

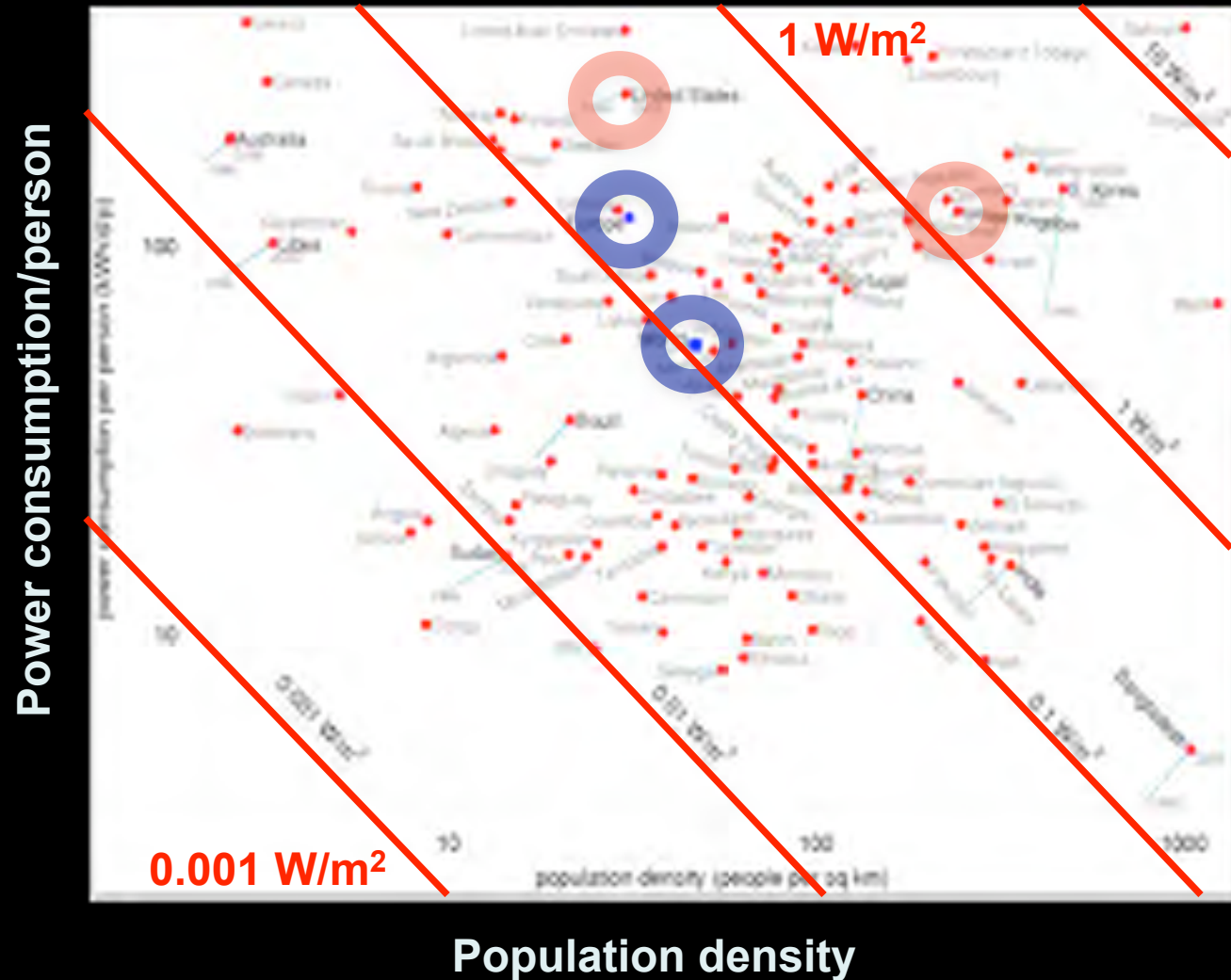
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# Birmingham Centre for Nuclear Education and Research



Martin Freer  
[M.Freer@bham.ac.uk](mailto:M.Freer@bham.ac.uk)

# The Energy Challenge

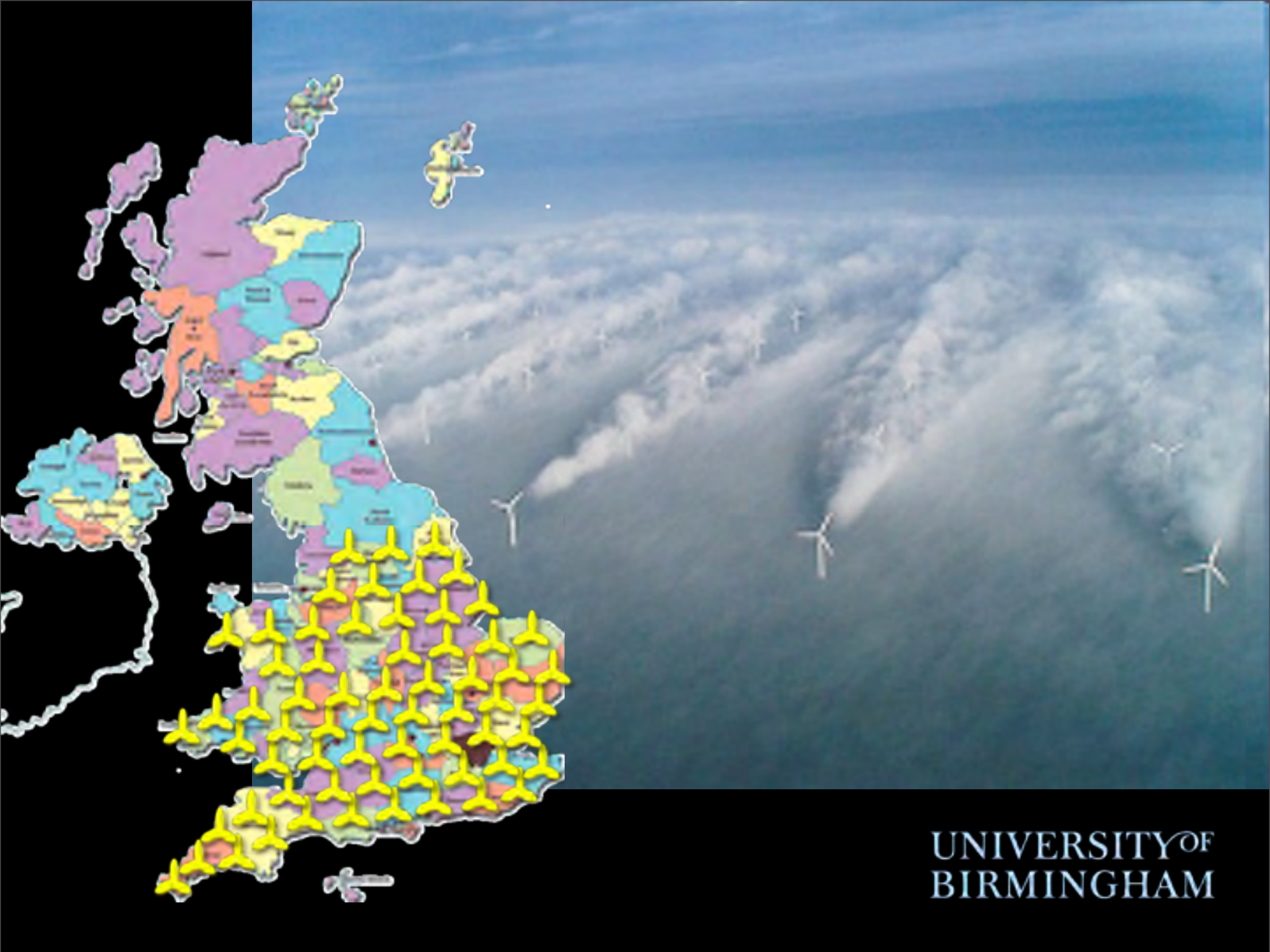


Average power  
output per unit  
area

Wind	2-3 W/m <sup>2</sup>
Tidal	3-6 W/m <sup>2</sup>
Solar	5 W/m <sup>2</sup>
Hydro	11 W/m <sup>2</sup>



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# The Pressures

**DEPARTMENT OF ENERGY & CLIMATE CHANGE**

Tackling Climate Change | Cutting Emissions | Meeting Energy Demand | Funding & Support

