The Future of the World's Energy

Prof Norman Lipman

Past Head of SERC's Energy Research Centre
Secretary of EWEA for it's first 10years
Past Vice-President of EWEA
Past Chairman of BWEA

Renewable Energy SERC Activity
Game Plan – form a Community

Launched RAL's Energy Research Support Unit (ERSU)

- Provided research resources at RAL and brought the university community together (Like the HEP model)
- Launched some 35 years ago

Godfrey’s interest and support was essential:

- He recognized the relevance and importance of this initiative
- He continued to have a great interest throughout his life

Wind energy now a multi billion pound global industry

The RAL centre made a significant input to European activity

Renewable Energy Community

- Some 100 academics involved from Universities & RAL at research site
- Close ties to many UK companies and European laboratories
- CEGB, Taylor Woodrow, McAlpines, John Laing, British Aerospace, Scottish Power, Scottish Hydro, Dale Electric and many others!
- Launch of British Wind Energy Assoc and European Wind En. Assoc.

  Members of RAL community played leading roles in these
- Many contacts with U.K. Govt. including Ministries & Overseas Govts.

  RAL representing UK at international conferences
- Strong contacts developed with EU energy directorates. (DG12 DG17)

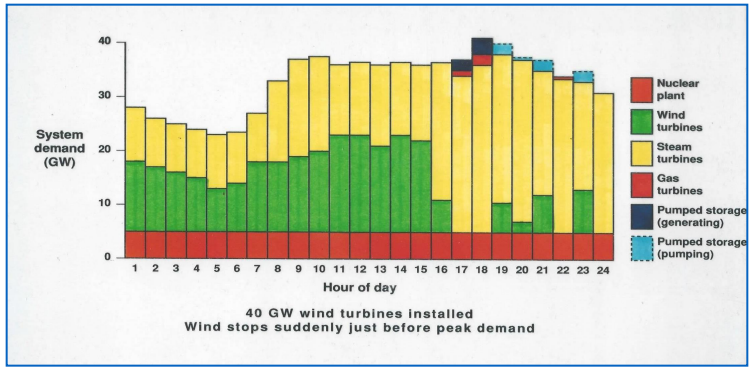
  Had quarterly meetings with these via EWEA Council

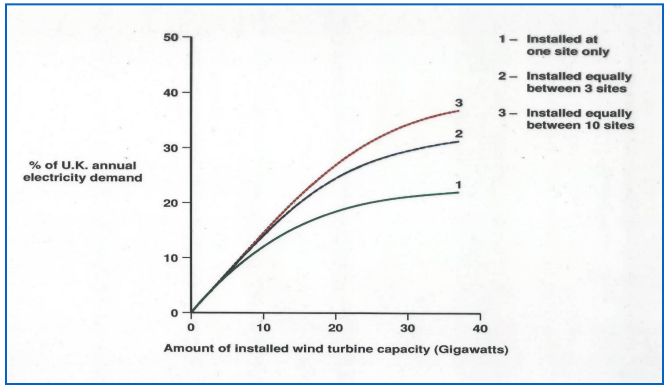
Research Activities of RAL/University community

- Renewable to electricity Grid - logistics – computer models
- Wind Meteorology – prediction of future wind power
- Material science of wind turbines – aero elastics
- Electrical engineering of wind turbines and grid connection
- An economy based on Hydrogen. Study for EU
- Energy storage strategies. Flywheels, etc
- Solar energy integration strategies
- Renewable energy strategies for small island communities
- Heat engine innovation – the Stirling Engine

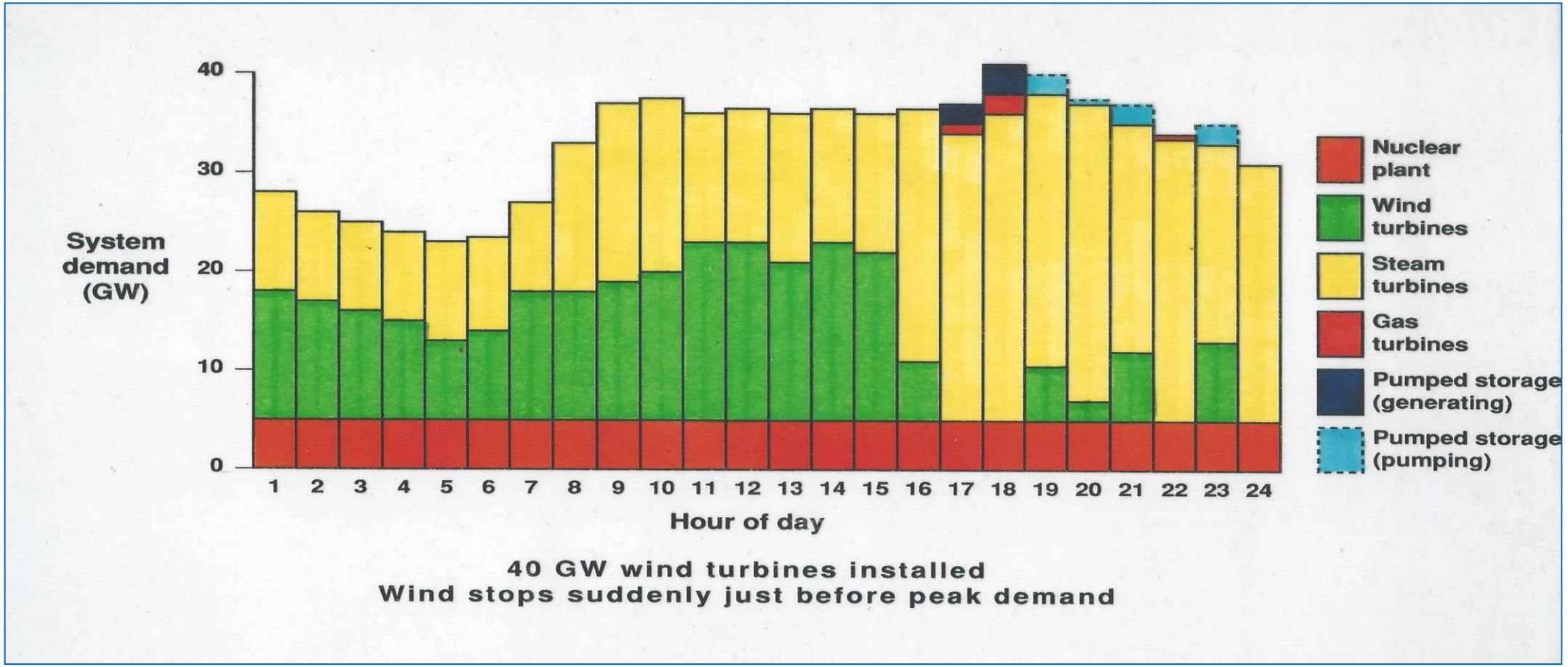
Question – how to integrate power sources

- Can all the variable powers sources be integrated into the grid
- This was a key question when we launched our research 35 years ago!
- A computer model study taking some 15 man-years of effort showed that wind might be able to provide some 30 – 40% of the annual average UK supply
- Similar studies have since been carried out in many countries
- Danish wind power sometimes reaches 90% of their load



