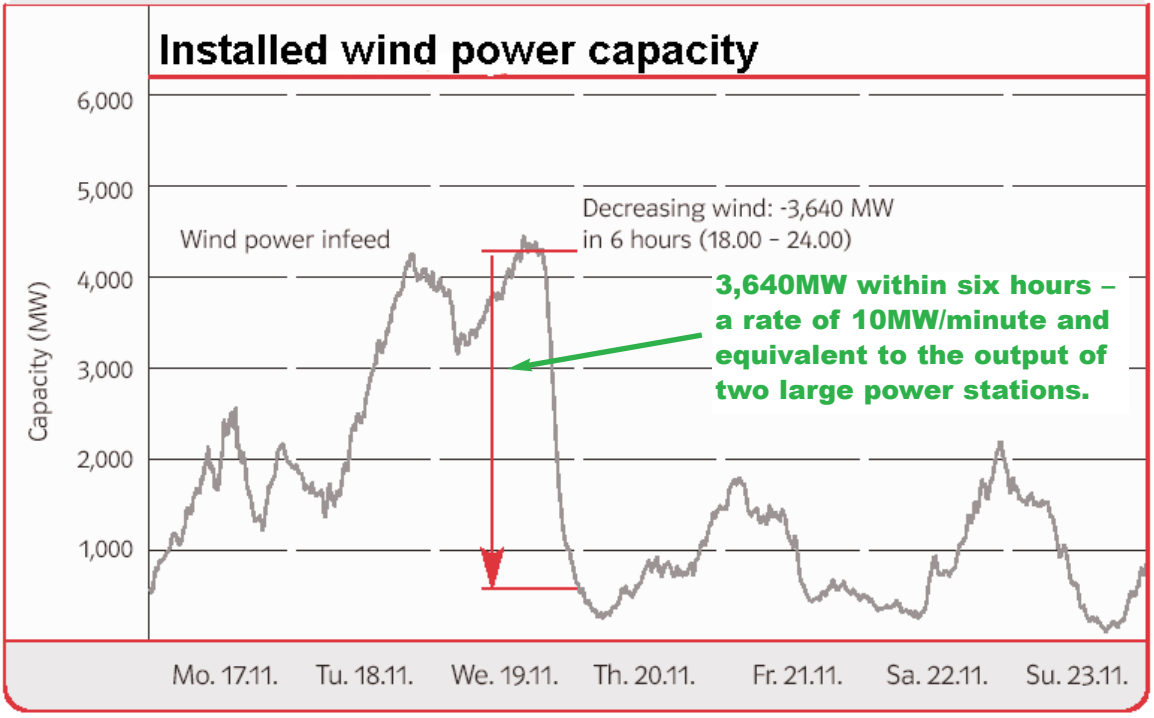
For instance, for 70 per cent of the time the whole Danish wind carpet of 2,374 MW produces less than 25 per cent of its potential output and often does this at times when it is not required.

Wind power is only as reliable as the weather forecast



Even with the best possible weather forecasting techniques for wind, there can be an enormous difference between what is predicted and what you get. German grid operator E.ON Netz showed that the error could be as much as two-thirds of a wind carpet with an installed capacity of 3000 MW – the equivalent of two nuclear power stations.

The effect of sudden input falls ...

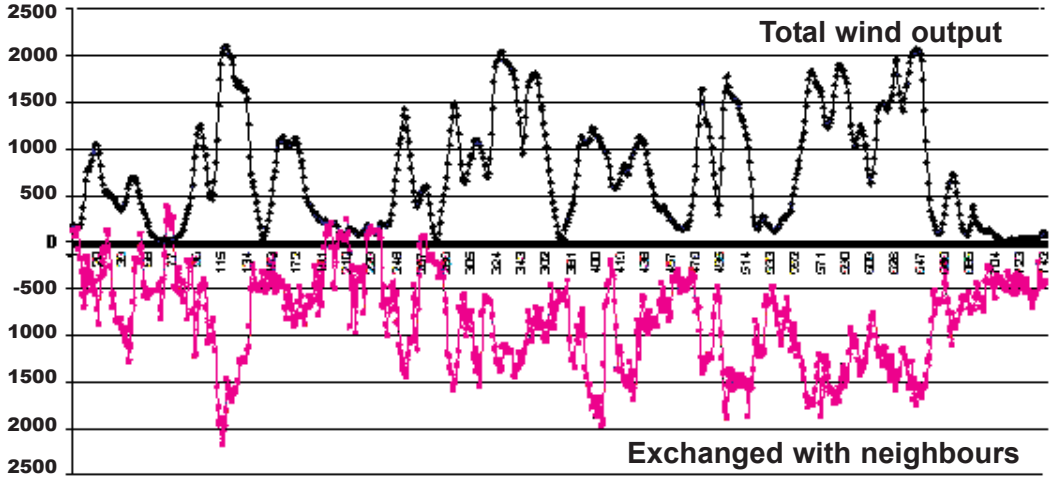


The sudden dying of the wind can result in a fall-off of power as high as 10 MW per minute – equivalent to losing double the typical output of Longannet coal-fired power station in five to six hours.

means no significant *firm* generation from wind ...