Policy & Legislation | Climate Change Act 2008

Energy Bill 2010-2011

Energy Act 2010

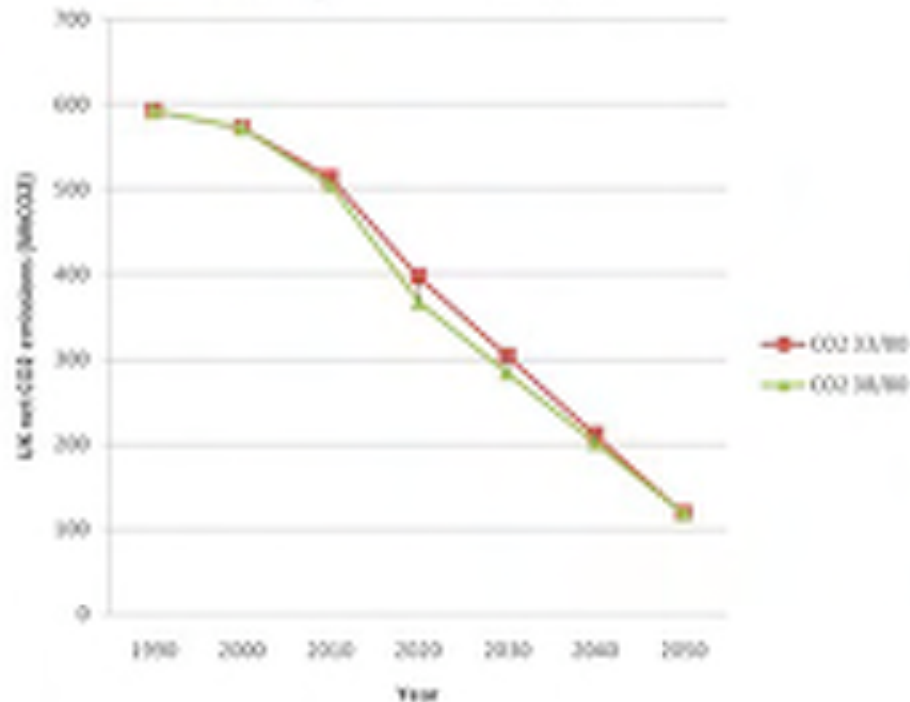
**CLIMATE CHANGE ACT 2008**

**DEPARTMENT FOR BUSINESS  
ENTERPRISE & REGULATORY REFORM**

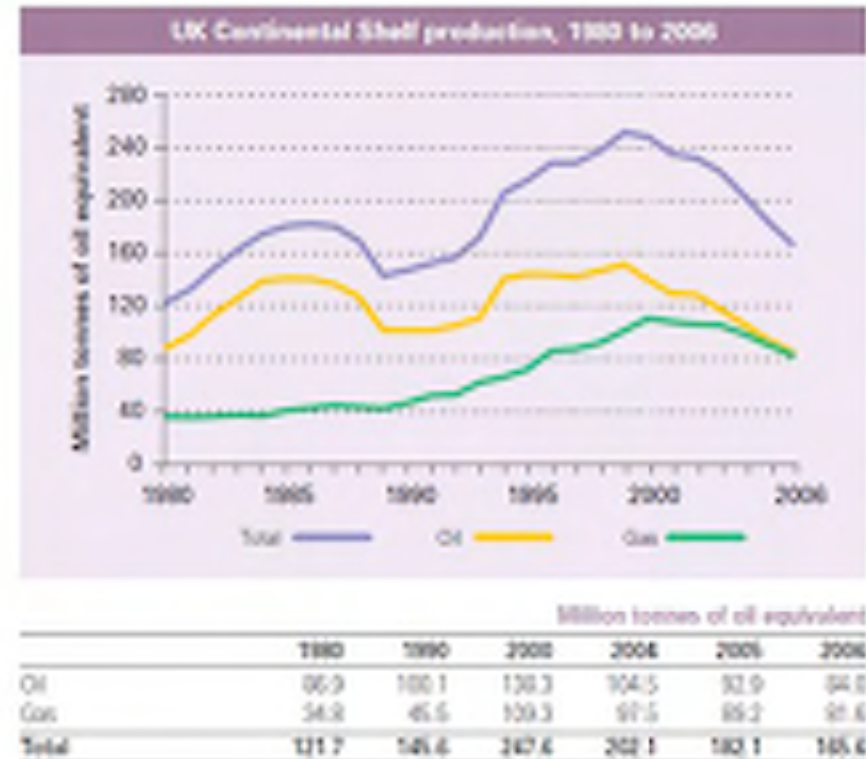
**UK ENERGY IN BRIEF JULY 2007**

**Statistics** A NATIONAL STATISTICS PUBLICATION

UK CO<sub>2</sub> emissions trajectories

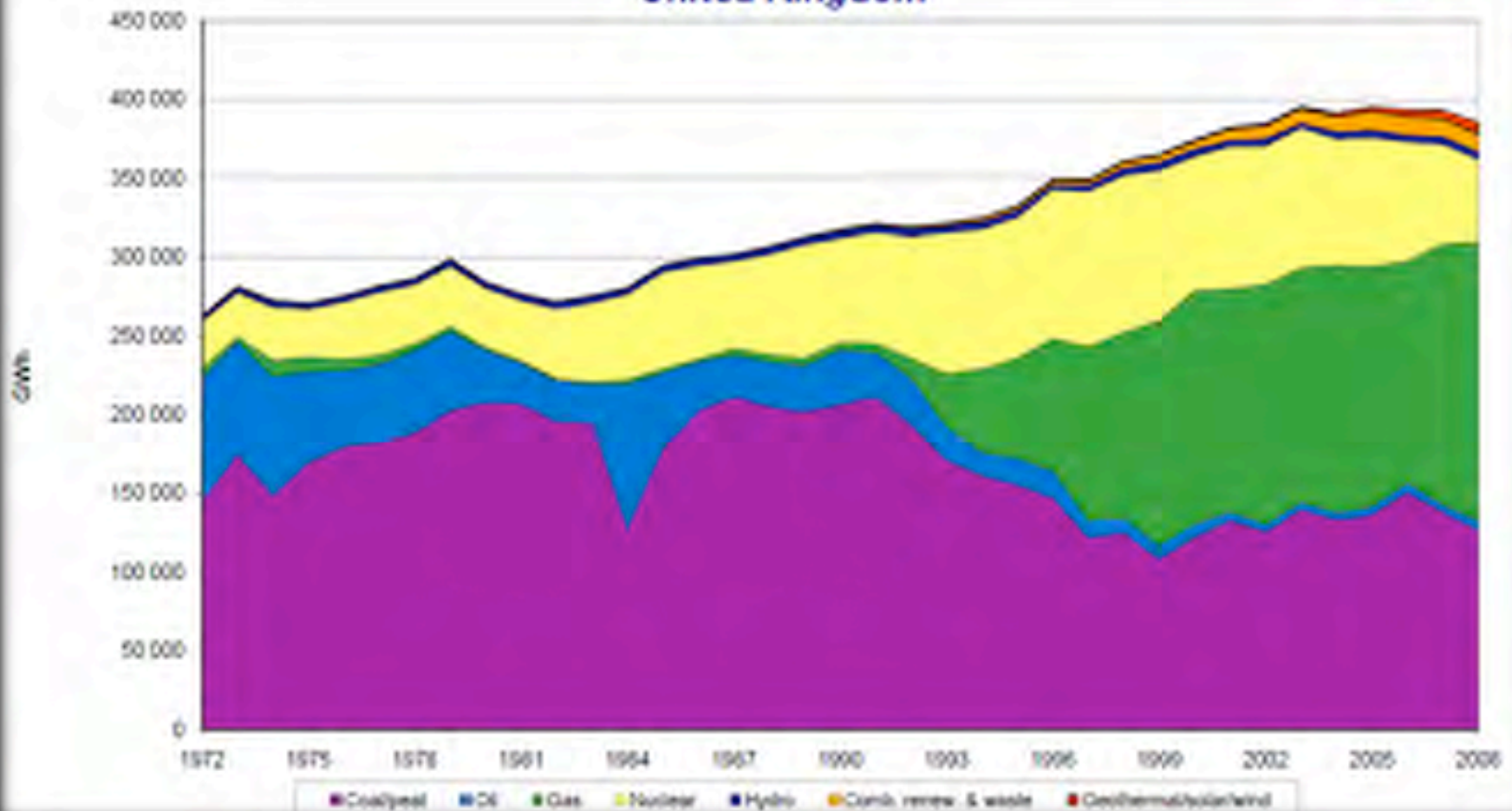


OIL AND GAS PRODUCTION





Electricity generation by fuel  
*United Kingdom*



<http://2050-calculator-tool.decc.gov.uk/pathways>

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### Generation By Fuel Type (graph)

Data referring to dates: 2012-01-26, 2012-01-26

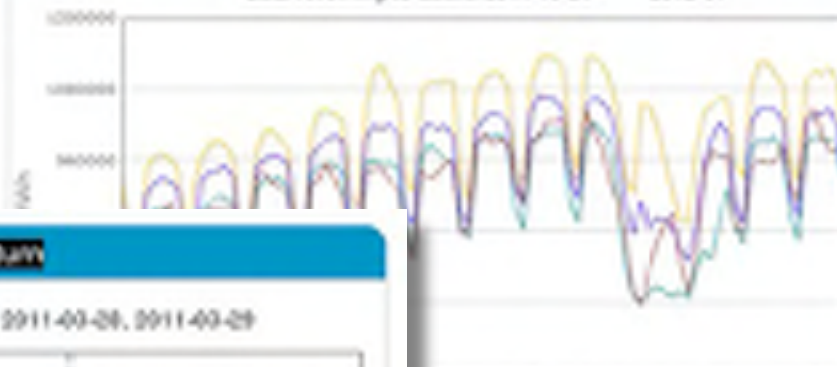


☒ Coal  
☒ CO2  
☒ Nuclear  
☒ Gas  
☒ Non-Fuel  
☒ Wind

Current / Historic

### Daily Energy Transmitted

Data referring to dates: 2012-10-01 - 2012-01



2012-10-01  
 2012-10-08  
 2012-10-15  
 2012-10-22  
 2012-10-29  
 2012-11-05  
 2012-11-12  
 2012-11-19  
 2012-11-26  
 2012-12-03  
 2012-12-10  
 2012-12-17  
 2012-12-24  
 2013-01-01

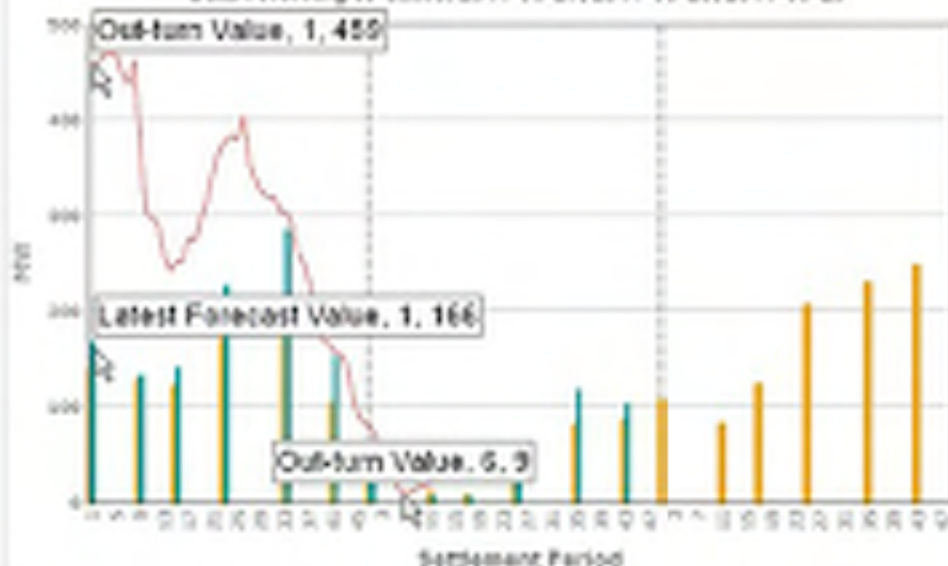
Date

☒ Data  
☒ Low Reference Data  
☒ Out-turn Energy

Information

### Wind Forecast Out-turn

Data referring to dates: 2011-03-27, 2011-03-28, 2011-03-29



☒ Initial Forecast Value  
☒ Latest Forecast Value  
☒ Out-turn Forecast Value

### Future Data

Data referring to dates: 2011-10-01 to 2012-01-01



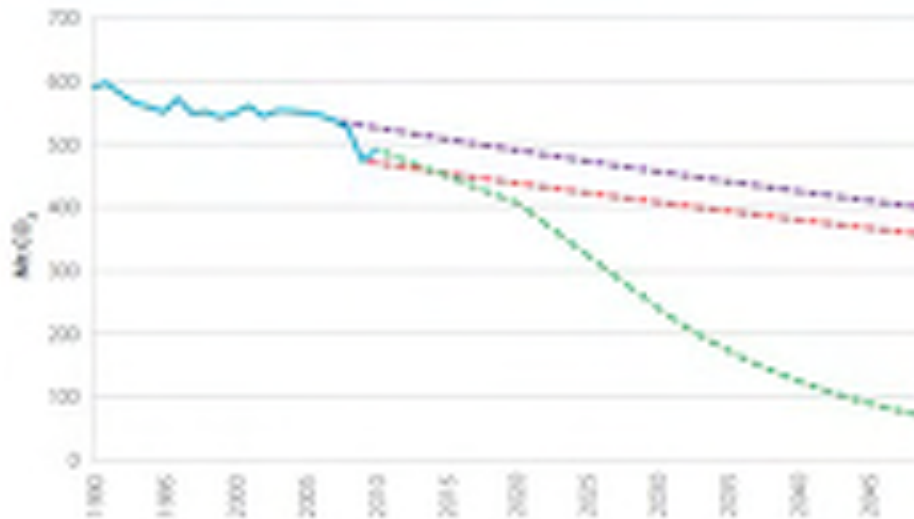
Date

☒ High Reference  
☒ Normal Reference  
☒ Low Reference  
☒ Out-turn Temperature

Current / Historic

Information

\_hom

Figure 3: CO<sub>2</sub> emissions under pre-recession trend versus required reductions (1990-2050)

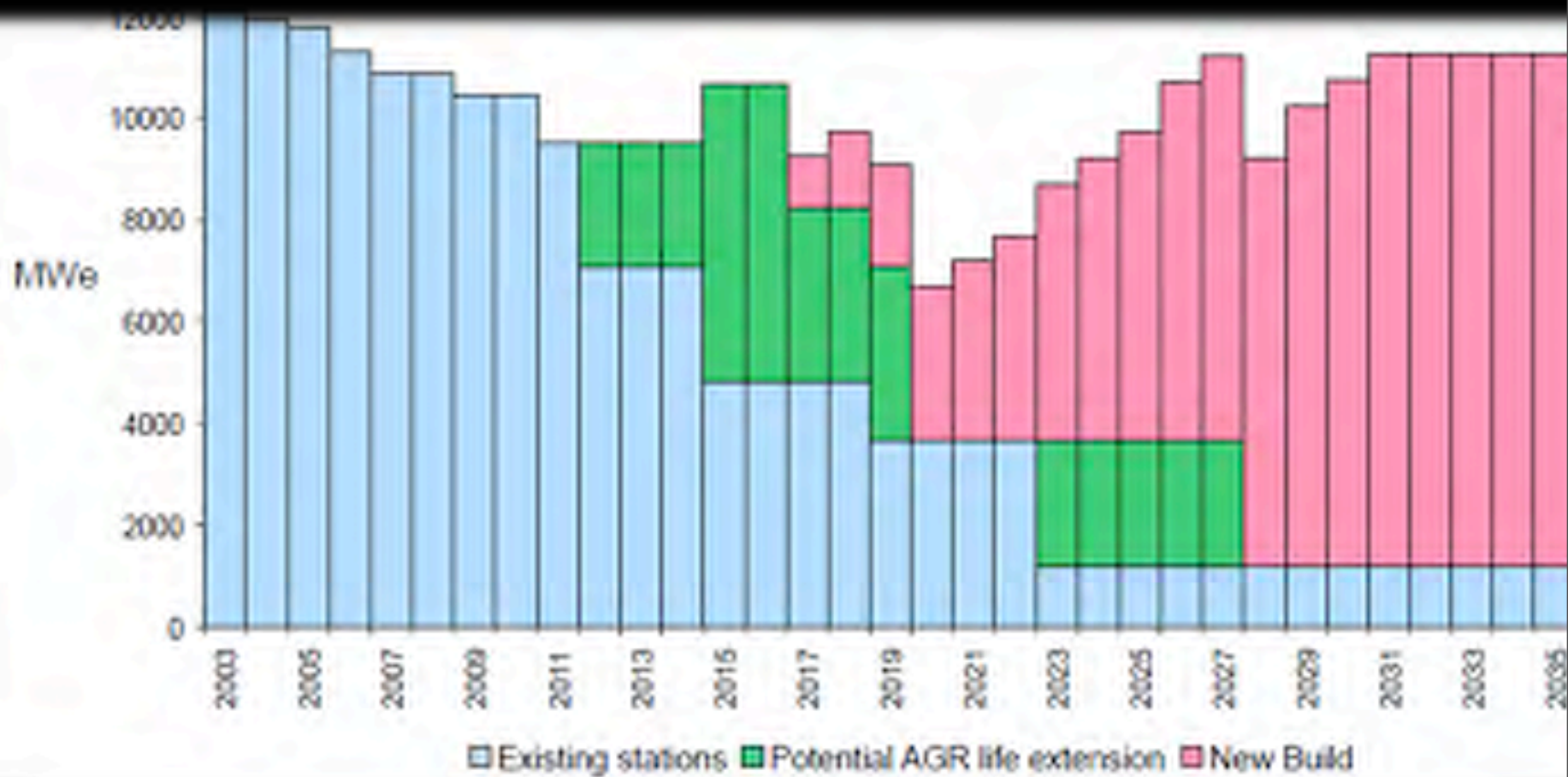
**Illustrative 2030 scenario.** We set out an illustrative scenario in which commitments on support for offshore wind and marine through the 2020s are broadly in line with planned investment and supply chain capacity to 2020. Together with ongoing investment in onshore wind, this would result in a 2030 renewable generation share of around 40% (185 TWh). **Sector decarbonisation would then require a nuclear share of around 40% and a CCS share of 15%, along with up to 10% of generation from unabated gas.**

