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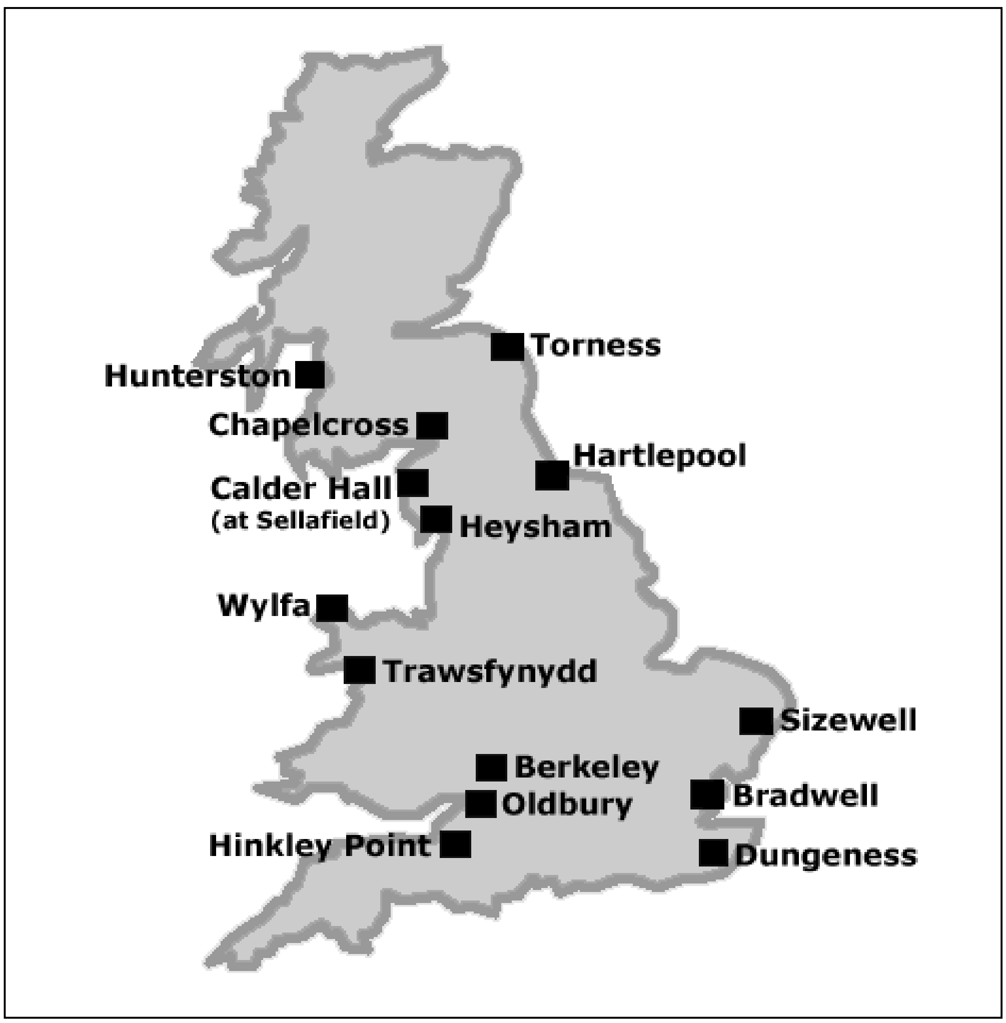
New reactors - more radioactive waste, same old problems

Britain stands at a crossroads in energy policy. One direction leads to more nuclear power stations. The other leads towards the sustainable exploitation of energy from the wind, waves and sun.
The decision should be easy. Renewable energy is affordable, safe and clean and the UK has some of the best resources in Europe. Wind power at sea alone could meet our electricity needs three times over and bring thousands of jobs to the UK.
Yet the Government is considering a proposal to build 10 more nuclear power stations[1].

This document outlines what we know about the plans:
- Where they might be built
- The types of nuclear power stations British Energy favour
- The nuclear waste problems and accident risks that would arise.

10 more nuclear power stations – where?

The nuclear power station operator British Energy has suggested that its new nuclear power stations should be built next door to its existing sites or those run by BNFL (the operator of Sellafield)[i]. The map below shows these potential locations:



What nuclear stations are they considering building?

