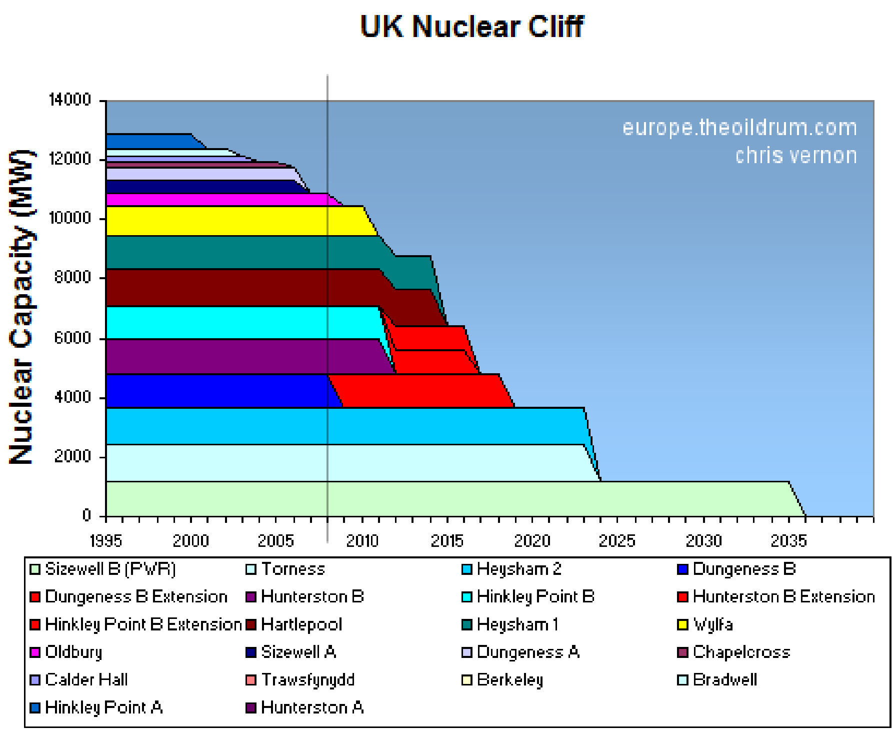
The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Nuclear Britain

Posted by Chris Vernon on January 15, 2008 - 3:45pm in The Oil Drum: Europe

On Thursday 10th January 2008 Business Secretary John Hutton announced to MPs that he was giving the green light for new nuclear build in the UK. He is inviting energy companies to bring forward plans to build and operate new nuclear power plants. However considering the nuclear cliff, has the decision come too late to maintain the nuclear contribution?



The nameplate capacity of the UK nuclear fleet, stacked, from the peak capacity in the late nineties and following the published decommission schedule. Three life extensions are shown in red. Source: British Energy & Nuclear Decommissioning Agency

Background

The UK pioneered civilian nuclear power generation with a young Queen Elizabeth II opening the world's first public grid connected power station on 17th October 1956. Calder Hall's four 50MW reactors were finally shutdown in 2003 after generating 70TWh of electricity and more than two tonnes of weapons-grade plutonium over its 47 years of operation. Astonishingly by today's standards, Calder Hall was designed, constructed and commissioned in just three and a half years following Prime Minister Winston Churchill's order in 1952. Amazing how quickly you can get things done when you don't know what you're doing!

Whilst this old power plant's electricity contribution was modest in the grand scheme of things its recent closure is representative of the fate facing the rest of the fleet in the near future.