The Renewable  
Energy Review

May 2011

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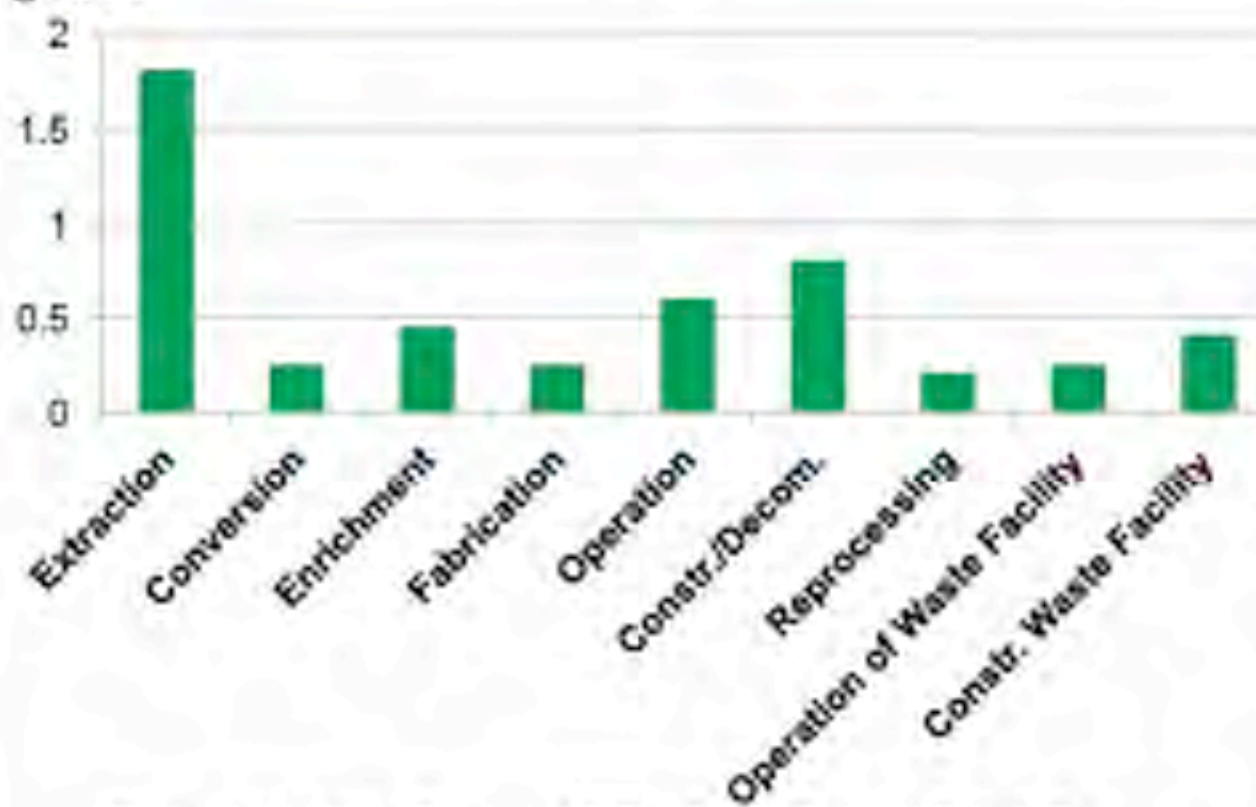
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# Carbon Footprint

gCO<sub>2</sub>/kWh

## Nuclear Electrical Generation

g/kWh

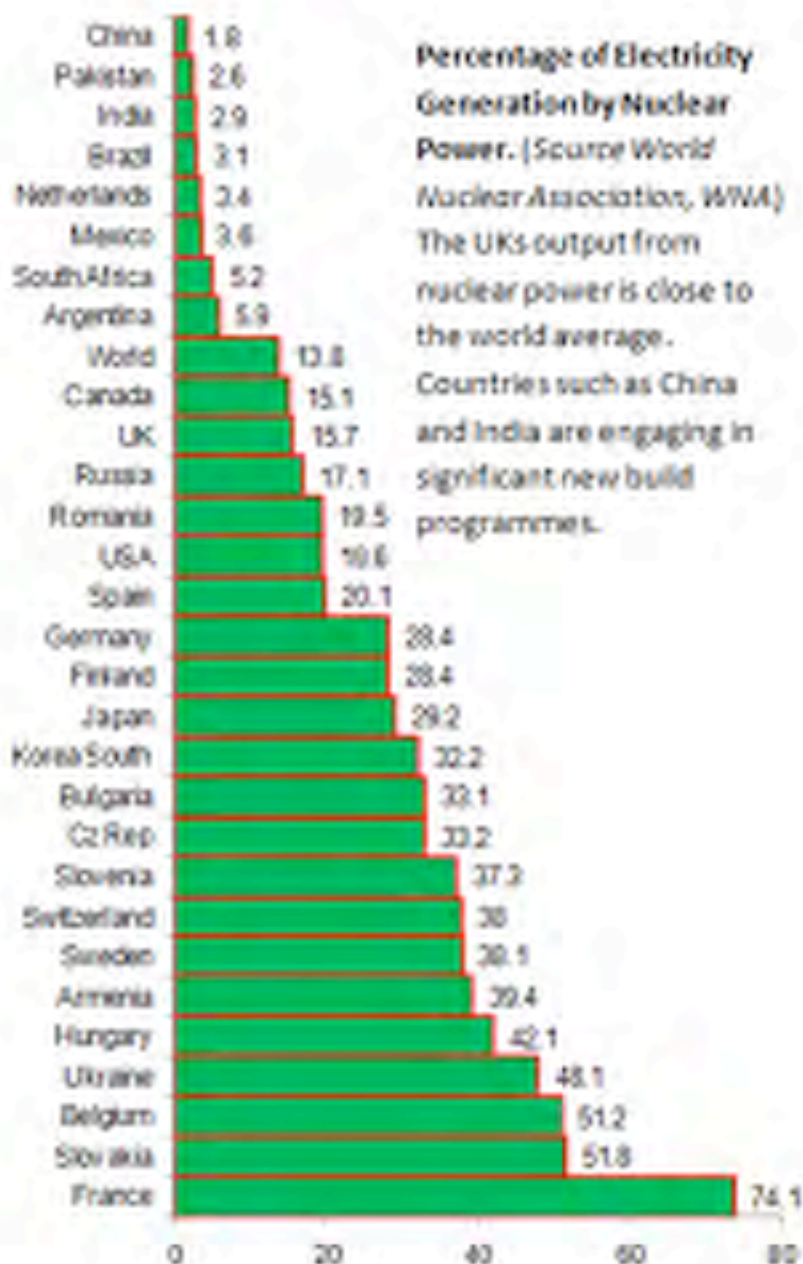
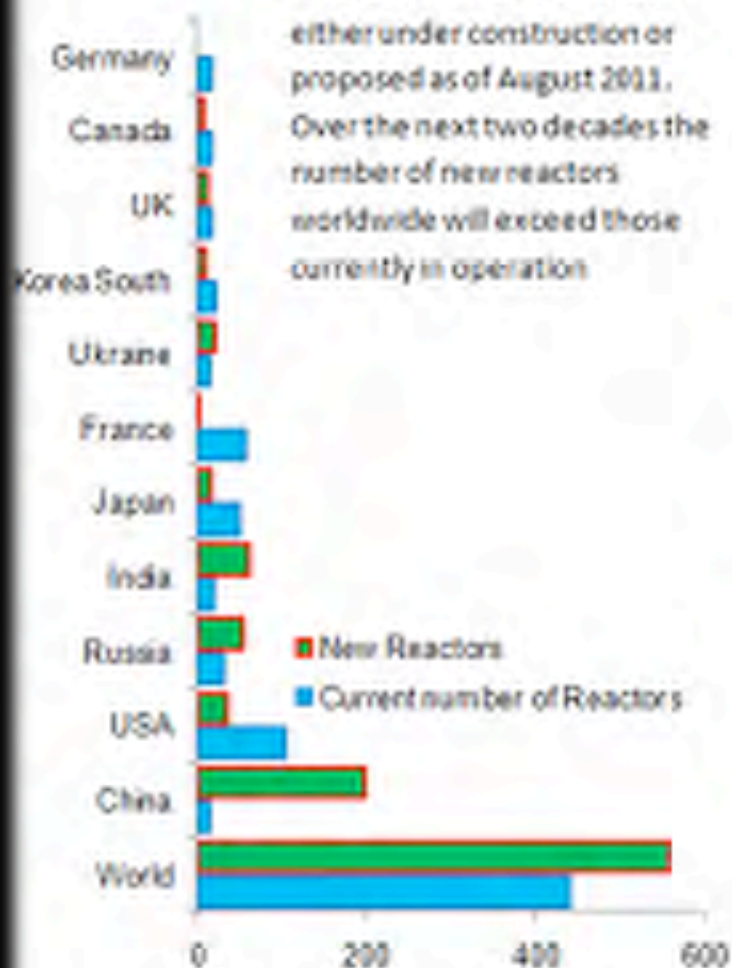


Figures based on Torness AGR in 2002. Source: British Energy

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### Number of Nuclear Reactors.

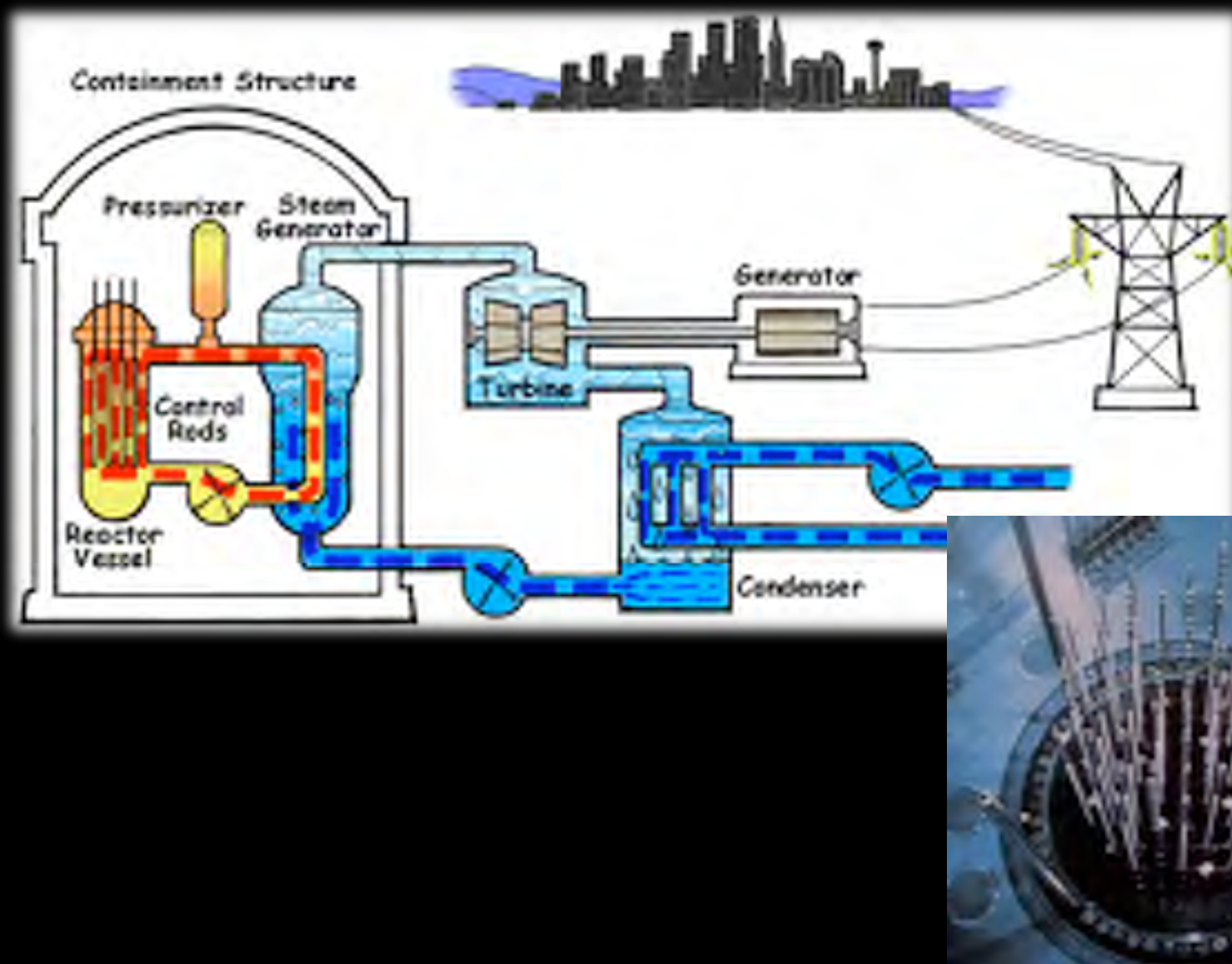
(Source World Nuclear Association, WNA) Current reactors in operation in main nuclear countries as of August 2011 and numbers of reactors either under construction or proposed as of August 2011. Over the next two decades the number of new reactors worldwide will exceed those currently in operation.