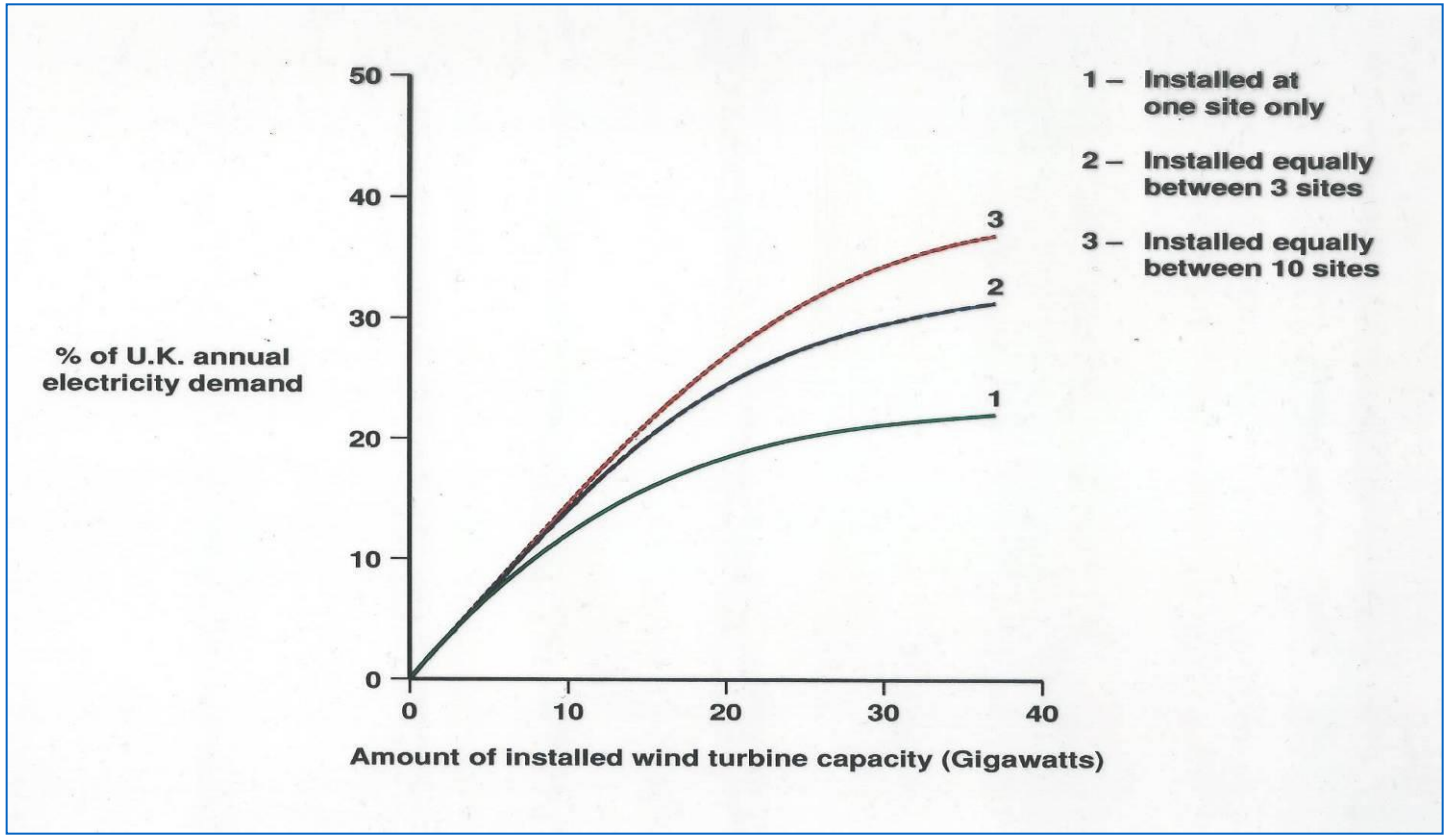


Integration of wind power into the grid



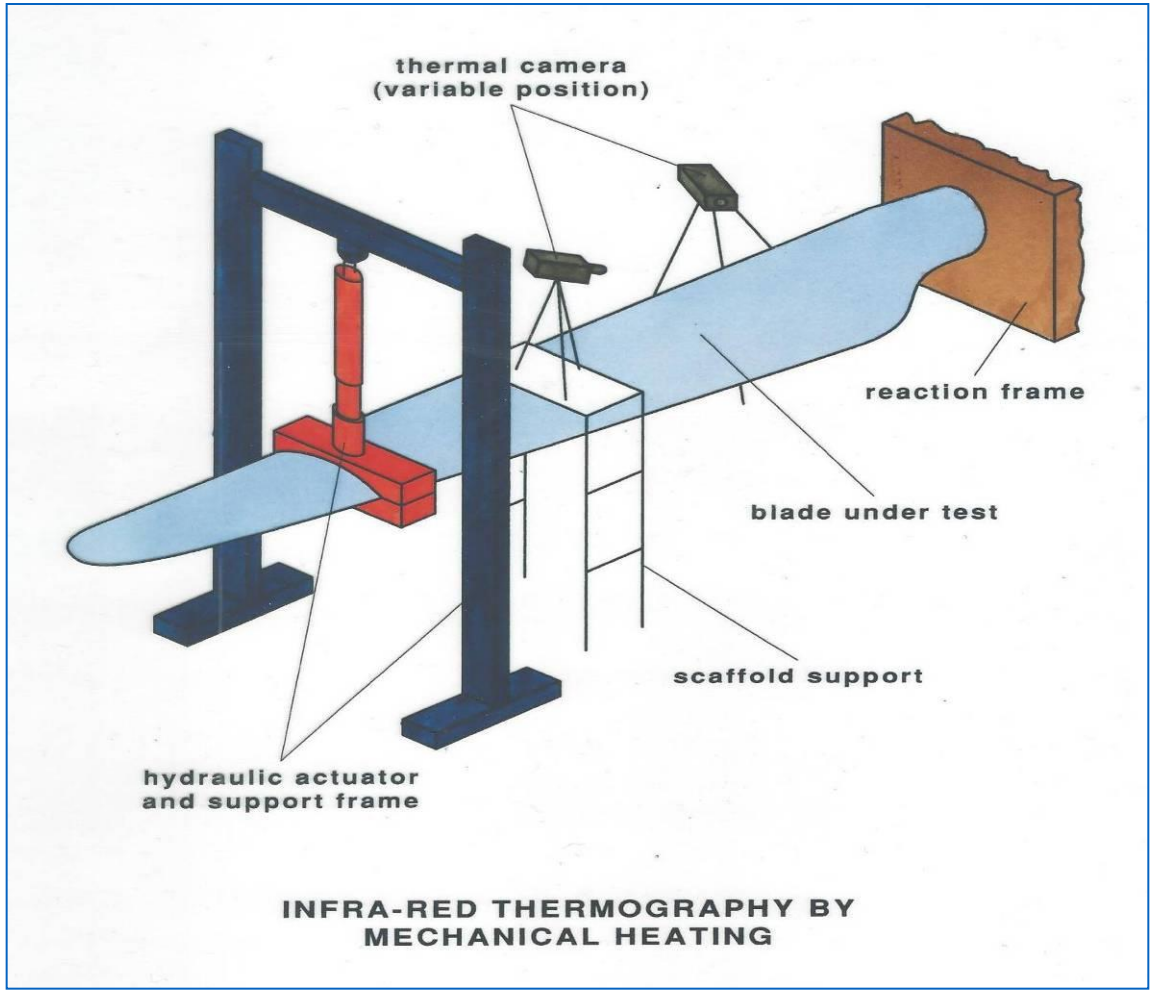
As the wind drops, other forms of power brought in to meet demand
Note pumped hydro and gas turbines provide very rapid response

Wind energy contribution to UK annual requirement



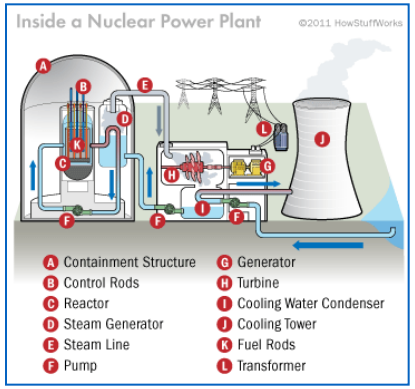
See diminishing returns as overall wind turbine installation increased: yet up to 30-40% of annual demand seems possible