Nuclear power stations of any type essentially follow the 1950s idea of using heat from a nuclear reaction to create steam. The steam drives turbines connected to generators that produce electricity. This complex, expensive and inherently dangerous technology generates not only electricity but also large amounts of highly radioactive spent fuel and other nuclear wastes that can remain lethal for millions of years. There is also the risk of accidents, like Chernobyl, with appalling long-term consequences for health, the environment and the economy.
British Energy identifies two nuclear power station designs as possibilities for the UK: the Westinghouse AP 1000 and the AECL CANDU NG[ii].

AECL CANDU NG (ACR)

Atomic Energy of Canada Ltd (AECL) has on the drawing board a number of variations of its original CANDU (Canadian Deuterium[iii] Uranium) reactor. These are referred to as the ACR (Advanced CANDU Reactor) and as yet are unlicensed and untested in Canada or anywhere else.

These reactors use heavy water (like H_20 only with a heavier isotope of hydrogen) as a coolant and to act as a 'moderator' that sustains the nuclear reaction.

The UK previously operated a similar prototype heavy water reactor, the Steam Generating Heavy Water Reactor (SGHWR) at Winfrith in Dorset. This reactor type was evaluated and rejected for future UK nuclear power stations, prior to the adoption of the PWR for Sizewell B in Suffolk.

It would seem that the CANDU is included by British Energy as a negotiating position with BNFL/Westinghouse. It does not appear to have been evaluated and costed to the same depth as the AP 1000 alternative. AECL is another example of a loss-making nuclear company that is relying upon government aid for continued trading. The fact that it is not a British-owned company is not likely to count in its favour.

Whilst it remains untested on AECL's drawing board, details of the new generation CANDU are unavailable. However, many of the generic issues raised for the AP 1000 (see below) apply. If built they would produce large quantities of nuclear waste, for which there is no safe solution, and they would be vulnerable to accidents or sabotage that have widespread, long-term consequences for our health and environment.

Westinghouse AP 1000

Westinghouse is owned by BNFL, the technically bankrupt operator of the notorious Sellafield nuclear site.The AP 1000 is a scaled-up version of the smaller Westinghouse AP 600 Pressurised Water Reactor (PWR). Neither of these designs has yet been built anywhere in the world[iv].

The new version is similar to the original PWR design that has been around for more than 50 years (as used by the Sizewell B station in Suffolk). Water flowing through the reactor core, which is packed with nuclear fuel, is heated by the nuclear reaction. It does not boil because it is under very high pressure. The hot water passes into steam generators where the heat is exchanged to water in second circuit. This water boils to create the steam that drives the turbo-generators.

Radioactive waste from new reactors

All nuclear power stations create large quantities of radioactive wastes for which there is no safe solution. Some wastes will remain lethal for millions of years. Radiation is known to cause cancer and genetic defects and has been linked to other

health problems such as asthma and heart disease. There is simply no safe dose as far as radiation is concerned. Any increase in exposure increases the risk of harm.[v]

The waste generated by the nuclear industry comes in various forms:

- Gases and liquids that are routinely discharged into the air and sea
- Solid wastes of various forms that become radioactive during the operation of the stations. These are either dumped in a landfill near Sellafield in Cumbria or stored on site.
- Intensely radioactive spent fuel that has been used in the reactor. This is sent by train to Sellafield for reprocessing[vi] (a process whereby the spent fuel is dissolved in acid and separated out into plutonium and other wastes, creating greater volumes and types of radioactive wastes to deal with).
- When it comes to the end of its life, the contaminated building and machinery of a decommissioned reactor.

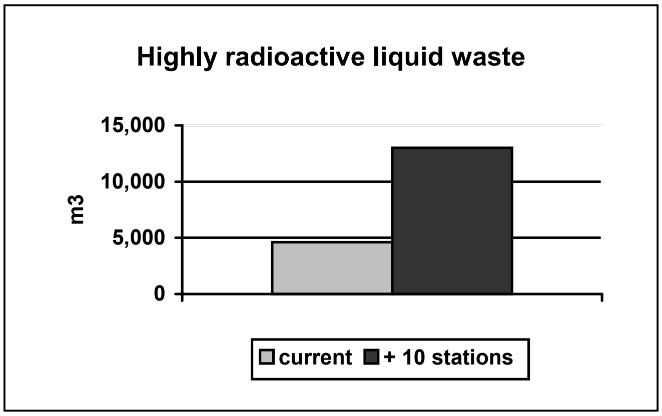
Approximately 500,000 tonnes of radioactive waste will have been accumulated by the end of this century from existing nuclear installations[vii]. Building 10 more nuclear power stations will, of course, add to the problem.