- West Denmark's 2,350MW of wind capacity could generate 67 per cent of its power demand
- During 2003 there were 54 days when it produced less than one per cent of demand
- 80 per cent of West Denmark's wind energy is sold overseas ***at a loss***, with a net transfer of wealth of £100,000,000 a year from a population of 5.5 million

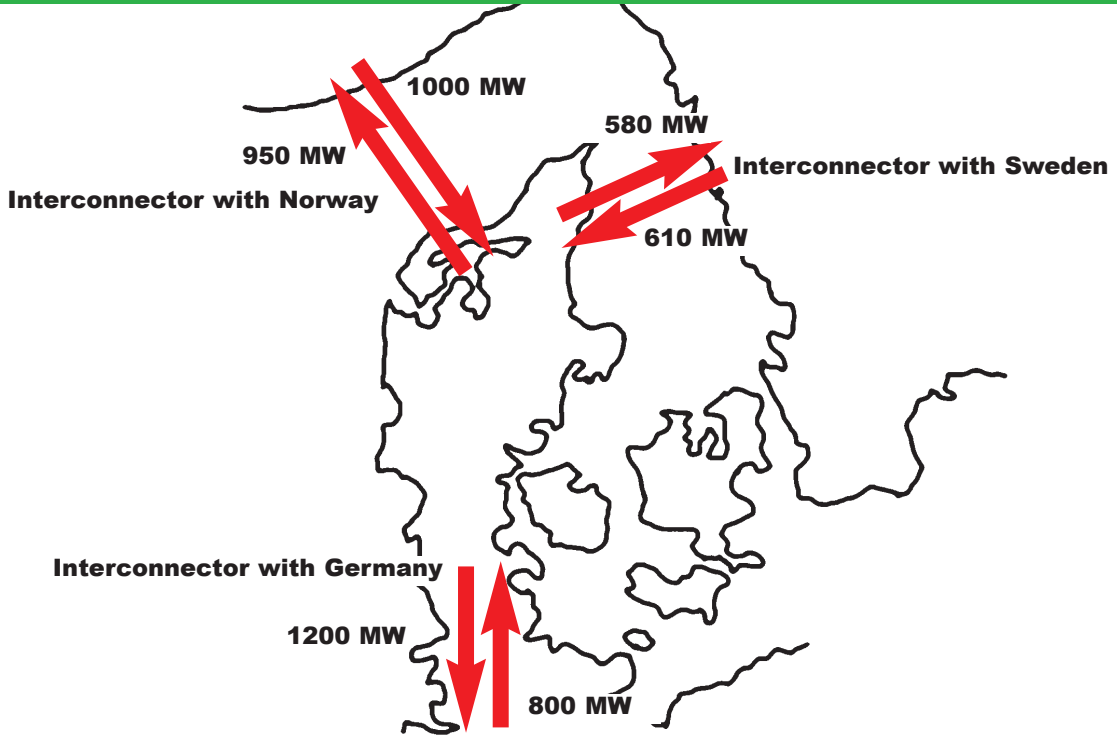
... with most wind product exported – at a loss.



West Denmark's Wind Generation and Electricity Trading – December 2003

In Denmark, so much of the wind-generated electricity is produced at a time when it is not needed that 80 per cent has to be exported through interconnectors to Norway, Sweden or Germany. CO_2-free wind power simply replaces CO_2-free hydro and nuclear power. The UK does not have the requisite infrastructure.

This strategy will not be possible in the UK.



It is only because of these interconnectors that the Danish wind industry is able to reach a penetration of 20 per cent of their national needs. The UK has just two interconnectors (2,000 MW) and has no way of stabilising a high level of wind-generated energy though at present it has enough coal and gas capacity to cope.

Wind turbines needed to 'replace' nuclear power

Power Station	Year of closure	Installed Capacity (MW)	No of 2.5MW turbines needed to replace lost capacity
Calder Hall	2003	194	78
Chapelcross	2005	196	78
Dungeness A	2006	450	180
Sizewell A	2006	420	168
Dungeness B	2007	1,110	444
Oldbury	2007	434	174
Wylfa	2010	980	392
Hinkley Point B	2011	1,220	488
Hunterston B	2011	1,190	476
Hartlepool	2014	1,210	484
Heysham 1	2014	1,150	460
Heysham 2	2022	1,250	500
Torness	2022	1,250	500
Sizewell B	2035	1,188	475
Total		12,242	4,897