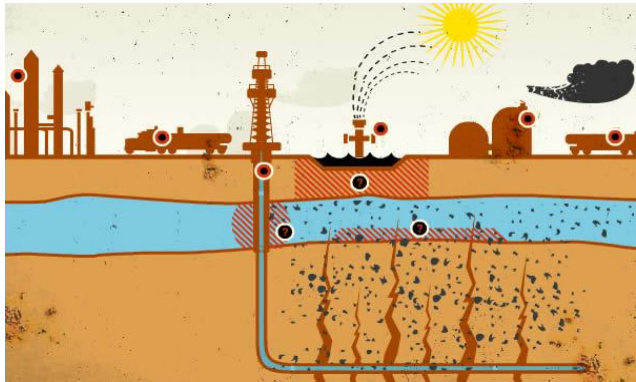
Studies of blade materials, blade fatigue, aero elastic behaviour & aerodynamics at the various universities in our research community



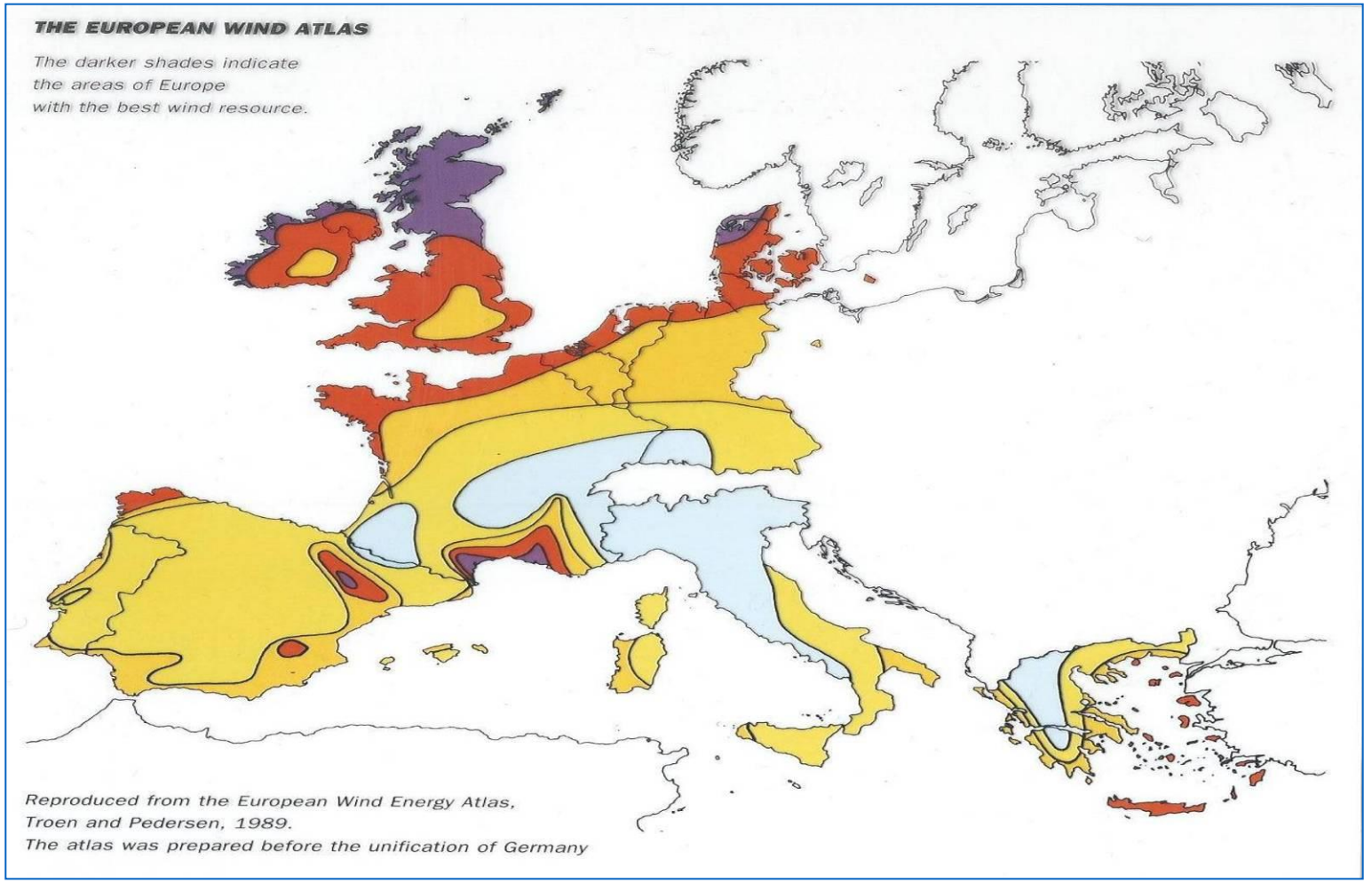
Energy alternatives: renewables, nuclear etc

- WIND ENERGY – TENS OF BILLIONS ALREADY INVESTED
- PHOTOVOLTAICS – MUCH ACTIVITY BUT STILL EXPENSIVE
- WAVE ENERGY – MUCH RESEARCH – BUT TOO EXPENSIVE
- TIDAL ENERGY – HIGH UP-FRONT COST - UK SCHEME SHELVED
- HYDRO POWER – A GOOD OPTION WHERE AVAILABLE
- BIOMASS – SMALL SCHEMES SO FAR – PROMISING
- NUCLEAR – VERY IMPORTANT – REQUIRES SUBSIDY – MANY PROBLEMS – UNPOPULAR IN SOME COUNTRIES
- FRACKING – GREAT ECONOMIC PROMISE - HUGE BOOST TO USA – HOPEFUL FOR UK – SOME ENVIRONMENTAL WORRIES – GREENHOUSE EFFECT HALF OF COAL