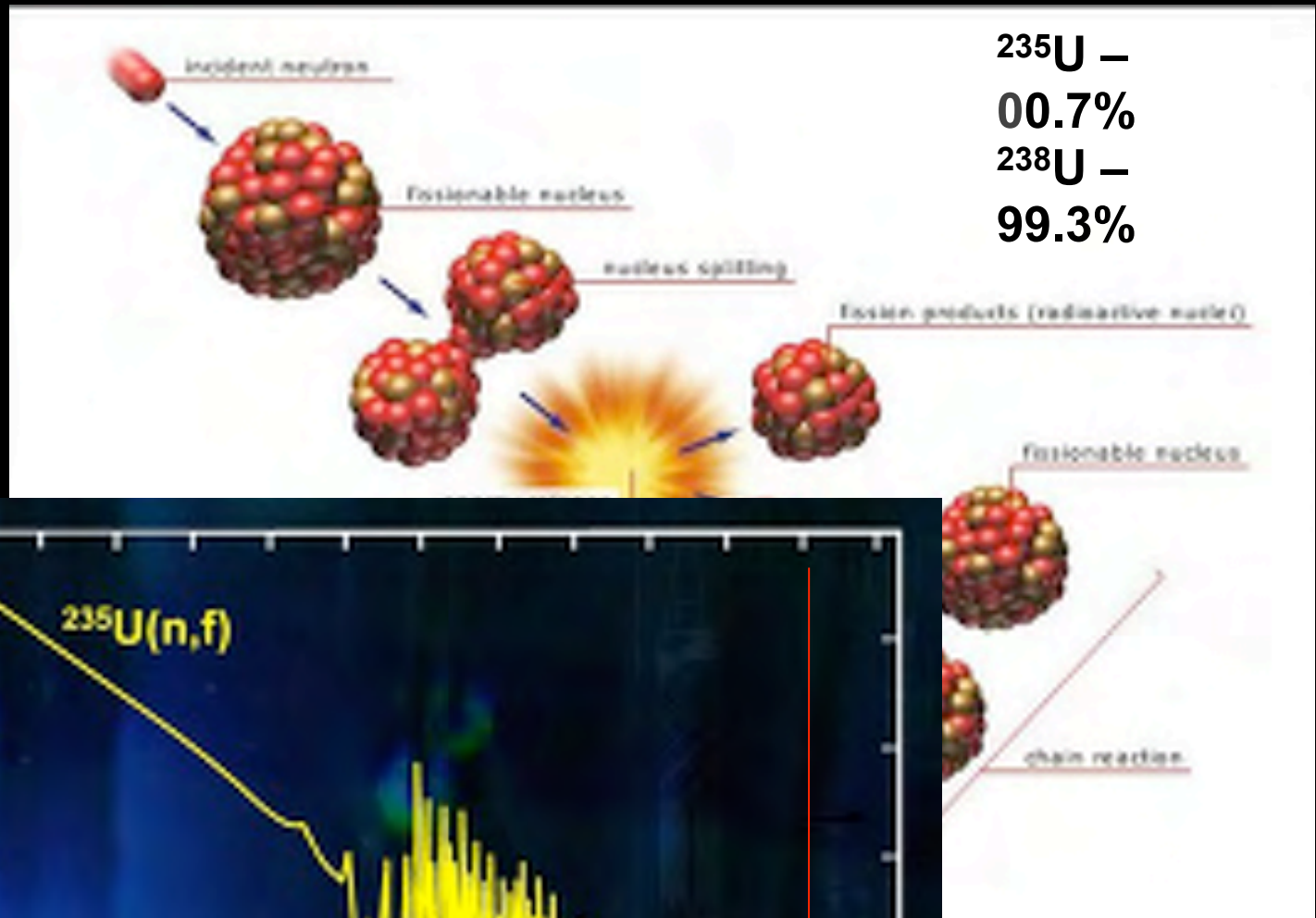


**Percentage of Electricity Generation by Nuclear Power.** (Source World Nuclear Association, WNA) The UK's output from nuclear power is close to the world average. Countries such as China and India are engaging in significant new build programmes.

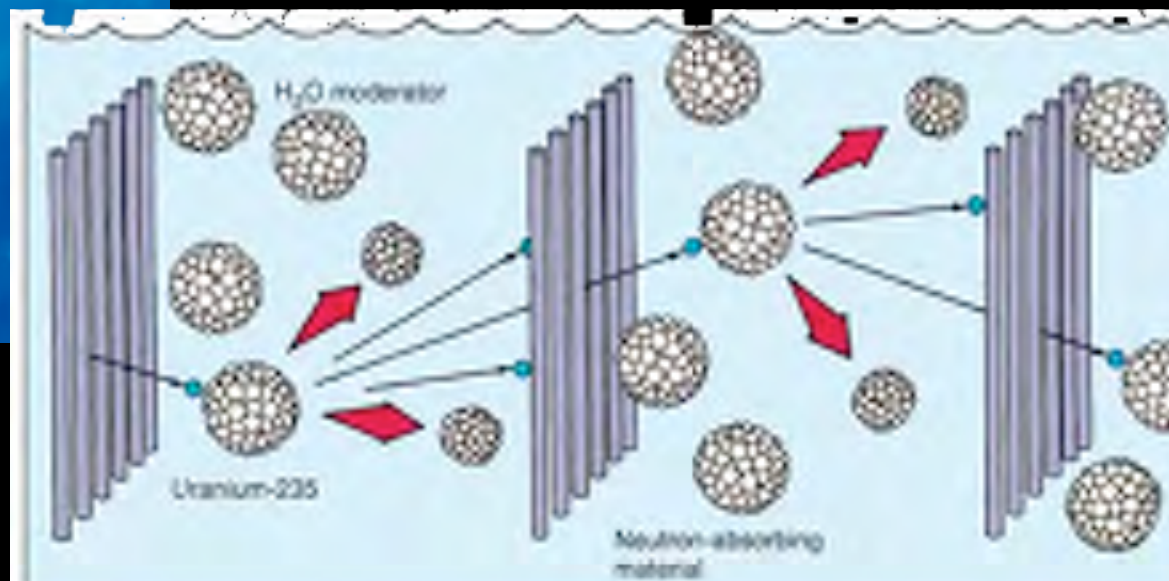
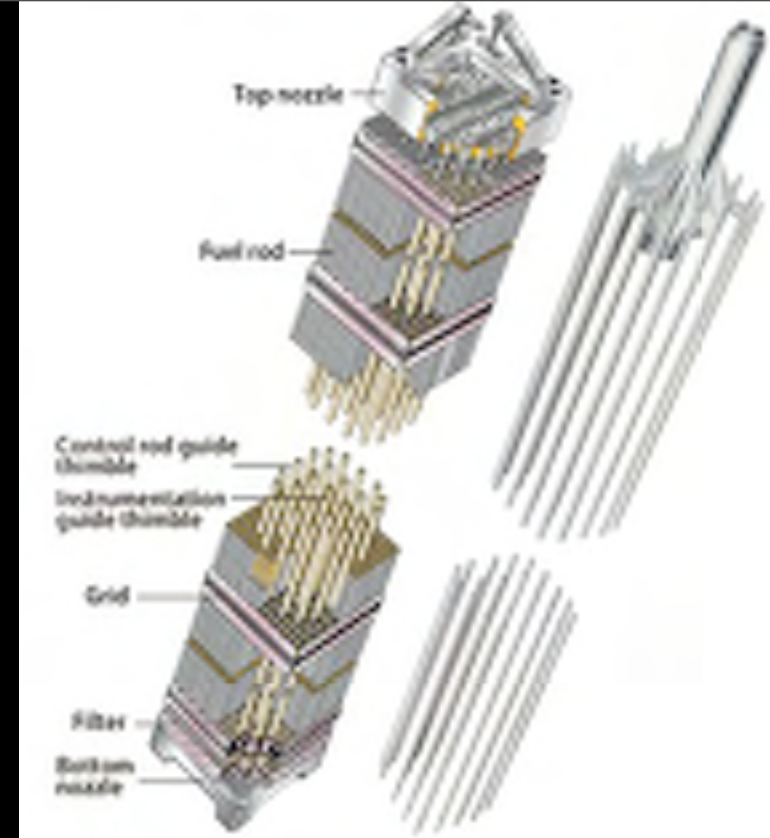
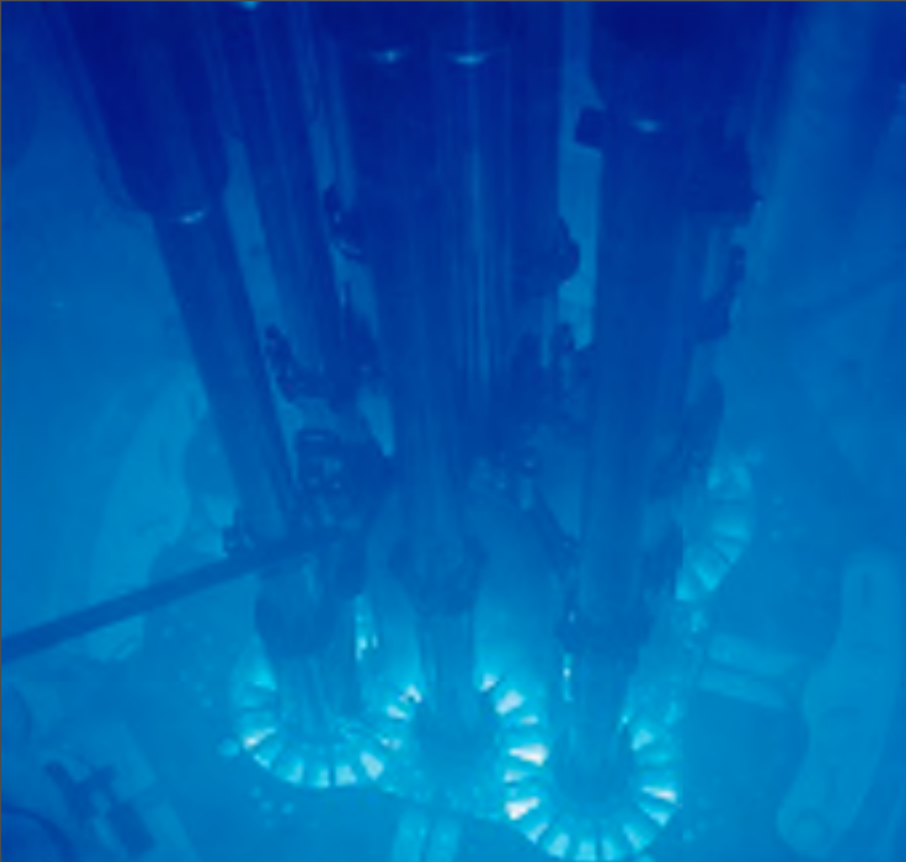