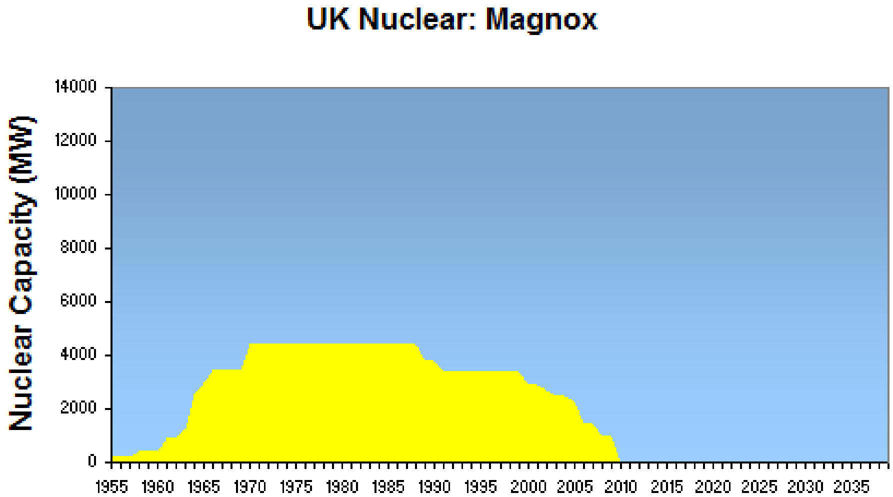
Oldbury Nuclear Power Station

This photo is my local nuclear power station, Oldbury on the East bank of the Severn Estuary, 15 miles north of Bristol. Opened in 1968 it is scheduled to close during 2008 with the loss of 435MW from its two reactors.

An important thing to remember about nuclear power plants is that they share a lot in common with fossil fuel plants. They generate electricity by using the heat given off by radioactive fission to raise steam which is then used in normal steam turbines. In the photo the turbine building can be seen in front of the two reactors. Each of the reactors at Oldbury for example generate 815MW of thermal output, of which only some 218MW emerges as electricity indicating a thermal efficiency of 27%. This is an important point to be aware of when making primary energy comparisons. The primary, chemical, energy contained in coal, oil or gas should not be compared directly with the electrical output from a nuclear power station without first accounting for this thermal efficiency, something to remember when looking at how many nuclear power stations it takes to replace fossil fuel depletion.

The British nuclear fleet is now split into two categories. There are the nuclear legacy sites which are now under the control of the Nuclear Decommissioning Agency (NDA) and the eight modern sites which remain under the control of British Energy. The NDA have responsibility for 20 civil nuclear sites including decommissioned research facilities, fuel plants, fusion research, storage sites and the Magnox fleet. 15 of those sites are managed by British Nuclear Group and Westinghouse under NDA contracts. These were until recently both British Nuclear Fuels (BNFL) group companies but Westinghouse was recently sold to the Toshiba Corporation to the surprise of many outsiders considering the then uncertainly surrounding the nuclear industry in the UK.

Magnox Fleet



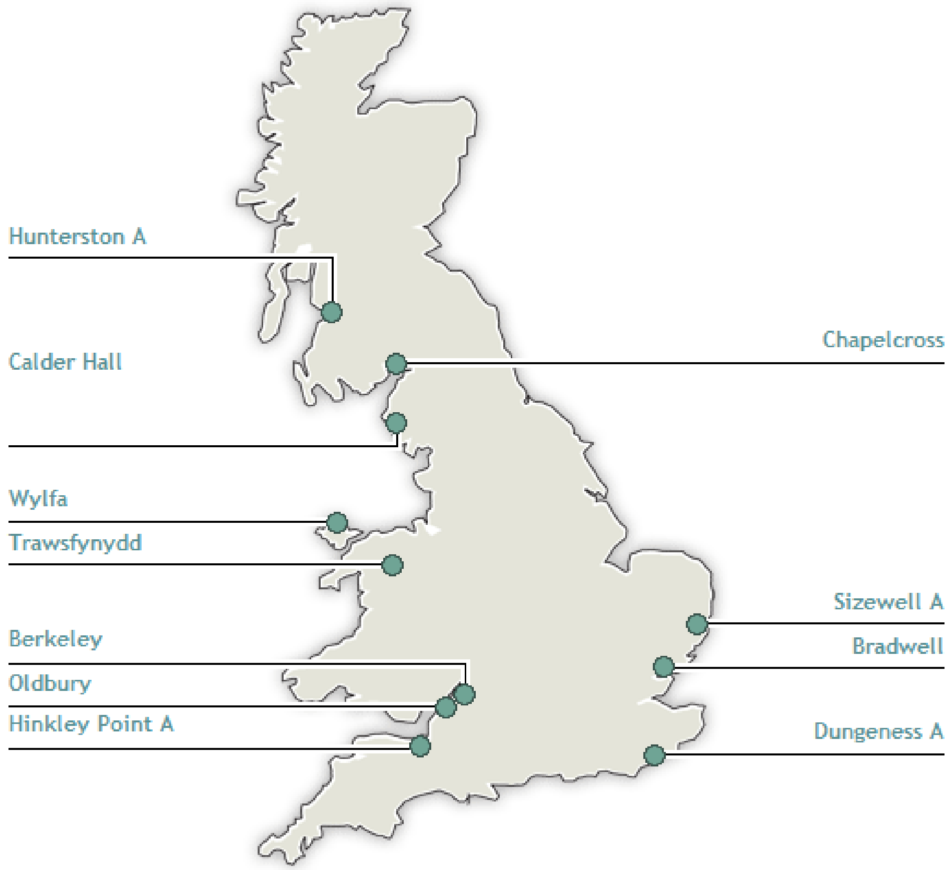
The nameplate capacity of the UK Magnox nuclear fleet, stacked, following their construction and decommission schedule.
Position mouse pointer over the chart to reveal power station breakdown.