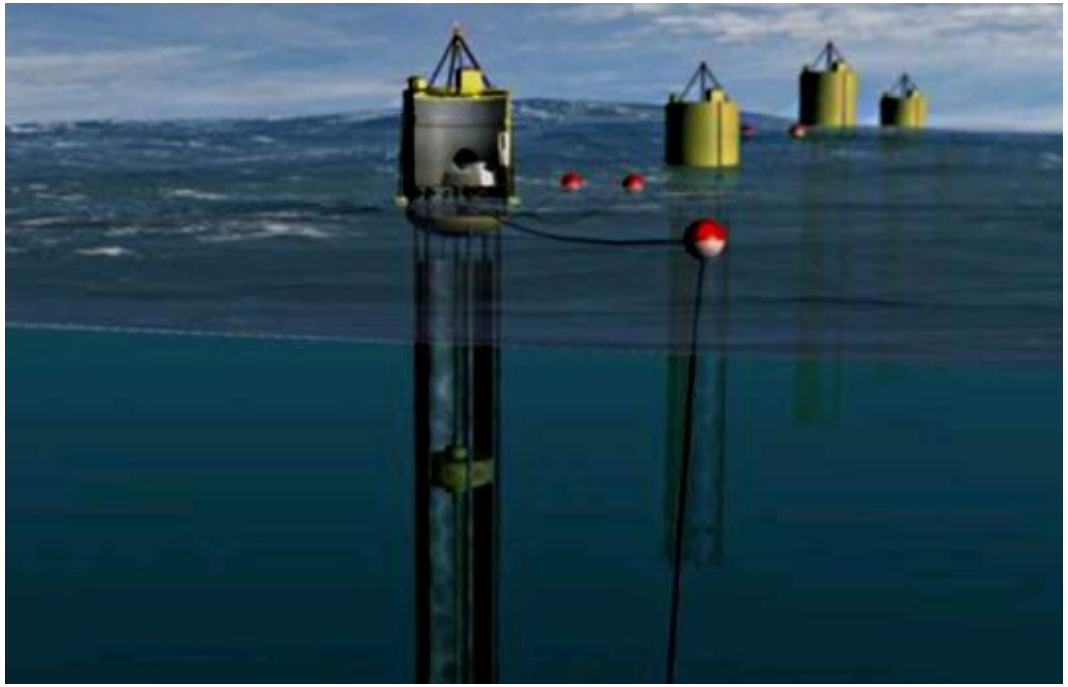
European wind power potential

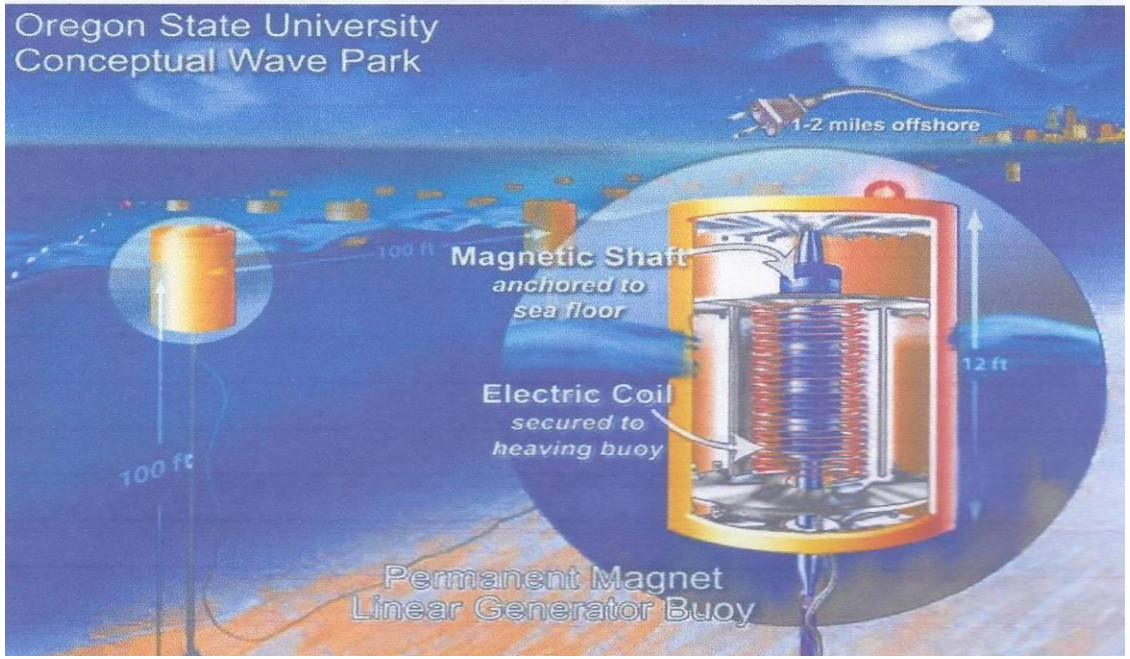


Darker colours denote areas of high average wind speed

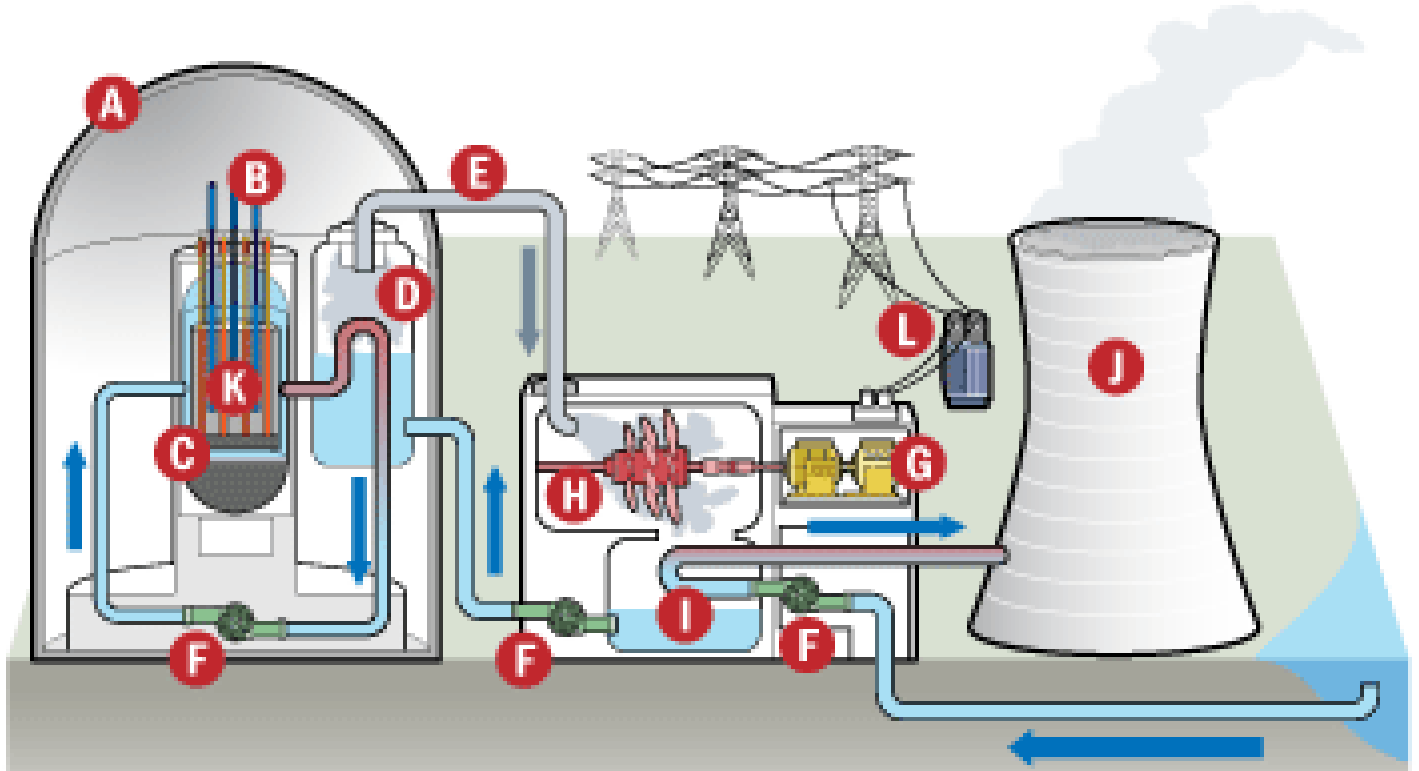
Note high winds for UK, northern Europe and parts of Med