# Pressurised Water Reactor (PWR)

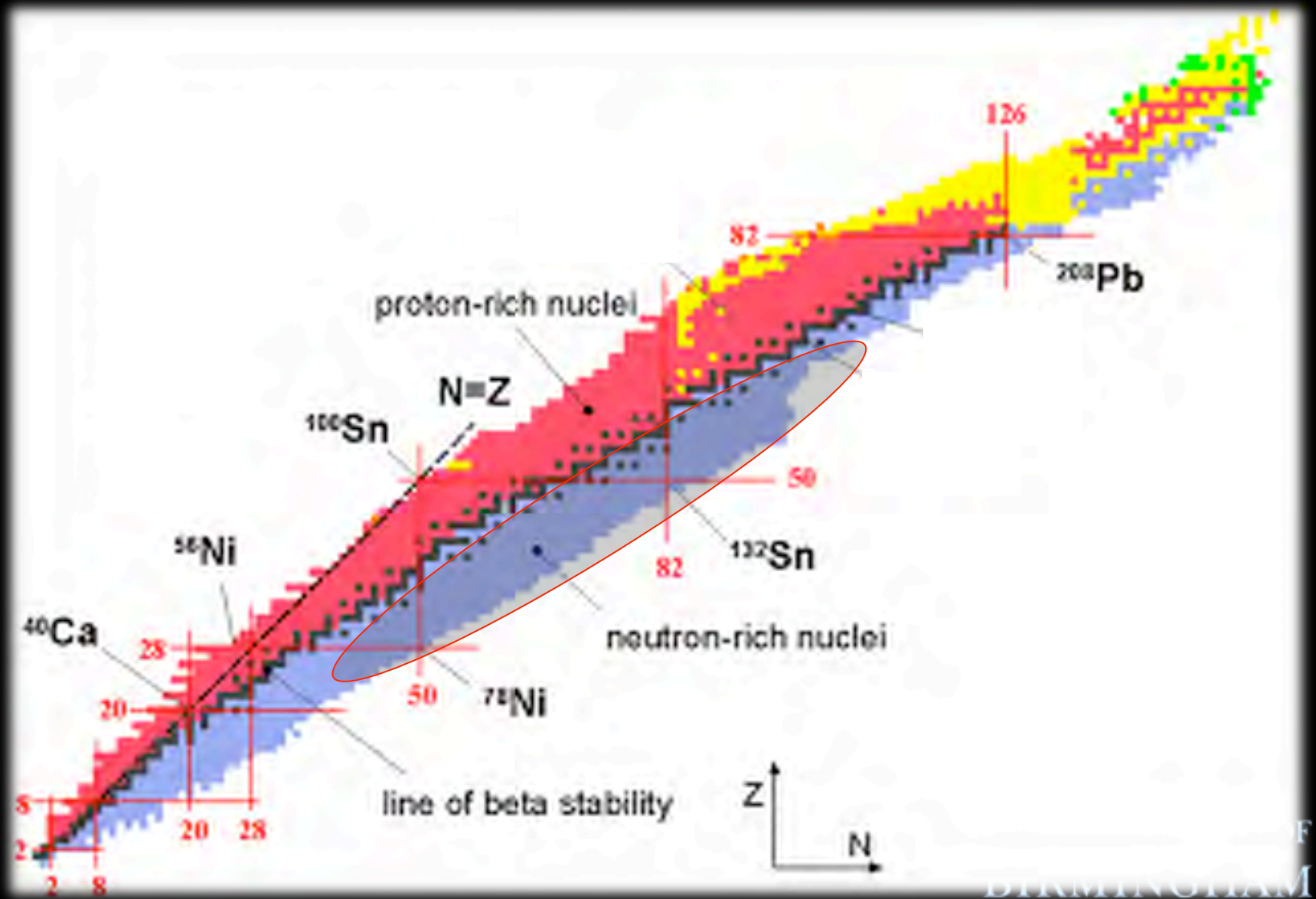




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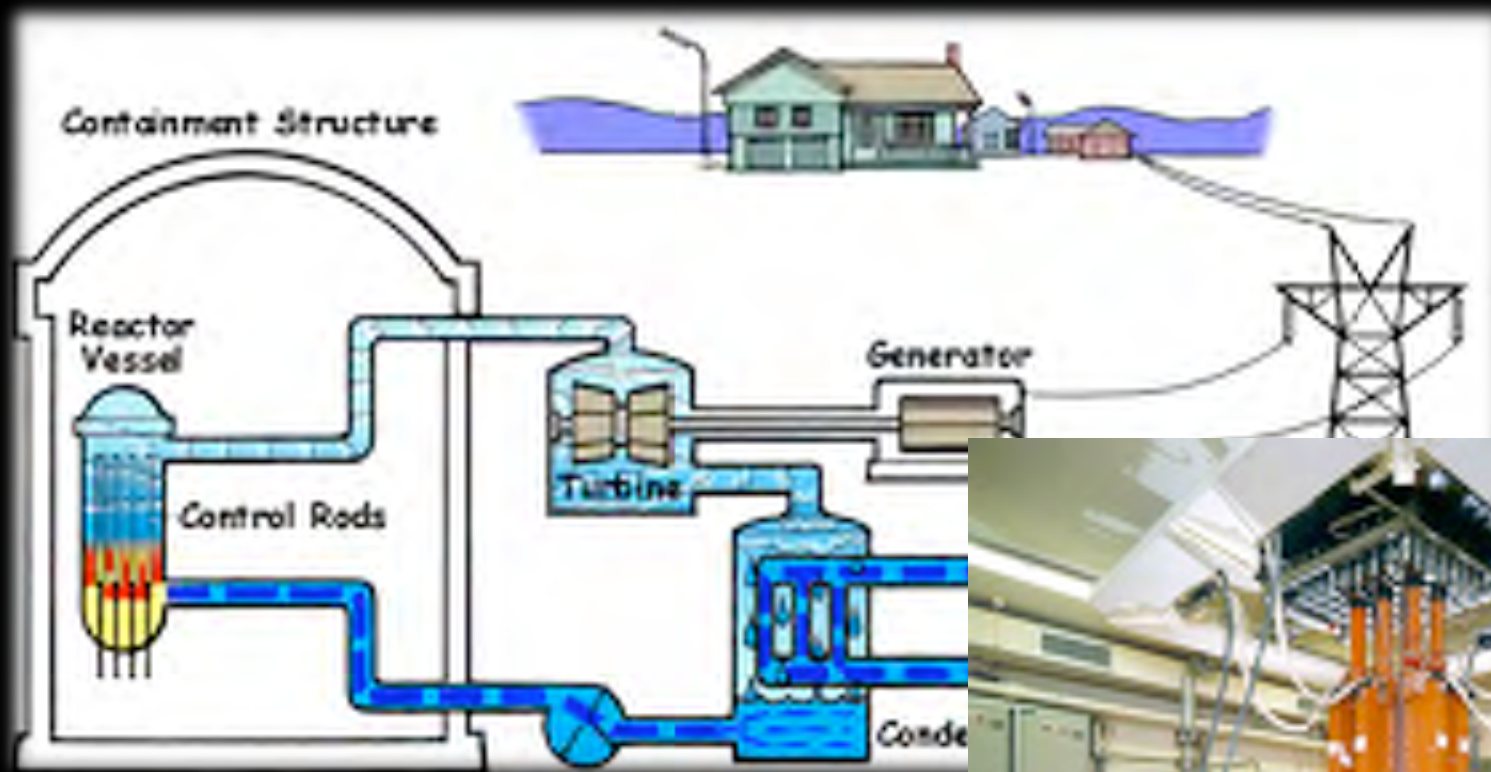




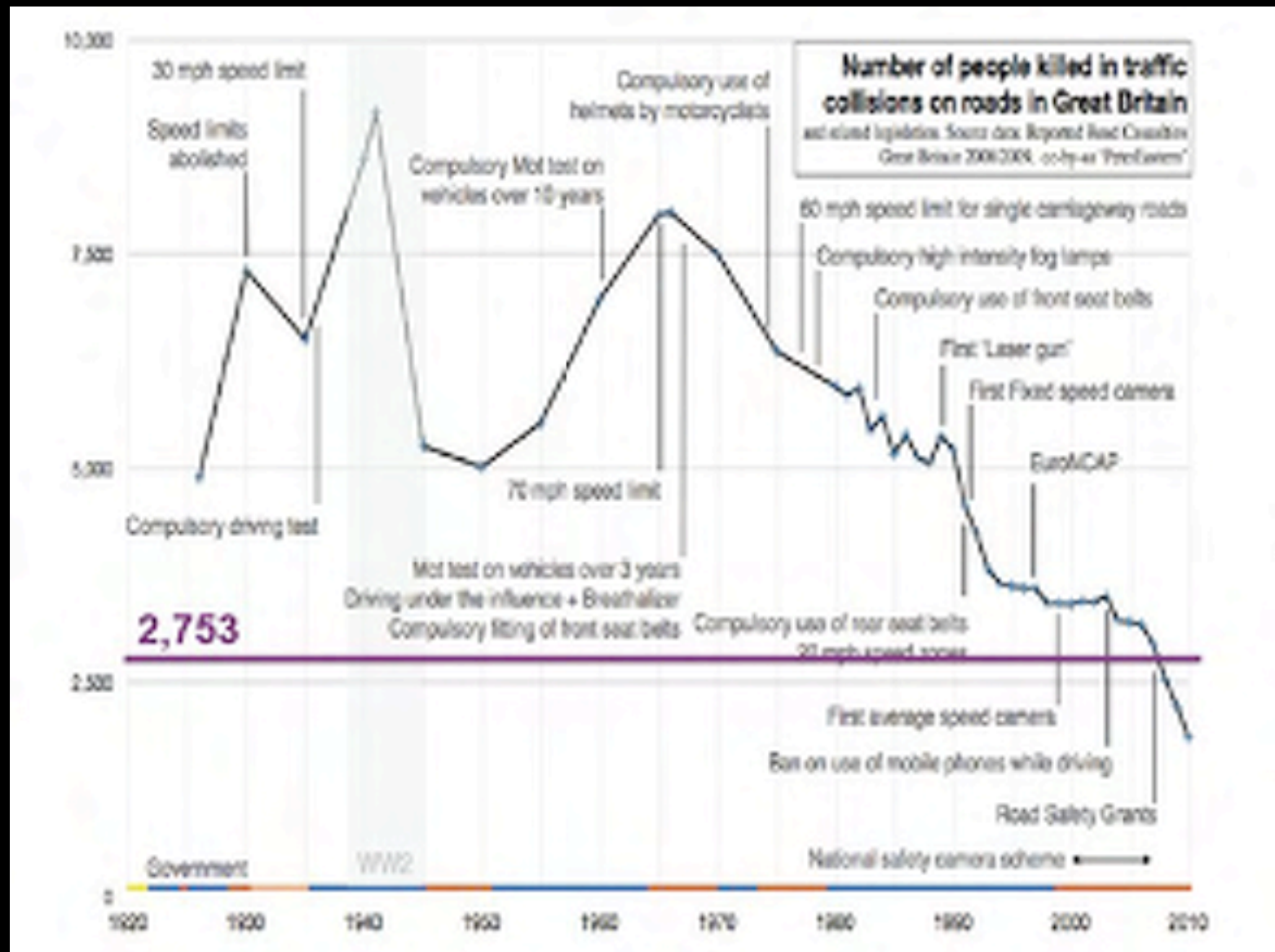


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# Boiling Water Reactor (BWR)

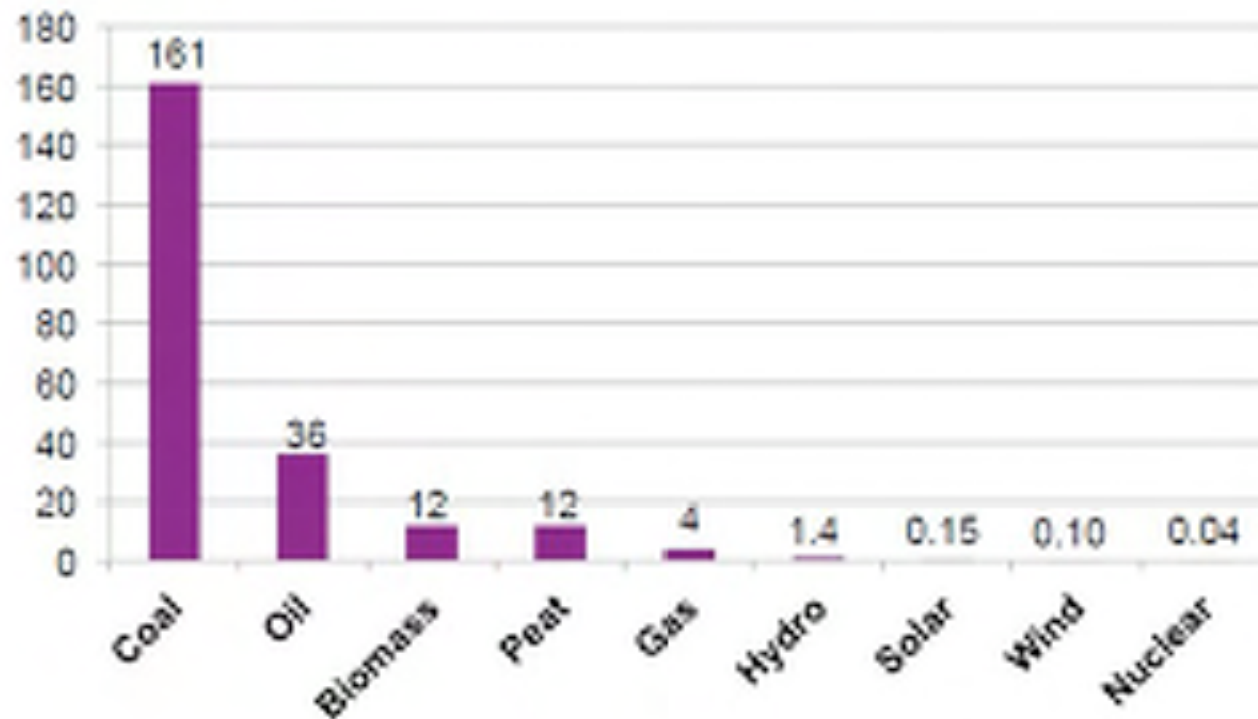


# Issues/Risks





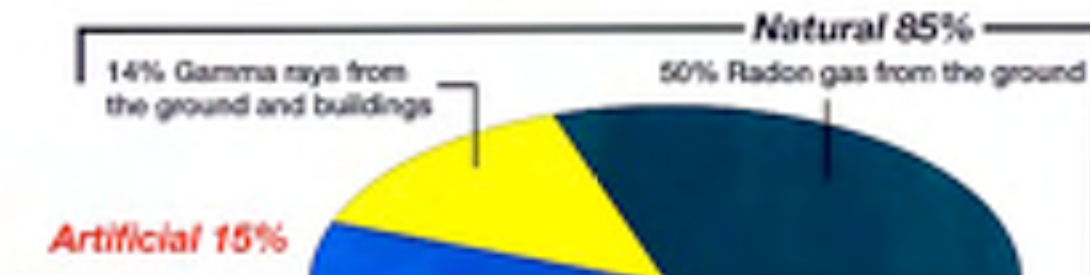
## Deaths per TWh



Source: IBM

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# Average Annual UK Radiation Dose