Magnox is short for Magnesium non-oxidising and refers to the alloy of magnesium and aluminium used as a cladding for unenriched uranium metal fuel. The design was initially created to produce weapons-grade plutonium but later larger reactors were exclusively used for civilian electricity generation. It is said that North Korea used the Magnox design developed from the declassified blueprints of Calder Hall to generate plutonium for their nuclear weapons programme.

The decommission schedule is almost complete now with the end of the Magnox era clearly in sight, due significantly to the fact that the fuel assembly corrodes in water, limiting storage and the required fuel reprocessing plant is also at end of life. The decommissioning project is extremely complex since no consideration was given to decommissioning during the design and build in the 50's and 60's. This was a phase of nuclear R&D resulting in many one-off designs and very poor records of site inventories, how the site was used and in some cases a lack of design drawings! Such problems are not expected when the British Energy sites are decommissioned. A wealth of information is available at the above linked websites.

	Build Date	Capacity MW	Published Lifetime	Decommission Age
Hunterston A	1964	360	1989	25
Berkeley	1962	276	1989	27
Trawsfynydd	1965	390	1991	26
Hinkley Point A	1965	470	2000	35
Bradwell	1962	242	2002	40
Calder Hall	1956	194	2003	47
Chapelcross	1959	196	2005	46
Sizewell A	1966	420	2006	40
Dungeness A	1965	450	2006	41
Oldbury	1967	434	2008	41
Wylfa	1971	980	2010	39

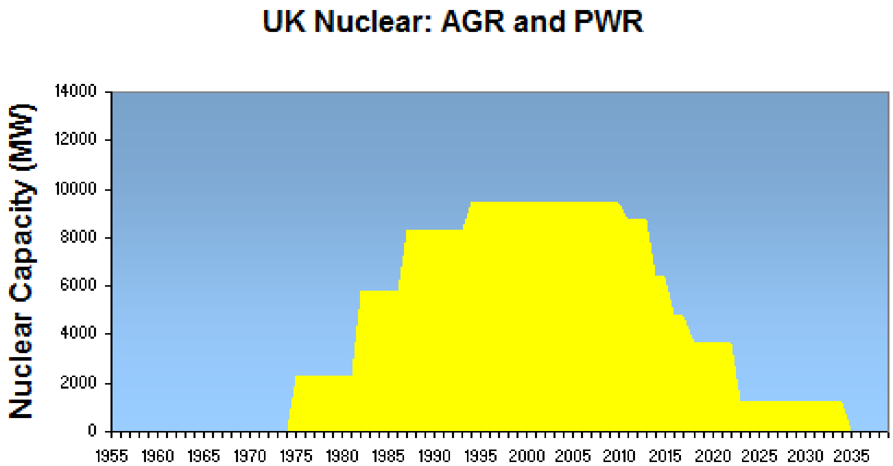
The nameplate capacity and life of the UK Magnox nuclear fleet.



The Magnox fleet

All the power stations are built approximately at sea-level on the coast, with the exception of Trawsfynydd located on lake in Wales. The long-term decommission schedule is unclear but over 100 years is not unreasonable. The Nuclear Decommissioning Authority currently have plans for 125 years. Any new build will most likely be on existing sites therefore maintaining operational power stations until at least 2080 followed by their decommission process. Placing such long lasting and potentially vulnerable assets at sea-level, given the current uncertainly surrounding ice-sheet melt sounds risky to me. If the main reason for reusing existing sites is public pressure this seems an unreasonable risk.