F.F.WIND

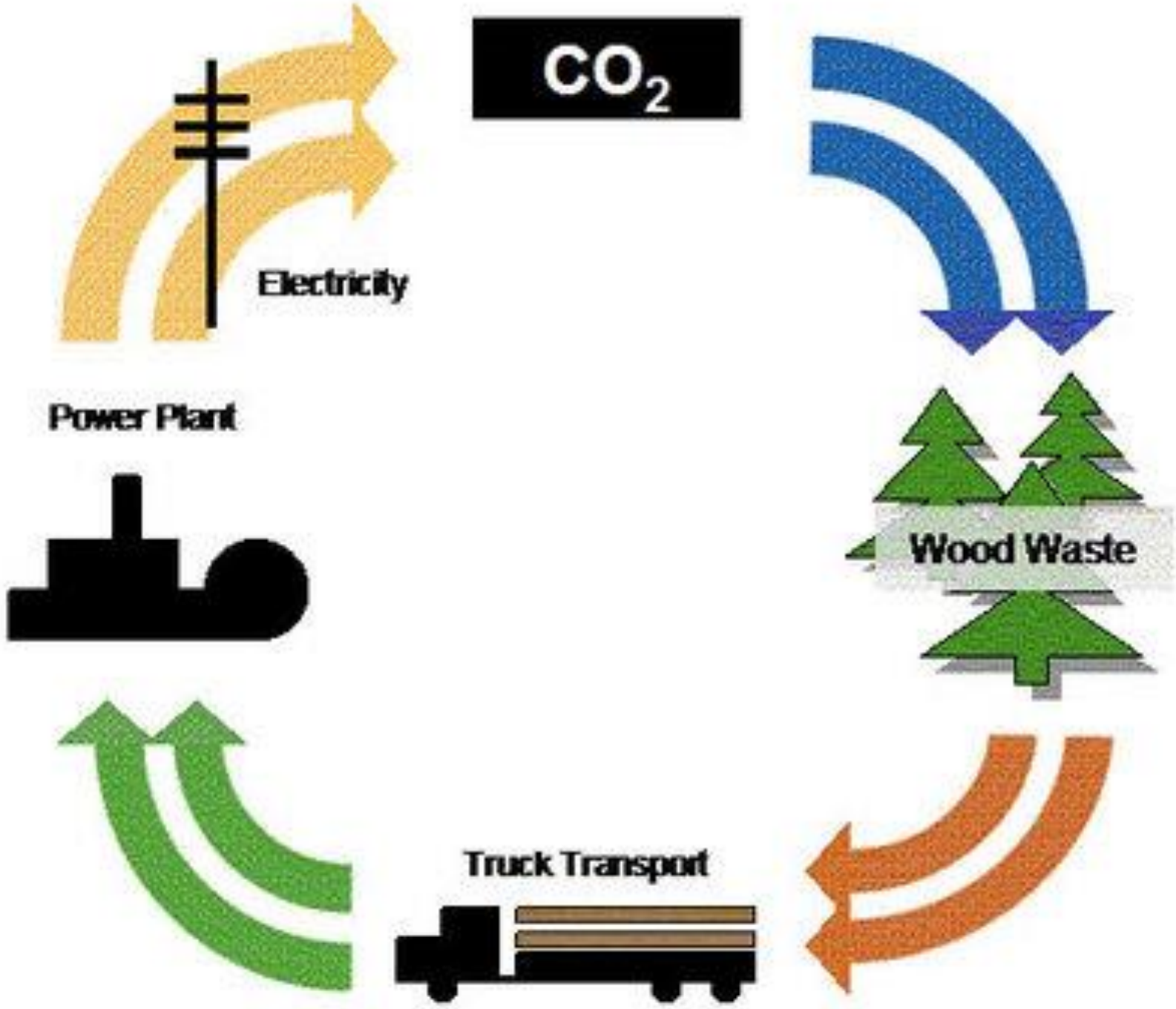


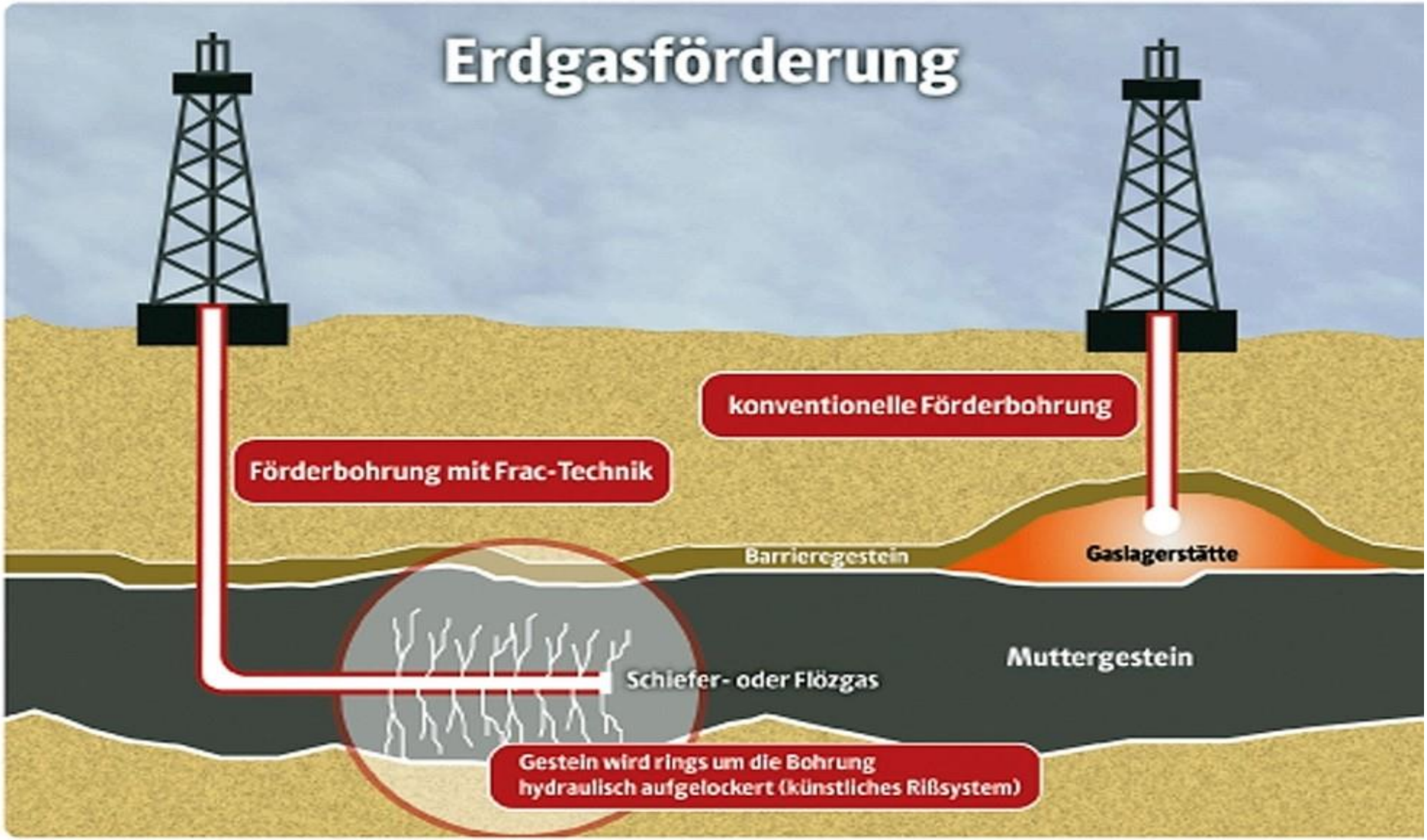

Oregon State University
Conceptual Wave Park
1-2 miles offshore
100 ft
Magnetic Shaft
anchored to
sea floor
12 ft
Electric Coil
secured to
heaving buoy
100 ft
Permanent Magnet
Linear Generator Buoy