As none have yet been built, there is little information on the radioactive waste that will be generated by new nuclear reactors such as the AP 1000. However, the volumes of waste produced can be assumed to be the same as that generated by the similar-sized, most recent UK nuclear power station, Sizewell B. Therefore, we can estimate what the additional radioactive waste burden from the new nuclear power stations will be (Table 1).

Table 1: Estimates of radioactive wastes from 10 new nuclear power stations

Waste type	each reactor over 60 years	10 reactors over 60 years
Operational wastes[viii]	1,700 m^3	17,000 m^3
Decommissioning wastes	7,000 m^3	70,000 m^3
Highly radioactive spent fuel[ix]	1,980 t	19,800 t

If reprocessed, the spent fuel from 10 more nuclear power stations would lead to an additional 13,000 m^3 of the most dangerous radioactive wastes that would need to be dealt by this and future generations – at least double the volume that has already been created[x].



For purposes of comparison, the radioactivity contained in these highly radioactive liquid wastes would be around 60 times more than estimates for the radioactivity released when the Chernobyl nuclear power station exploded in 1986[xi].

Where will the radioactive waste go?

The Government is embarking once again on a process that will probably lead to a proposal for nuclear waste being dumped down one or more deep holes (the option favored by the nuclear industry).

Until deep dump sites are identified, some wastes will be sent to a shallow burial site near Sellafield in West Cumbria. The rest will be stored at the nuclear power stations themselves or at Sellafield.

Thus locations for additional nuclear power stations will also serve as radioactive waste storage sites for an indefinite period of time. It is likely that these stores will be quite sizeable given that, at the same time as constructing more nuclear power stations, the existing stations will be coming to the end of their lives. Nuclear power station sites would have to cope with the new wastes that are generated and the vast quantities that arise during decommissioning of the old reactors.

The search for the dump and eventual construction (in the event that that occurs) is likely to take several decades. Criteria the Government and industry will use to pick potential sites will include:

- Geological considerations
- Transport issues - where the wastes will be located and where they will have to end up
- 'Willingness' of communities to accept them (usually places already dependent on the nuclear industry).

The most recent search for a dump picked a site at Gosforth near Sellafield. Sellafield has by far the largest amount of accumulated waste and most other industries in West Cumbria have been allowed to die whilst BNFL has been continually propped up by the Government for decades. In the end, the proposal floundered when the planning inquiry found that the geology is unsuitable: it is geologically complicated and, is likely to have leaked like a sieve and contaminated important water sources.

Where might they look next time? At the Gosforth planning inquiry it was revealed that the type of geology considered most 'suitable' is the type found underlying East Anglia[xii]. In fact three East Anglian sites were short-listed last time.

Considering the criteria it uses, the Government will be looking for somewhere near an existing nuclear power station (large quantities of waste will be stored there and it will have an existing 'nuclear community') in East Anglia. If you are fond of a bet, Sizewell would be a good tip.

If a dump goes ahead it will be impossible to contain the waste indefinitely. It will eventually leak and allow radioactivity back into the environment as the waste containers disintegrate. The radioactive wastes will remain potentially lethal for millions of years. Long before then seeping radioactivity will pose serious health risks to ourselves and future generations.

Greenpeace believes that every step should be taken to isolate nuclear waste from the environment. For this reason, Greenpeace opposes disposal of nuclear waste deep underground. The only way to 'solve' the problem of nuclear waste is to not produce it in the first place. For existing wastes, above ground storage is the only method for isolating them and ensuring that they are properly monitored so they can be retrieved and repackaged should leaks be detected. Sadly, the nuclear industry has committed future generations to deal with the wastes accumulated over the last 60 years. The least we can do is bequeath them the possibility of controlling them.

Accident scenario

The safety of PWR-type reactors centres around keeping the core and the nuclear fuel sufficiently cool at all times to prevent the fuel melting down.
The worst group of accidents involve some part of the complicated reactor circuit failing. In a few fractions of a second, the pressure drops allowing the water to flash into steam and making it unable to cool the nuclear fuel sufficiently. Unless checked, the overheating fuel will melt and control of the nuclear fission reaction will be lost. If there is a significant release of radioactivity, the consequences could be catastrophic: immediate deaths to workers, emergency personnel and others who may be in the immediate vicinity; widespread long-term fatal and non-fatal diseases to thousands; vast areas rendered uninhabitable for decades; devastating impacts on food production and economies.