AGR and PWR Fleet



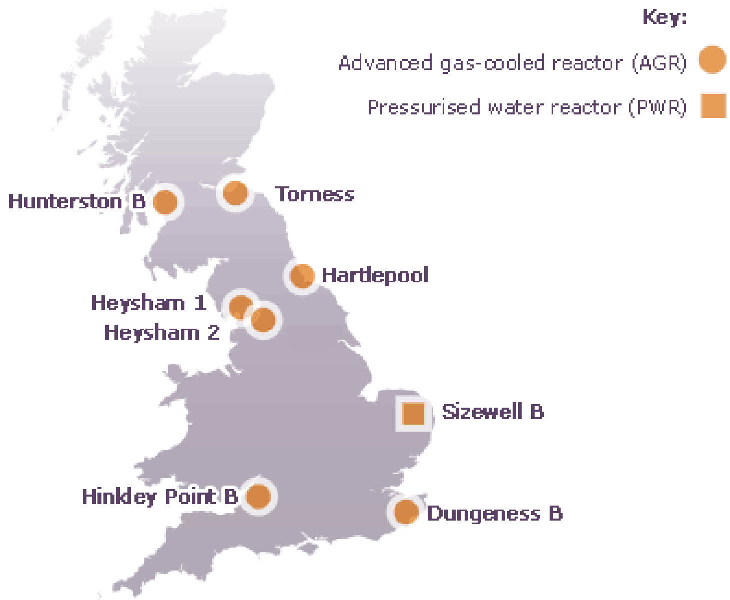
The nameplate capacity of the UK AGR and PWR nuclear fleet, stacked, following their construction and decommission schedule.
Position mouse pointer over the chart to reveal power station breakdown.

Whilst the Magnox fleet's time has all but passed the future of the more modern British Energy sites comprising of seven advanced gas-cooled reactor (AGR) power stations and one pressurised water reactor (PWR) is not quite as certain. British Energy was privatised in 1996 with what was then seen as the commercially viable British nuclear interests. The private venture didn't turn out to be particularly viable though with the government forced to invest £3bn in 2004, assume liabilities worth between £150m and £200m p.a. over the next ten years and reclassify the company as a public body. The 1996 privatisation had netted just £2.1 billion.

The red areas in the chart above illustrate the recently granted extensions. Dungeness B's operation was extended by 10 years from 2008 to 2018 and more recently Hunterston B and Hinkley Point B were extended by 5 years from 2011 to 2016. The extension of the latter two, as well as only being 5 years came with a caveat. The output has been reduced to 70% of full power. The three that have been granted extensions were, by no coincidence I'm sure, the first three to face decommission in 2008, 2011 and 2011 respectively. Without any other information to hand it is probably reasonable to assume similar modest extension to the remaining four - something that might become critical as we will see later.

	Build Date	Capacity MW	Published Lifetime	Decommission Age
Hinkley Point B	1976	1220	2016	40
Hunterston B	1976	1190	2016	40
Hartlepool	1983	1210	2014	31
Heysham 1	1983	1150	2014	31
Dungeness B	1983	1110	2018	35
Heysham 2	1988	1250	2023	35
Torness	1988	1250	2023	35
Sizewell B	1995	1188	2035	40

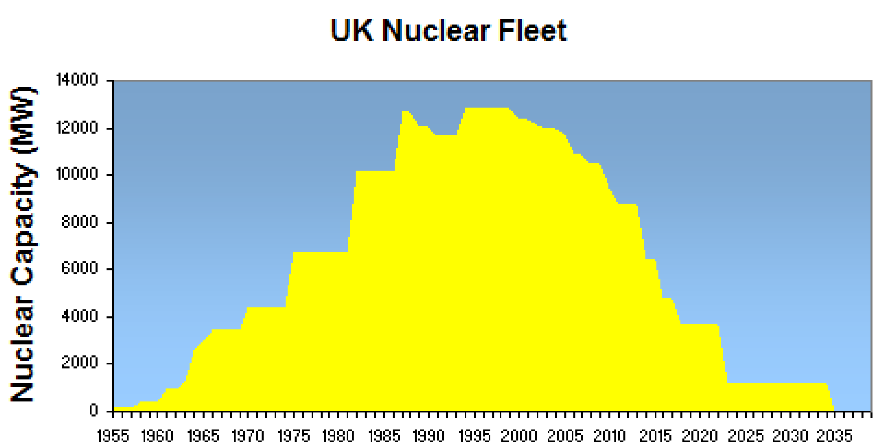
The nameplate capacity and life of the UK AGR and PWR nuclear fleet. Includes extensions (Dungeness B 10yrs, Hinkley Point B 5yrs, Hunterston B 5yrs)



The AGR and PWR fleet

Again, sea level, coastal locations.