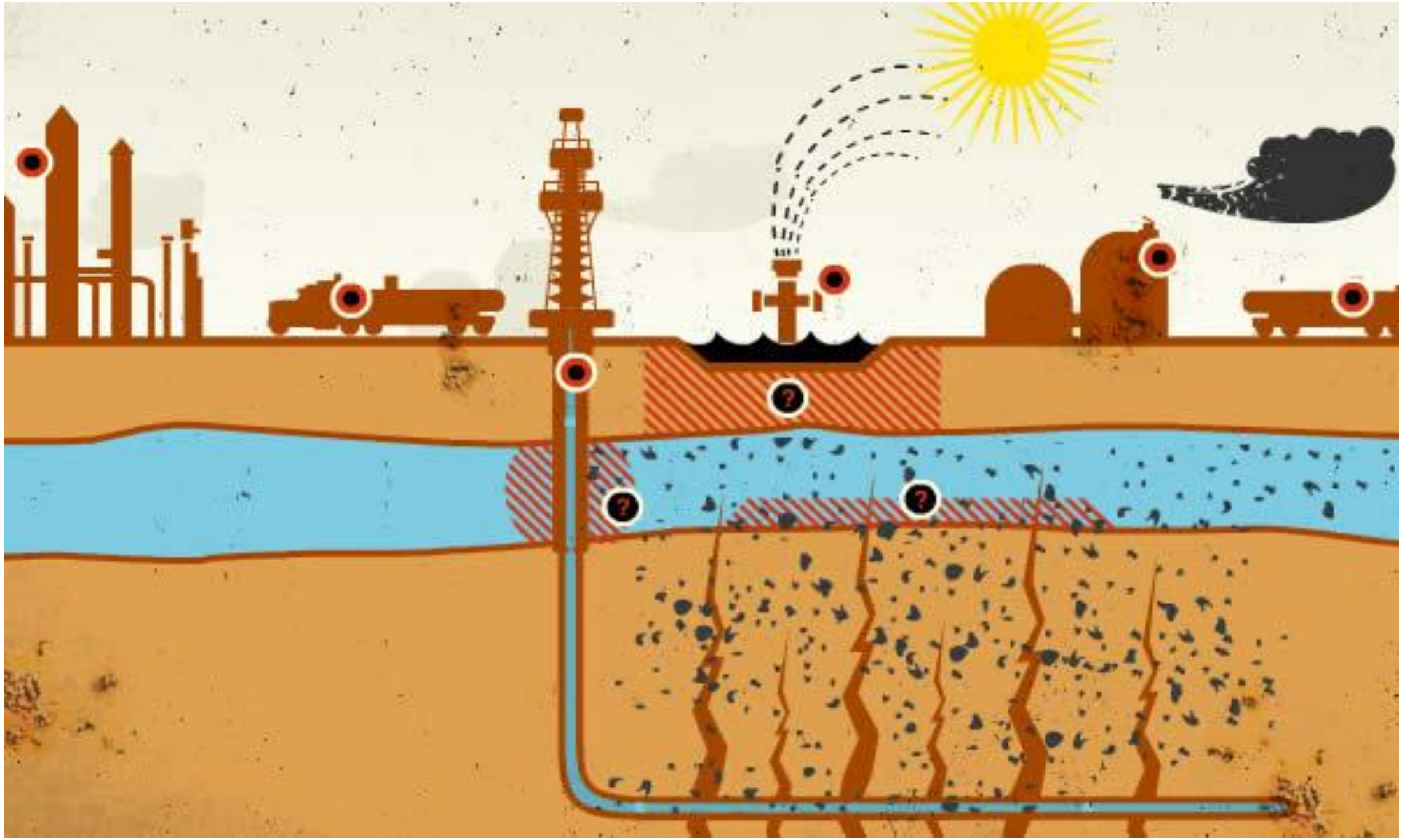
Inside a Nuclear Power Plant



- A Containment Structure
- B Control Rods
- C Reactor
- D Steam Generator
- E Steam Line
- F Pump
- G Generator
- H Turbine
- I Cooling Water Condenser
- J Cooling Tower
- K Fuel Rods
- L Transformer


CO_2
Electricity
Power Plant
Wood Waste
Truck Transport


Erdgasförderung
konventionelle Förderbohrung
Förderbohrung mit Frac-Technik
Barrieregestein
Gaslagerstätte
Muttergestein
Schiefer- oder Flözgas
Gestein wird rings um die Bohrung
hydraulisch aufgelockert (künstliches Rißsystem)



COST COMPARISONS:-

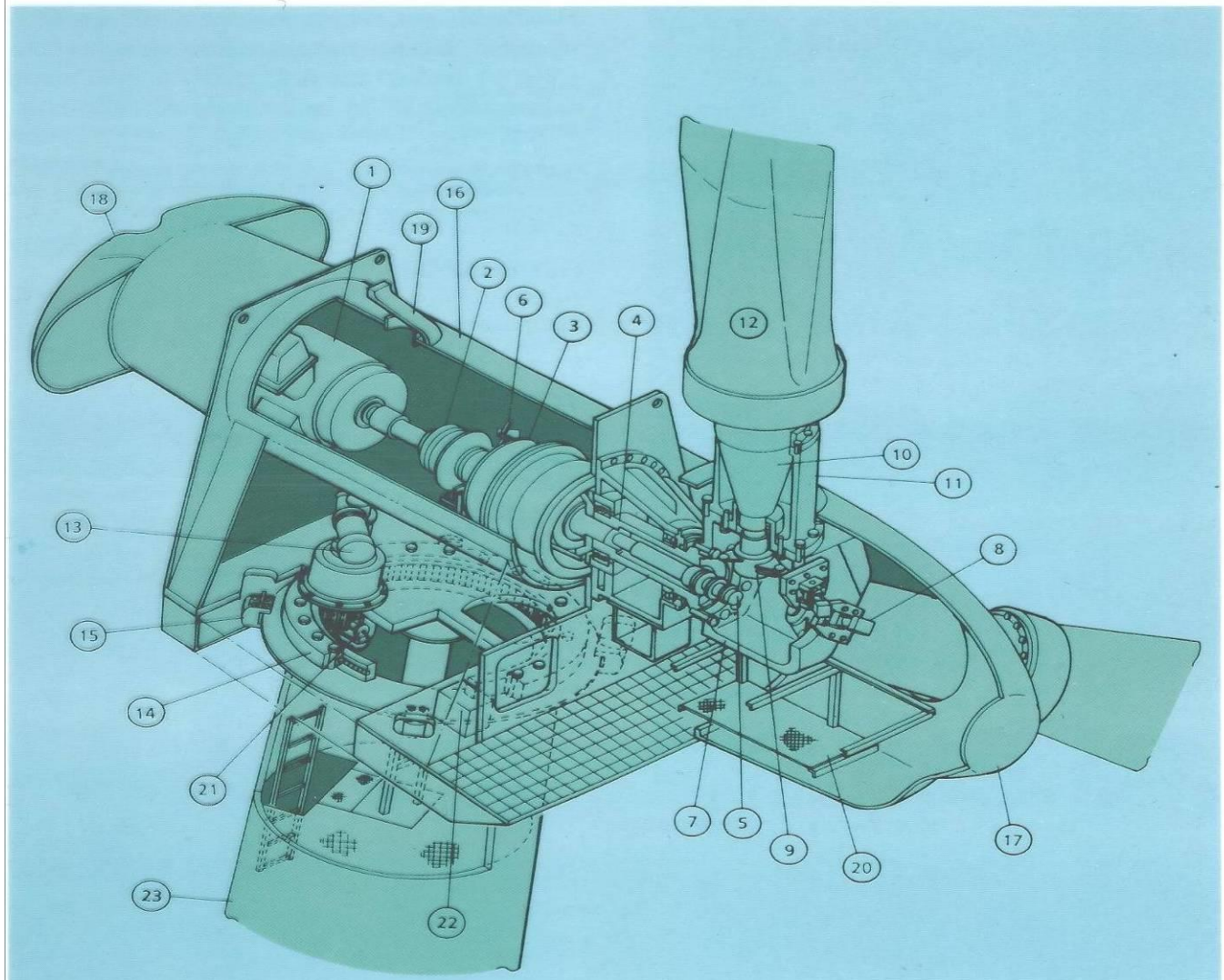
(Interest rates of 10% in all cases)