- **At a nuclear-power Load Factor of 85%, the electricity produced would be 91,156 GWh (91.1 TWh)**
- **At a wind-power Load Factor of 30%, the electricity produced would be 31,172 GWh (31.2 TWh)**
- **To replace the lost nuclear capacity would need 16,323 turbines**

Wind turbines needed to 'replace' coal stations

Power Station	Year of closure	Installed Capacity (MW)	No of 2.5MW turbines needed to replace lost capacity
Kilroot & Fifoots, Point 2	2010	913	365
Fiddlers Ferry & Ironbridge	2012	2,931	1,172
Lynemouth & Rugeley	2013	1,426	570
Kingsnorth & Eggborough (50%)	2014	2,900	1,160
Aberthaw B & Tilbury	2015	2,475	990
Didcot A & Cockenzie	2016	1,007	403
Longannet & Ferrybridge	2017	4,259	1,704
Total		15,911	6,364

- **At a Load Factor for coal of 60 per cent, annual production would be 83,628 GWh or 83.6 TWh**
- **At a Load Factor for wind of 30 per cent, annual production would be 41,814 GWh or 41.8 GWh.**
- **To replace the lost coal-generated electricity would require 12,726 turbines**

… and over 12,000 to replace the closed coal fired power stations.

The conclusions are that wind power

- is only randomly available and is unpredictable and unreliable
- cannot replace firm sources of power
- cannot fill the power gap
- but can destroy our natural landscape heritage

So what about other renewables?

Wind power simply cannot meet the requirements, cannot significantly close the 'energy gap' and cannot make a major impact on CO_2 release into the atmosphere.

Electricity from Renewables – what is expected?

The Energy White Paper (EWP) ... recalls a government aim ... for renewables to supply ten per cent of UK electricity by 2010 ...

Demand in 2010 is projected to be 395TWh – ten per cent would be 39.5TWh

The EWP refers to Wind, Wave, Tidal, Solar, Geothermal and Biomass

Can other renewables close the gap? Consider the government's targets for 2010, stated as 10 per cent from renewables by 2010 (39.5 TWh). The Energy White Paper refers specifically to wind, wave, tidal, solar, geothermal and biomass. Is this realistic?

2010 Targets – The Tyndall Centre Study

Technology	Load Factor	Electricity (GWh)	Electricity (%)	Capacity (GW)
Energy crops	0.80	1,900	5	271
Offshore wind	0.34	4,950	13	1,662
Onshore wind	0.30	8,000	21	3,044
Small hydro	0.35	400	1	130
Waste incineration	0.87	6,100	16	800
Other Biomass	0.80	1,900	5	271
Landfill gas	0.85	6,100	16	819
Other	0.23	1,900	3	943
Existing	0.44	7,600	20	1,972
Total		38,850	100	9,912

Studies from the Tyndall Centre in Manchester suggest that it could be met by a mix of renewables, including 8,000GWh of onshore wind (from an installed capacity of 3,044 MW at 30 per cent Capacity Factor – 1,522 2MW turbines). This may not seem too bad – but the targets escalate beyond this date to 20 per cent by 2020.

Estimates of potential supply from other renewables

Source	Currently		Reference	Projection (TWh/yr)
	IC (MW)	TWh		
Offshore wave	0	0	DTI	50
Onshore wave	0	0	DTI	2.1
Tidal energy	0	0	DTI	36
Tidal stream	0	0	G Aggidis	50
Solar	4	0	Ove Arup & NUSRC	175
Small hydro	194	1	G Aggidis	10
Total	198.00	0.61		323.1

Various other sources, including the DTI, suggest that there are huge potential resources – including tidal and solar power – that could be realistically tapped given adequate investment and incentives. These figures can only be regarded as broadly indicative at this time as the technology for realising them does not exist.

Energy Efficiency

An EU report published in April 2000 entitled

Action plan to Improve Energy Efficiency in the European Community

says

'An estimated economic potential for energy efficiency improvement of more than 18 per cent of present energy consumption still exists in the EU today ... the potential is equivalent to roughly the total final energy demand of Austria, Belgium, Denmark, Finland, Greece and the Netherlands combined'.

Even if these targets are unrealisable at present or are over-optimistic, much more could be done to reduce electricity usage and improve efficiency. The government is talking of four million new houses over the next 20 years – none of which will be insulated to even a quarter the level of several Scandinavian countries.

Overall Conclusions

- Deregulation has caused many problems in energy generation
- Britain faces a critical energy gap
- The 'Dash for Gas' is fraught with security, economic and political problems
- Wind can only be a marginal source of electricity
- 'Firm' renewables coupled with efficiency measures may begin to address the long-term problems
- An urgent refocussing of government policy is needed

Overall conclusions – a serious rethink of the entire government strategy towards electricity generation is needed to ensure security, stability and a cost acceptability of supply. Current policy is a betrayal of the British people and must be resisted.