The UK Nuclear Fleet



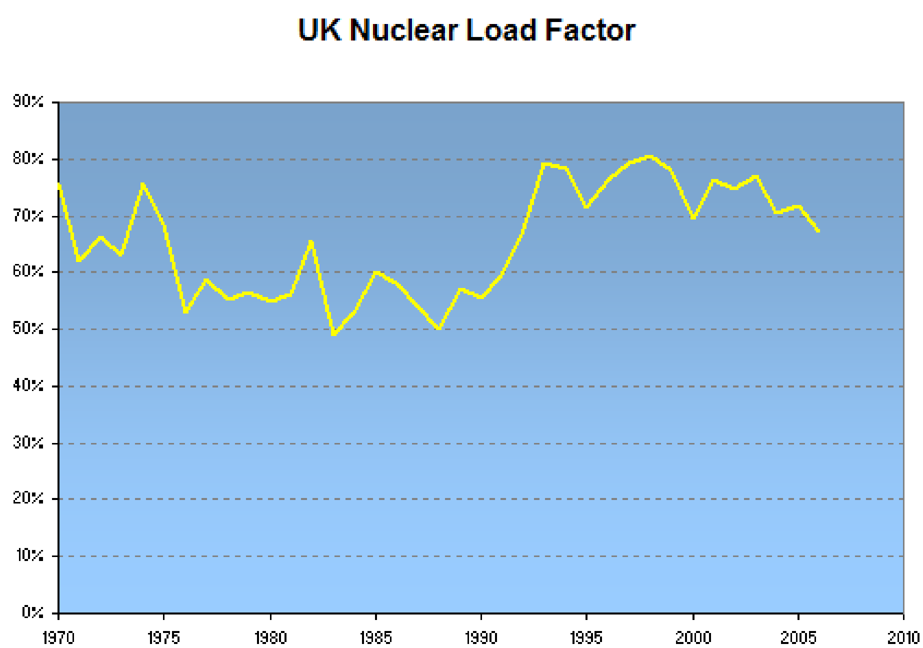
The nameplate capacity of the UK nuclear fleet, stacked, following their construction and decommission schedule.
Position mouse pointer over the chart to reveal power station breakdown.

Combining all the power stations produces the above chart.

One interesting observation is that if we sum the annual nameplate capacity from the grid connection of Calder Hall in 1956 to 2007 to produce a total energy figure of 389 GWyears and similarly sum the capacity from 2008 to the decommission of Sizewell B in 2035 to produce 123 GWyears we can say we have depleted 76% of our installed capacity. This percentage assumes a constant load factor however the situation is probably worse as the load factor is decreasing as the infrastructure reaches end of life. The UK's installed nuclear resource is as depleted as our North Sea oil and gas resource!

Load Factor

In 2006, in nameplate capacity terms the nuclear fleet represented 15% (DUKES 5.7) of grid connected capacity, this is slightly misleading as the load factors of generators vary with nuclear being higher than average, 69.3% opposed to 52.8% for the average load factor over all plant (DUKES 5.10). Despite its relatively low nameplate proportion nuclear managed to generate 19% (DUKES 5.1) of the UK's electricity in 2006. As the fleet ages though, this high load factor can not be assumed to remain. The chart below shows how the nuclear fleet's load factor has declined over the last decade after a string of technical problems reduced the operation hours.