COAL (OLD STATIONS)	**2-2.5p +**
COAL (NEW STATIONS)	**4-4.5p +**
GAS COMBINED CYCLE	**3-3.5p +**
WIND POWER	**5-7p**
NUCLEAR (NEW STN.)	**8-12p**
NUCLEAR (OLD STN.)	**SUBSIDY***

+ Damage to the environment may attract a "Carbon Tax" in the EEC in the future. Estimate approx. 2p/kWh

*** Old nuclear stations are being permitted to show a rate of return of only 5%, (essentially a Govt subsidy). They also receive a NFFO subsidy.**

MWT-250 MITSUBISHI WIND TURBINE



KEY TO COMPONENTS

① Generator
② Coupling
③ Main gear
④ Main shaft
⑨ Link
⑩ Blade spindle
⑪ Blade guide
⑫ Blade
⑰ Front capsule
⑱ Rear capsule
⑲ Manhole
⑳ Maintenance floor

ENERGY FUTURE – WHERE ARE WE GOING

1) Energy is by far the worlds largest industry
   Essential input to all national economies

2) Yet 1.6 billion – no access to modern energy

3)Massive growth in China and India's economies: 2 billion people looking for great expansion in energy usage – cars, etc

4)Kyoto agreement ratified Feb 2005 - but not including USA
(Yet USA to spend $5.8B on research.

5) China and India each investing $3Billion in Yukos of Russia

6) UN "Climate Panel" estimate world temperature rise of 1.4C to 5.8C by 2100

7)UK plans for 10% electricity from renewables by 2010 (billions to be spend on offshore wind

8)London plan for "Green City" announced Feb 14 2005 – wind turbines, local "heat and power plant", etc

20/150

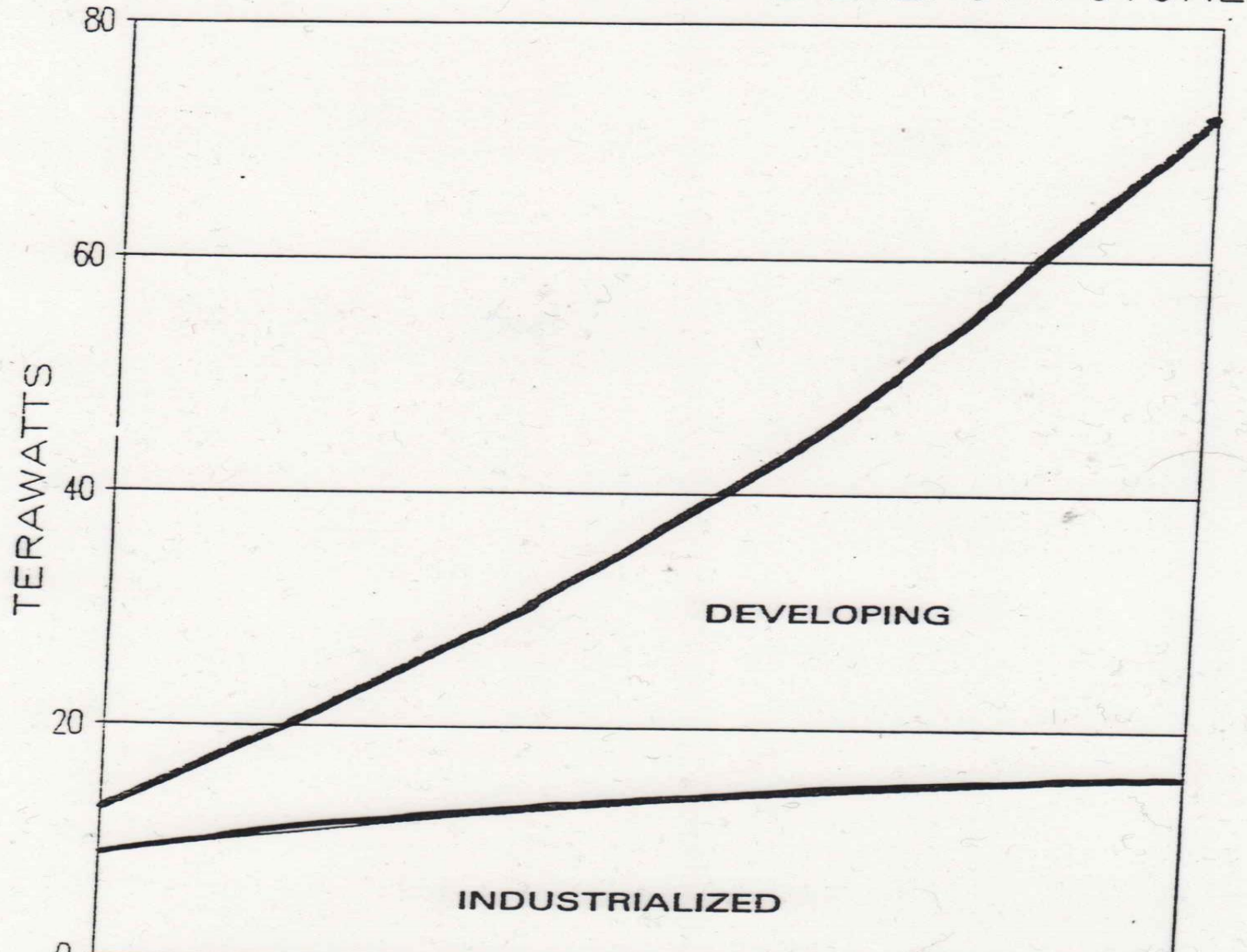
El aerogenerador ECOTÈCNIA 20/150 es consecuencia de un acuerdo de colaboración establecido entre el IDAE (Instituto para la Diversificación y el Ahorro de la Energía) sociedad estatal y Ecotècnia, sociedad cooperativa, con el objetivo común de impulsar los desarrollos tecnológicos nacionales en el sector de la energía eólica. El esfuerzo conjunto realizado ha permitido afrontar el proyecto, incorporando las más avanzadas tecnologías para obtener un producto competitivo, con bajo coste de mantenimiento y teniendo en cuenta los aspectos de seguridad y facilidad de acceso a todas las piezas durante los trabajos de supervisión y control.

20/150

The ECOTÈCNIA 20/150 wind turbine is the result of the technological collaboration agreement established between the state company IDAE (Institute for Energy Diversification and Saving) and the cooperative firm Ecotècnia, with the common objective of promoting Spanish technological developments in the wind energy sector. The collective effort made has allowed the project to include the most advanced technologies in order to obtain a competitive product with a low maintenance cost which offers safety and accessibility during supervision and inspection work.