# UK New Build Programme



Westinghouse AP1000



Areva EPR

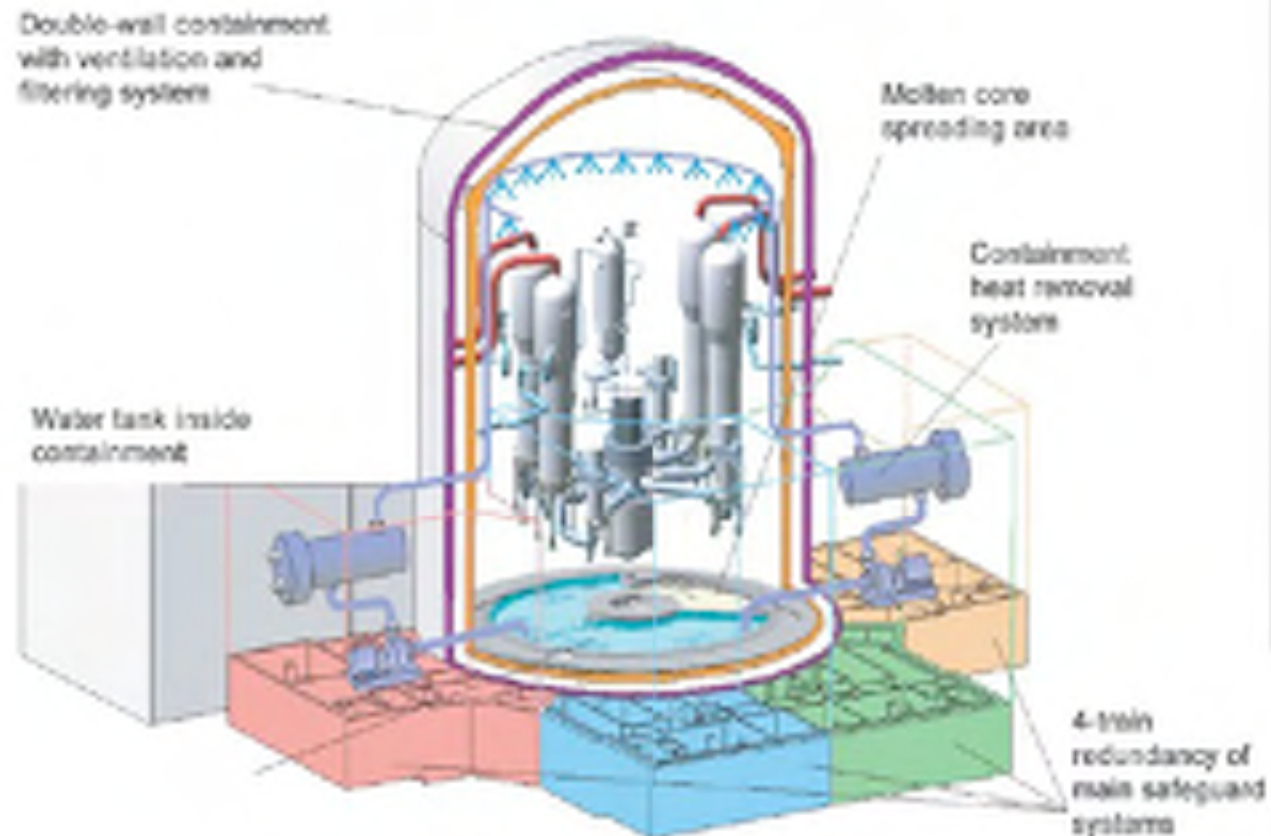
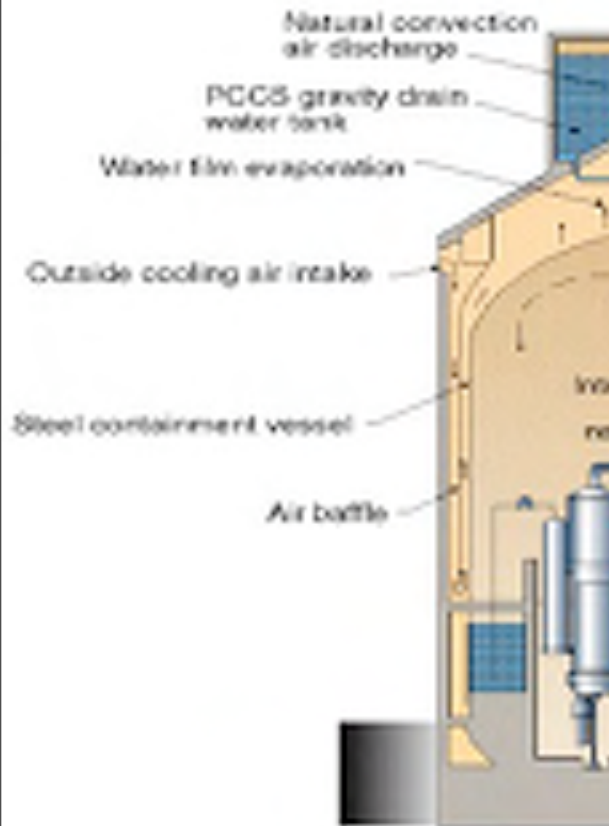
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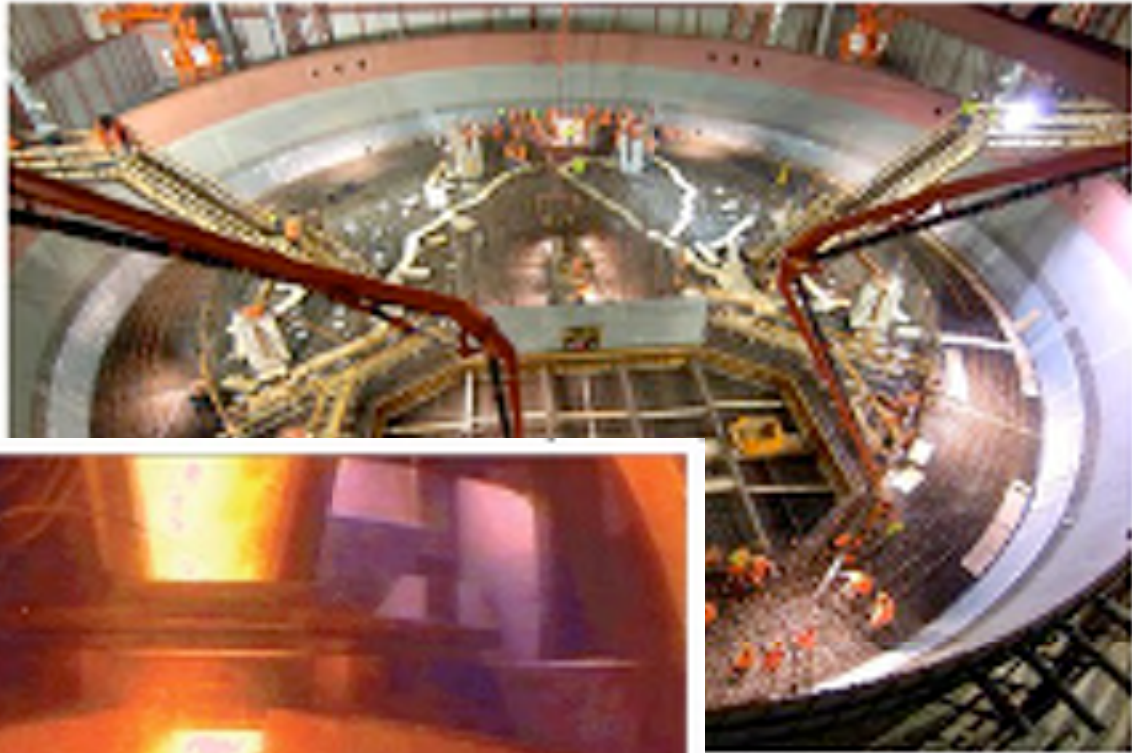
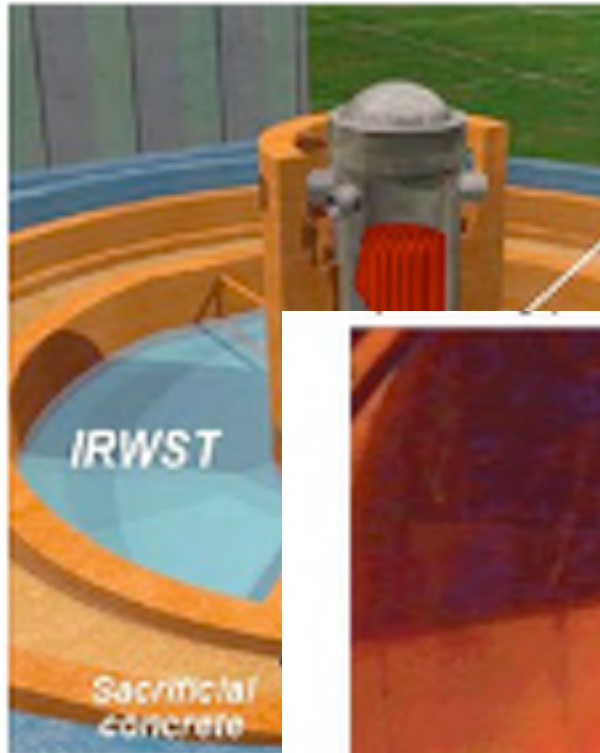
# Passive Cooling



## EPR Safety Systems



# EPR Core Melt R



VULCANO (real  $\text{UO}_2$  with some  $\text{Zr O}_2$ )