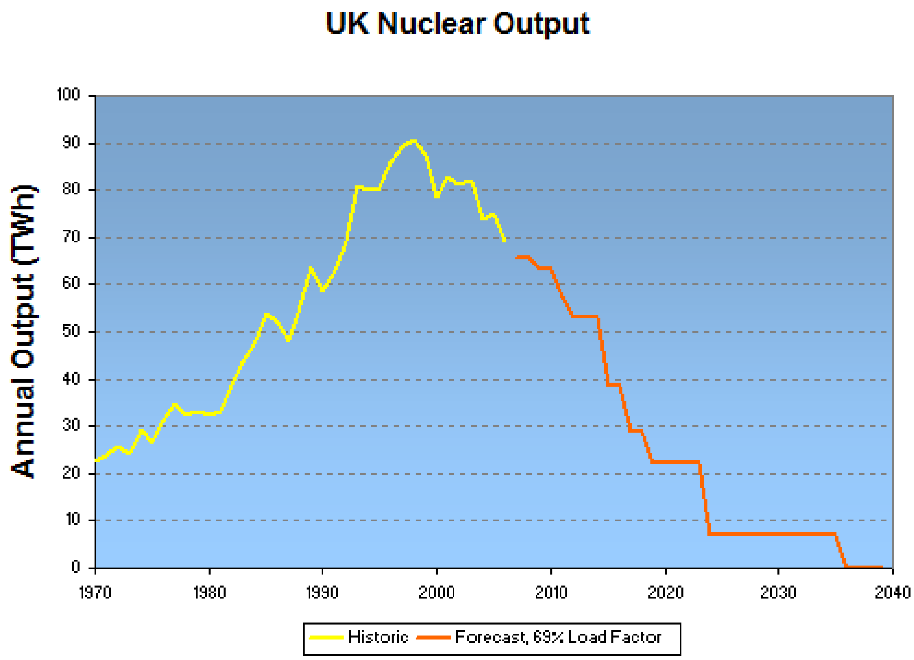


Load factor of the UK nuclear fleet. Generated by dividing the nameplate capacity by the annual output.

I have no explanation for the low load factor in the late 70s and 80s. I can hypothesise that during this period the new AGRs were commissioned (two in '76, three in '83 and two in '88) and that in the first few years, during their commissioning they were operating at significantly less than optimal load factors for tests and observations.

The data for 2007 is not available yet but given the increased level of closure last year I can only assume the figure will be significant lower, low 60s I expect. The power derating of the extended AGRs above is not the same as reducing load factor but is analogous in that less electricity will be produced in the future than the nameplate capacity would suggest.

Looking forward, assuming the current load factor of 69% can be maintained the output of the existing fleet will decline as shown below. Remember the 2006 data point was only 19% of the total supply.



UK nuclear output, forecast based on decommission schedule and 69% load factor.

New Nuclear Build

On Thursday 10th January 2006 the widely anticipated announcement came, the green light for new nuclear build in the UK. Business Secretary John Hutton announced to MPs:

> "The Government believes it is in the public interest that new nuclear power stations should have a role to play in this country's future energy mix alongside other low-carbon sources, that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations and that the Government should take active steps to open up the way to the construction of new nuclear power stations."
>
> "It will be for energy companies to fund, develop and build new nuclear power stations in the UK, including meeting the full costs of decommissioning and their full share of waste management costs,"

It has taken a long time and two consultations to reach this decision and it is important to note that this isn't the Government ordering power stations, they will be built with private money, Hutton confirming there would be no subsidies except in event of emergency at a nuclear plant.

This 6 minute video package was broadcast by BBC's Newsnight programme on Tuesday 8th January 2008. It provides a good background and touches on many of the main points.

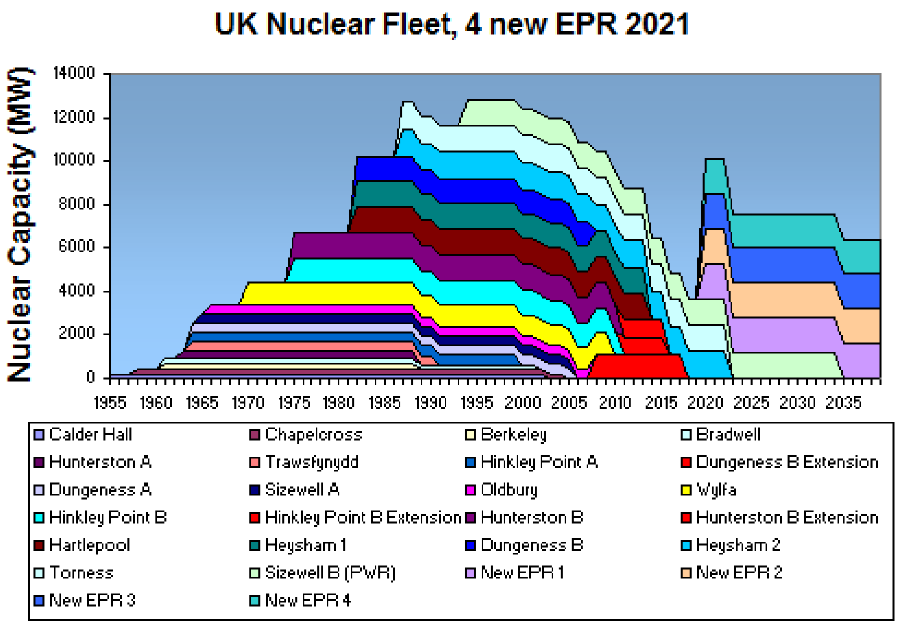
The clip reports the Government's consultation as saying even if the decision to build new power stations was taken today, would be 8 years before construction would begin, going on to add construction would take an optimistic 5 years meaning new power stations could not be online before 2021.