J.H 6

THE BUSINESS-AS-USUAL ENERGY FUTURE



RECENT ENERGY DEVELOPMENTS

1. EU & UK PLAN 20% ELECTRICITY FROM RENEWABLES BY 2020

2. UK SAY 80% FROM RENEWABLES BY 2050

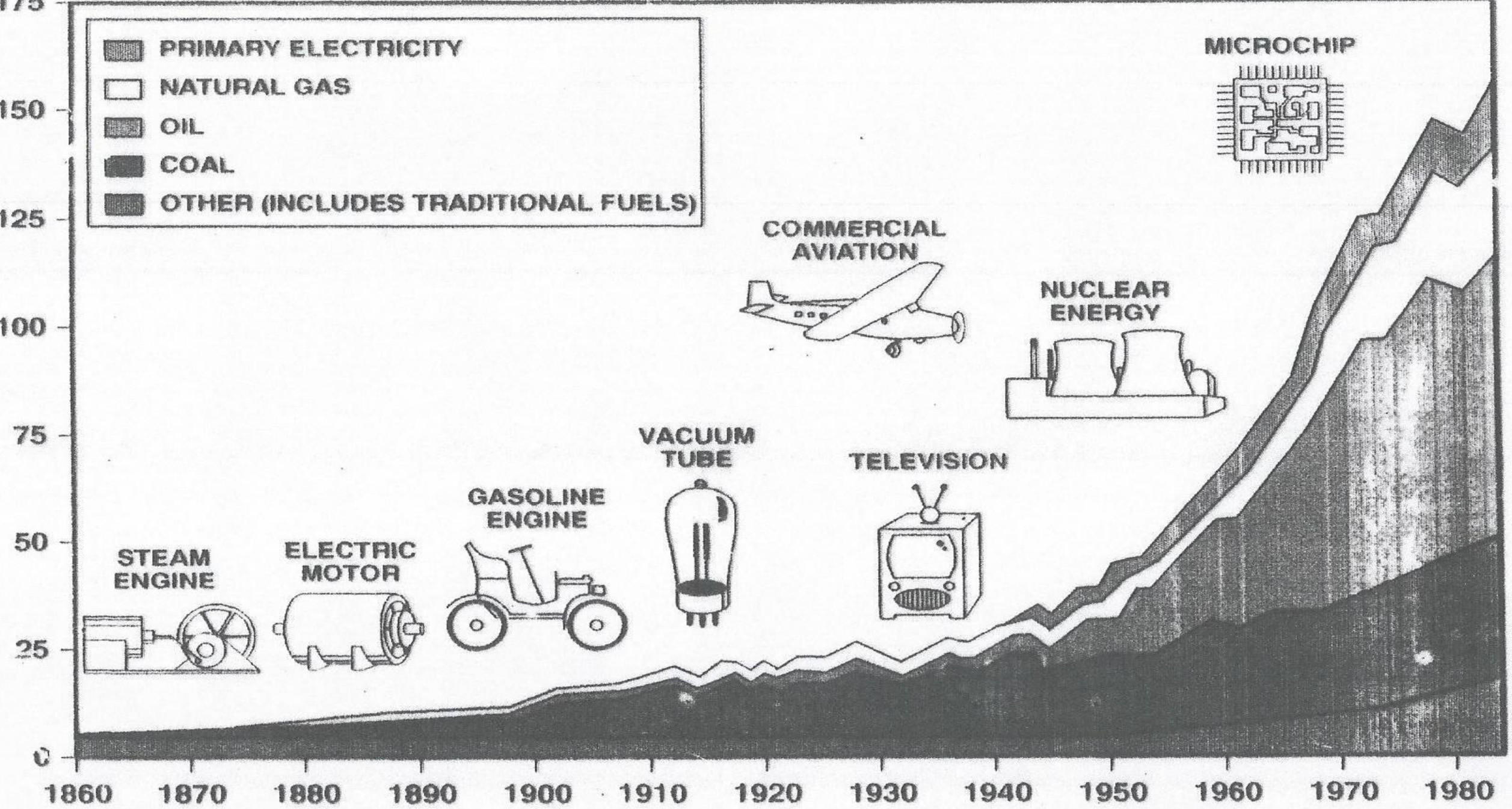
3. UK WIND POWER REACHES 6GW

4. FURTHER SUBMISSIONS FOR 3GW

5. SEVERN BARRAGE STUDY - £30BILLION COST – NOW REJECTED BY GOVT.

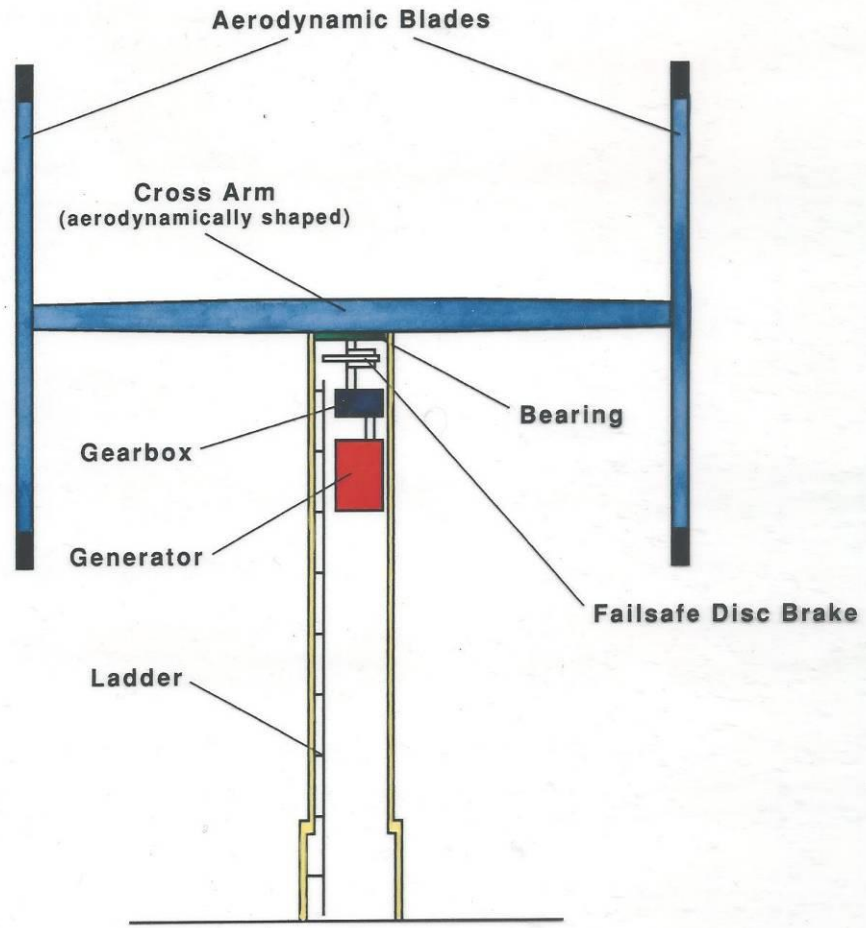
6. WAVE POWER HARDWARE DEMO PROJECTS FOR WEST COUNTRY & SCOTLAND

7. NUCLEAR – 5 NEW POWER STATIONS TO BE BUILT – GOVT.


PRIMARY ELECTRICITY
NATURAL GAS
OIL
COAL
OTHER (INCLUDES TRADITIONAL FUELS)
175
150
125
100
75
50
25
0
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
STEAM ENGINE
ELECTRIC MOTOR
GASOLINE ENGINE
VACUUM TUBE
TELEVISION
COMMERCIAL AVIATION
NUCLEAR ENERGY
MICROCHIP

RECOVERABLE NONRENEWABLE ENERGY RESOURCES, TWyr	
OIL & GAS, CONVENTIONAL	1,000
...UNCONVENTIONAL	2,000
COAL	5,000
OIL SHALE	30,000
URANIUM IN LWRs	3,000
...IN LMFBRs	3,000,000
FUSION, D-T FUEL (Li LIMIT)	140,000,000
...D-D FUEL	250,000,000,000
GEOTHERMAL STEAM	4,000
...HOT DRY ROCK	1,000,000

RENEWABLE ENERGY RESOURCES, TWyr/yr	
SUNLIGHT REACHING EARTH SURF	88,000
...LAND SURF	26,000
GLOBAL BIOMASS PRODUCTION	100



Cut away diagram of a typical Vertical Axis Wind Turbine