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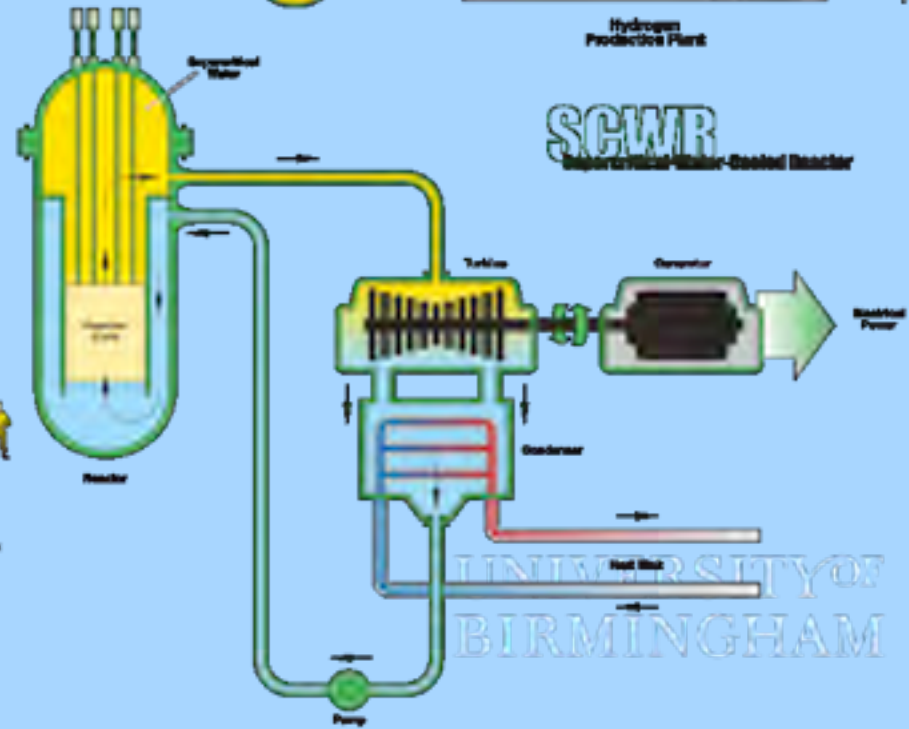
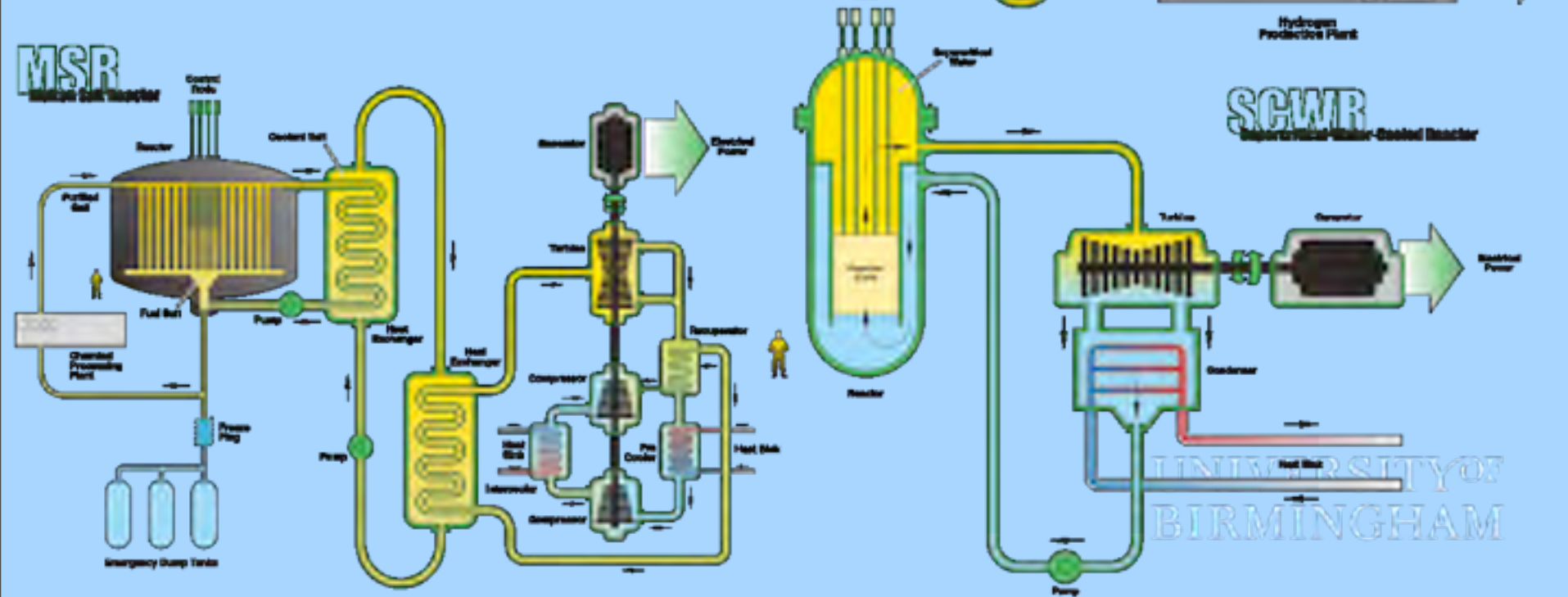
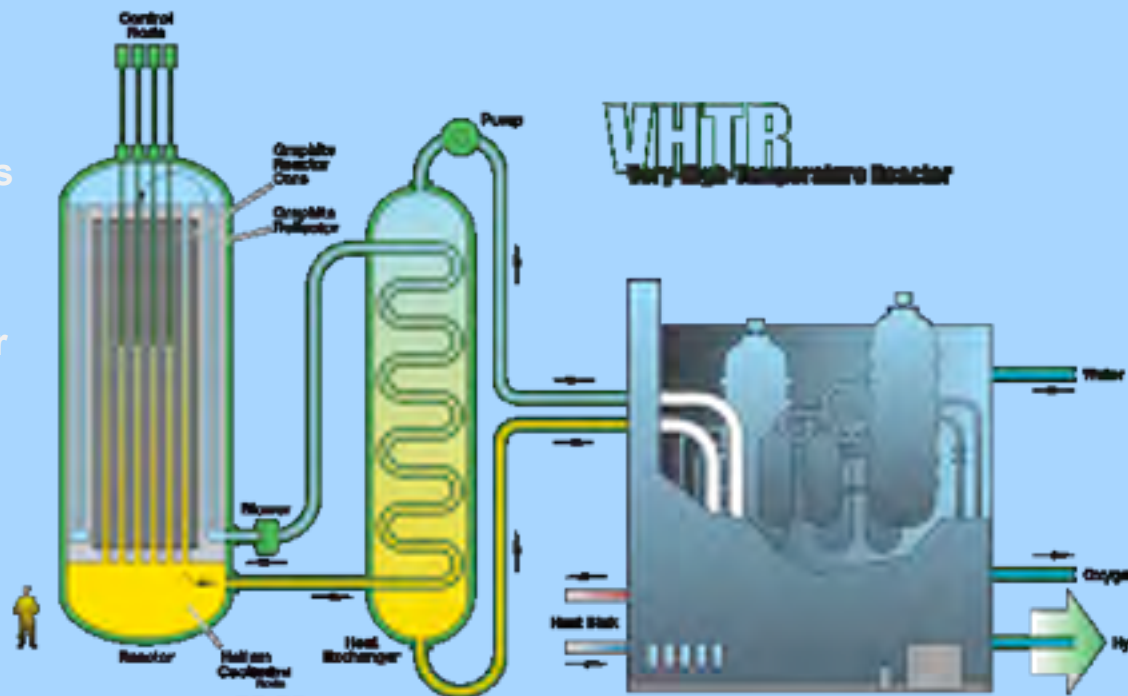


# Future: Gen IV

- Nuclear waste that lasts a few centuries instead of millennia
- 100-300 times more energy yield from the same amount of nuclear fuel
- The ability to consume existing nuclear waste in the production of electricity
- Improved operating safety

## Thermal Reactors

- Higher efficiency

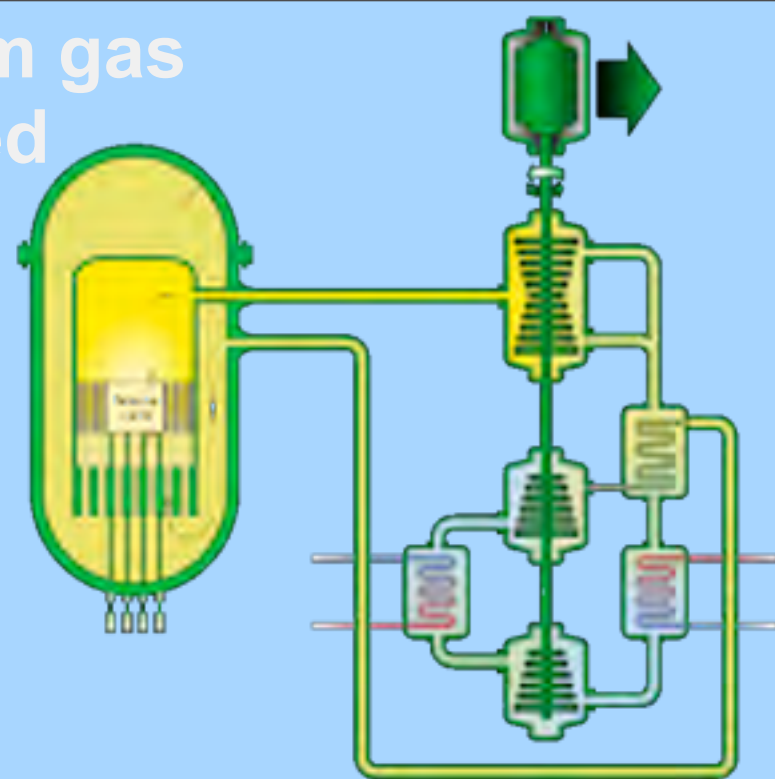


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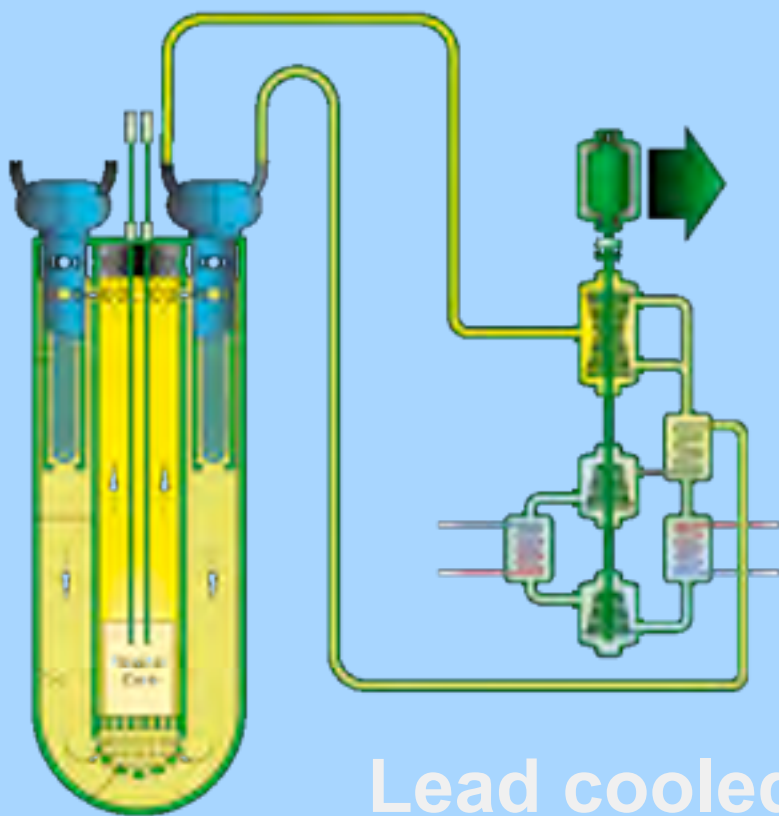