EDF Energy anticipated this decision and in September of 2007 submitted the plans for their 1.6GW EPR (Evolutionary Power Reactor) power station to the UK regulators for design assessment (Press Release) . Detailed information on this design is available from the EDF/AREVA website: www.epr-reactor.co.uk. This is the same design as is being built in Finland at Olkiluoto and in France at Flamanville.

The Finland build is the first one and has had some problems. Initially it was meant to cost 3.7bn euro and be complete in 2009, construction started in 2004. Since then there has been a 2 year slip and the cost increased by 1.5bn euros. So we're looking at 7 year build time and 5.2bn euro (£3.9bn).

What if the UK does manage to create the environment needed for EDF to build? Newsnight's 2021 figure assumed 5 years. If there's one thing that the UK doesn't have a good reputation for it's building large capital projects on schedule. 5 years is likely too optimistic, lets say 7 years but also cut a couple of years off the planning/regulatory approval stage bringing us back to 2021. Let's order 4.

The chart below shows what 4 new 1.6GW EPRs in 2021 do for the UK fleet. A sizeable gap remains and why some are calling the decision of new build too little, too late. The new capacity does not come online soon enough. However, Heysham 1 and Hartlepool have not yet been granted extensions, if like the three AGRs before them they are also granted extensions the gap closes up considerably. Position your mouse pointer over the chart to reveal the impact.



The nameplate capacity of the UK nuclear fleet, stacked, following their construction and decommission schedule and including 4 hypothetical 1.6GW EPRs in 2021.
Position mouse pointer over the chart to reveal impact of 6 year extensions to Heysham 1 and Hartlepool.

The extensions I've hypothetically added to Heysham 1 and Hartlepool are 6 years and derated to 70%, I don't think this is unreasonable and it does make a real difference. A sizeable gap still remains, capacity stands at a minimum of 5.3GW in 2019 and 2021, down from 10.9GW in 2008 representing a loss of 5.6GW. I think this is the best realistic scenario for future nuclear output (I don't think bringing on new generation before 2021 is realistic) so in that sense the decision has come too late - if the goal is to maintain >10GW of nuclear capacity. Of course this isn't a universal goal and some would be quite happy to see the back of nuclear altogether but this article is only considering the energy contribution of the nuclear fleet.

John Hutton said in his speech that he hoped the first new reactors would be online by 2018. I'm of the opinion he's basing that hope more on the nuclear cliff graph than realistic analysis of how long it will actually take. He needs the first one in 2018. If it's taken this long to get this far, how long is it going to take to (a) choose a design and (b) create the commercial environment the manufactures will demand?

A loss of 5.6GW generating capacity doesn't sound awful until we consider the background against which it is likely to occur. UK gas production will be almost over by the end of the next decade leaving the country reliant on imports from Norway, Russia and beyond. This raises serious question marks over the long term viability of the 36% (2006 DUKES 5.1) electricity the country currently generates from gas. In addition to that approximately one third of the existing coal fleet is scheduled to close under the EU Large Combustion Plant Directive. In times of hardship EU directives will be the first thing to ignore but even the coal supply is questionable as the UK imports most of its coal and is now competing in an increasingly competitive market.

In 2006 the UK generated 394 TWh of electricity - what will the country generate in 2020?

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