# Future Fast Reactors

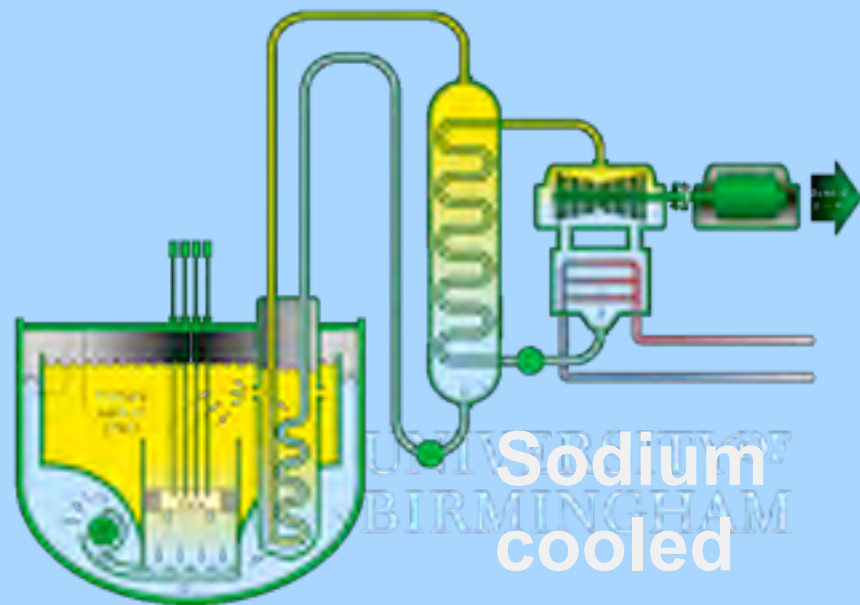
Helium gas  
cooled



Lead cooled



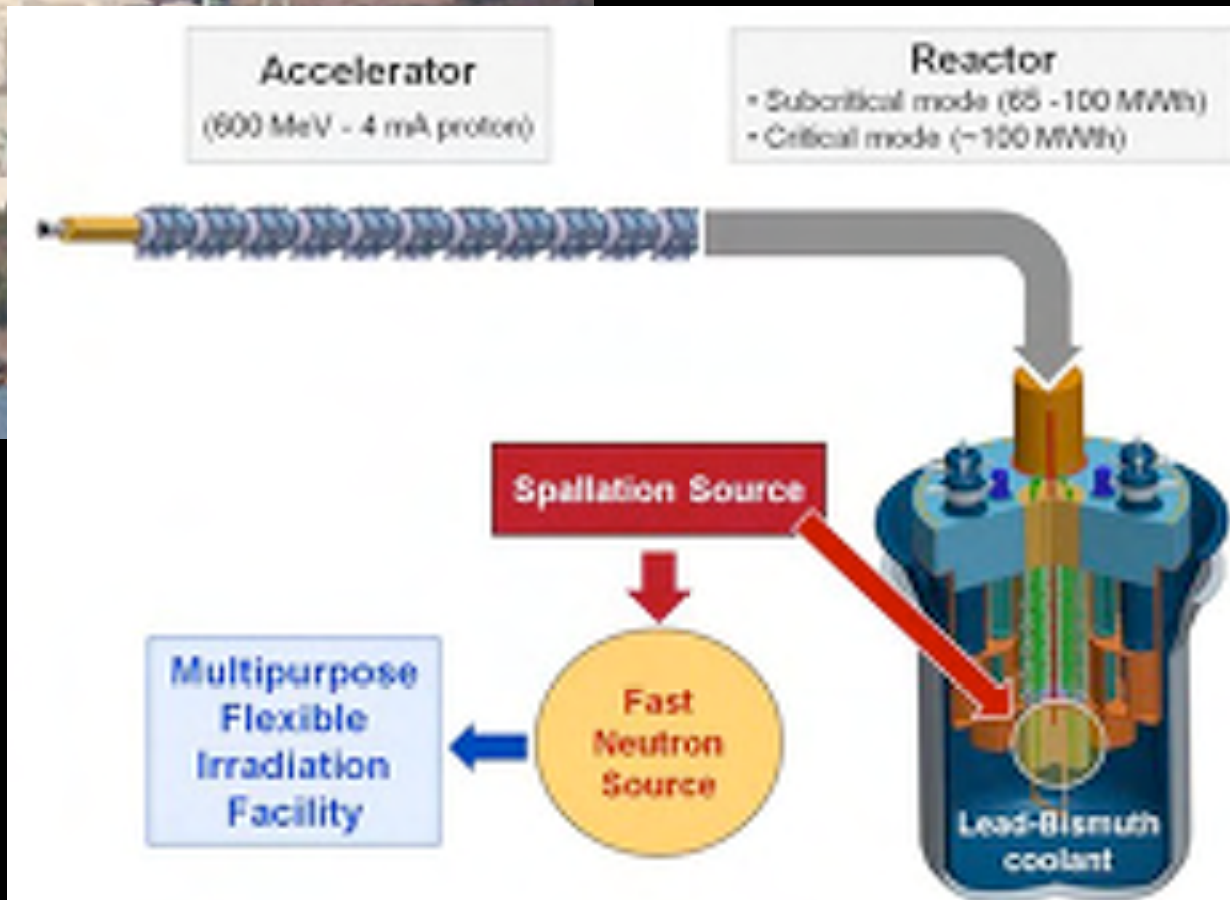
Sodium  
cooled



# Monju, Japan



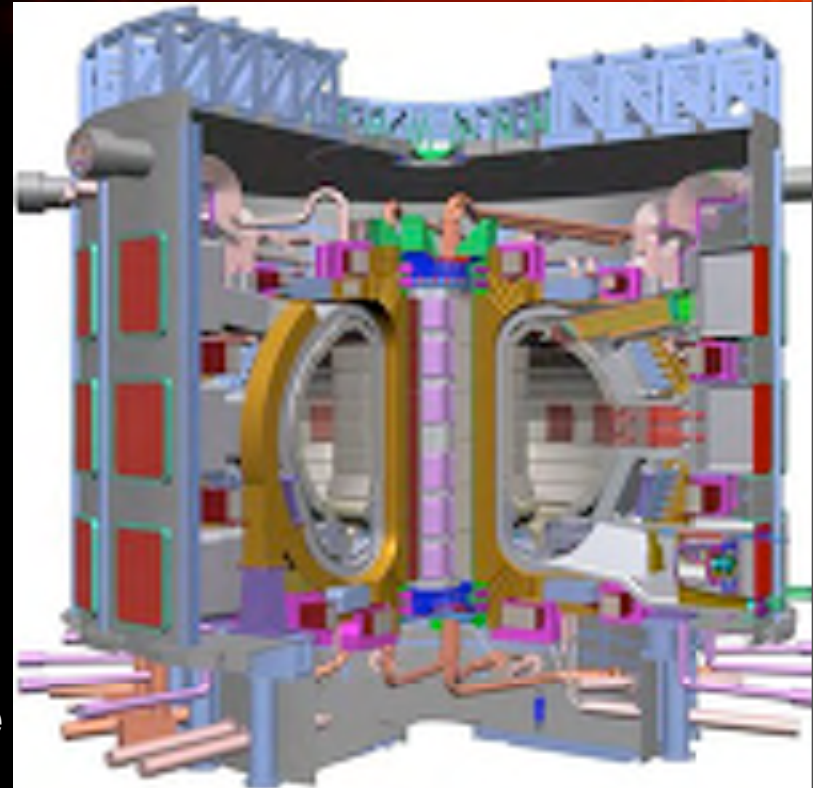
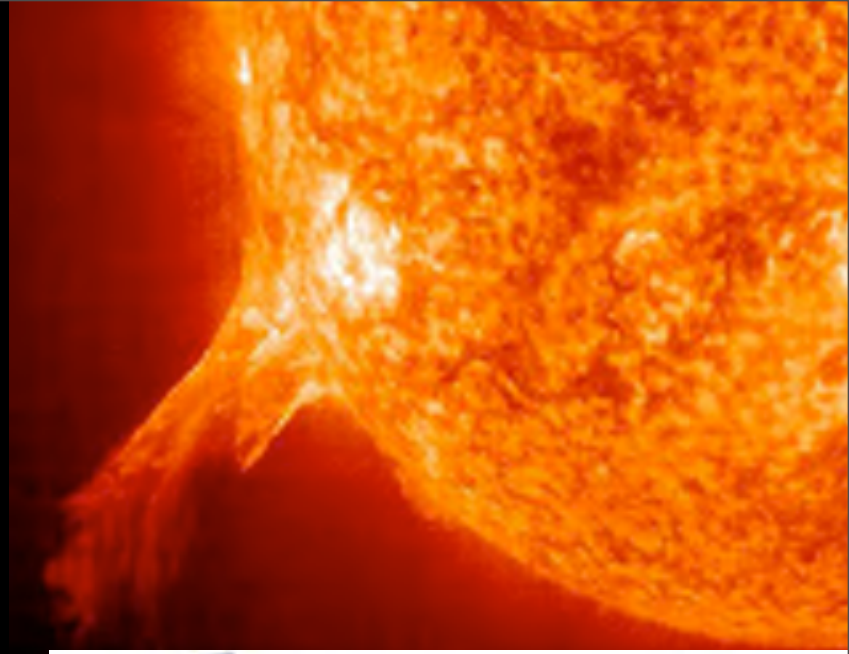
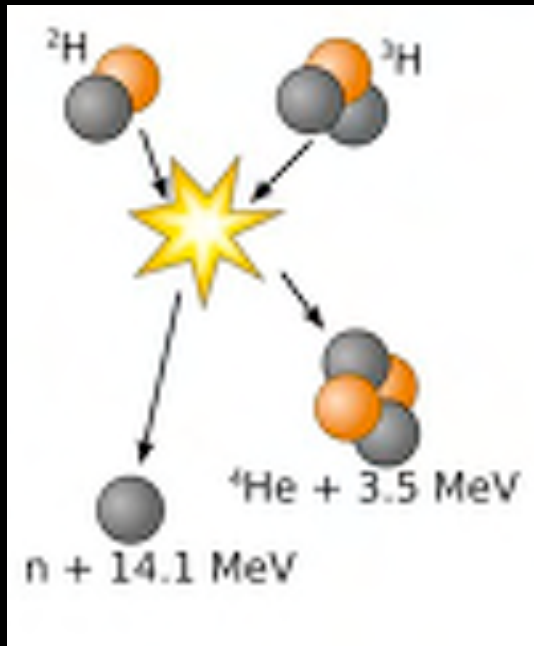
# MYRRAH, Belgium



# The future of nuclear power

## Fusion

Harnessing the power of the sun



ITER is being built in France with UK expertise



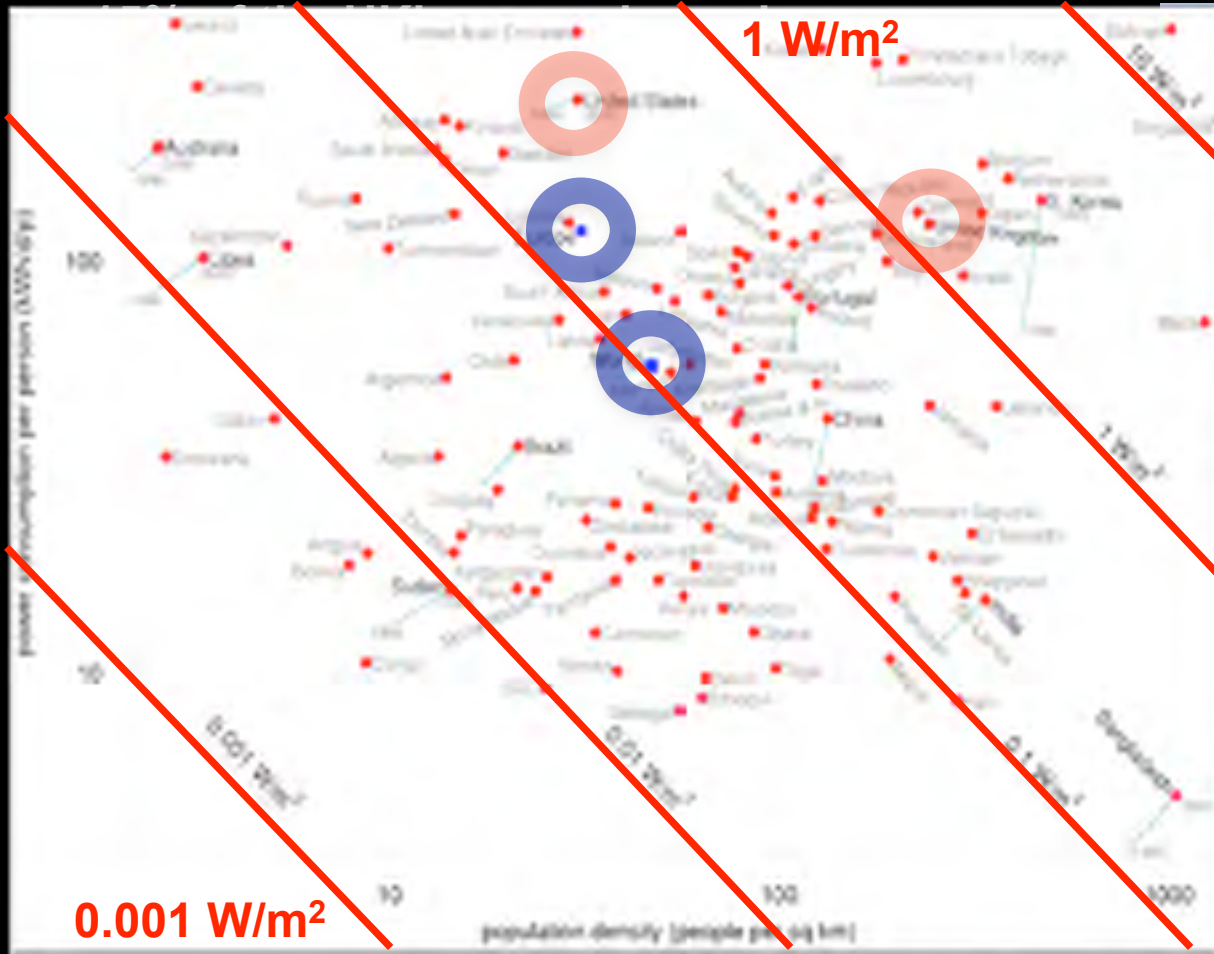
# UK Future Energy

Power consumption/person

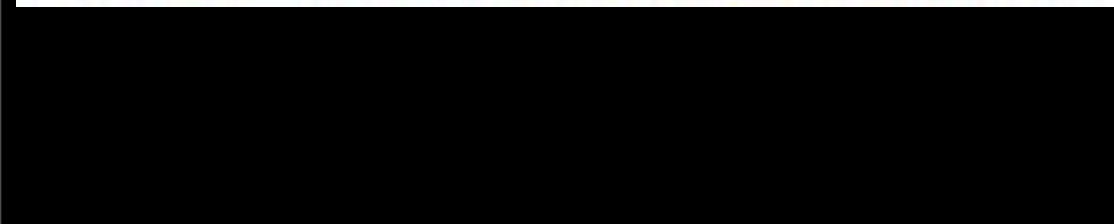
1 W/m<sup>2</sup>

0.001 W/m<sup>2</sup>

Population density



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A comprehensive survey of the population exposed to high level natural radon is presented. The population living in Krasnoyarsk is both in Russia, India, presents a unique opportunity for studies on the health effects of chronic exposure to low level radon. The co-environmental radon sources largely from the Russian deposited mostly along coastal areas. In certain locations on the coast, it is as high as 70 mBq/l-year and on average is 7.1 times the level found in coastal areas. Using gamma spectrometry, radon levels in more than 80,000 houses were measured; radon levels were also measured in the same houses compared. Of the total population of 40,000, 140,000 lived in areas with high natural radon. Information on lifestyle, socio-demographic factors, occupation, housing, radon source, and education level was obtained by house-to-house visits and examination of every resident individual. A population cancer registry system has been established to obtain cancer incidence rates. In the preliminary analysis, there is no evidence that cancer occurrence is consistently higher because of the levels of external gamma radon exposure in the area. Further chemistry, soil studies are needed along with biological studies. Studies of soil, radon in house, and the radon decay levels in houses are ongoing and health care control studies are continuing.