Inherently unsafe

The main differences between the original and new PWR designs concern the emergency safety systems, particularly the emergency core cooling systems[xiii]. Westinghouse has recognised that, no matter what the designers intend to happen, they can not engineer what the operators will do when faced with a potential catastrophe.
For the AP 1000, Westinghouse's response is to remove many of the emergency components, such as pumps and valves, which require human intervention or power. Instead the design places greater emphasis on gravity and convection (so-called passive safety systems: the 'P' in AP 1000) to keep the reactor from overheating. Removing many of the reactive and proactive intervention safety systems also allows Westinghouse to cut costs.

The key failings with this approach have long been recognised by those involved in nuclear reactor safety design:

"A nuclear reactor can never be completely inherently safe because it contains large quantities of radioactive materials to generate usable heat-energy." **[xiv]**

As for all technologies, even the best designs can never assure absolute safety from accident or attack.

"Nuclear power plants are very large, very complex systems that cannot be completely accurately modeled .... Current plant performance statistics must not be accepted as "good enough" because they may not be good enough for the future, and one accident is one too many."xv

Westinghouse is relying on theoretical calculations and computer models, some of which were originally formulated for the smaller AP 600[xvi]. Even if the nuclear boffins managed to avoid making mistakes in their immensely complicated calculations, it is by no means certain that real nuclear power stations will behave in ways the scaled-up theoretical calculations say they will.

"Where reliance is placed solely on inherent safety features or on purely passive engineered safety features, it would not be possible for an operator to select or even influence the final condition of the plant." **xvii**

There is a trade-off in trying to remove human error. What if the emergency event has not been predicted by designers and requires intelligent intervention by the operators? Reliance on passive safety systems could result in a worsening situation with the plant workers left with no means to do anything about it.

"However, many new reactor designs are actually more vulnerable to terrorist attacks than existing designs. For example, the Westinghouse AP600 has only a single instead of a double containment so that heat would be removed more quickly in the case of a loss of coolant accident. Increasing the containment thickness to protect against aircraft collisions would put the safety design of this "inherently safe" reactor back on the drawing board."**xviii**

Since the emergency cooling for the AP 600 and AP 1000 has to be entirely passive, this heat transfer role means that Westinghouse has had to sacrifice some of the structural integrity of the dome. As a consequence, it will be less able to withstand natural hazards, such as earthquakes, and accidents and deliberate actions such as aircraft impact and nearby explosion.

The design and licensing of nuclear reactors and other highly hazardous plants have involved assessing the risk of a number of predictable, 'unintelligent' accidents.
After the recent appalling terrorist atrocities we now live in a world where the inconceivable is possible. The hazards facing nuclear power stations include deliberate attack on a scale that can topple enormous skyscrapers with devastating effect.
Engineers will not be able to calculate the risk of, or defend, any nuclear power station - old or new – from a fanatical yet intelligent act of this sort.

Conclusions

As the 10 new nuclear power stations do not exist, there are many things about them that are unknown. However there are also some certainties:

- 10 more nuclear power stations will substantially add to the existing radioactive waste crisis
- More nuclear power stations mean an increased risk of catastrophic accident that could devastate our health, the environment and the economy for generations. Nuclear power is not worth the risk

We can meet our energy needs several times over by harnessing simple energy efficiency technologies together with the sustainable energy production technologies that modern-day technical insights in the fields of quantum physics, fluid dynamics and electronics have brought us: solar, wind and wave power. The lights will stay on without nuclear power.

Notes & sources:

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[i] British Energy, 'Replace Nuclear with Nuclear', Submission to the Government's Review of UK Energy Policy, September 2001, para. 29.

[ii] BNFL press release, "British Energy and BNFL sign reactor agreement", 26 February 2002.

[iii] Deuterium is an isotope of Hydrogen, a constituent of heavy water.

[iv] PIU, 'The Economics of Nuclear Power', Energy Review Working Paper, February 2002.

[v] NRPB (1995) Risk of radiation induced cancer at low dose rates for radiation protection purposes. Documents of the NRPB Vol.6 No.1.

[vi] In the case of Sizewell B, spent fuel is temporarily stored on site.

[vii] Michael Meacher, Environment Minister, House of Commons, Hansard, 31 January 2002, column 470W.

[viii] Derived from Sizewell B projections in the 1998 United Kingdom Radioactive Waste Inventory (NIREX, 1999), taking account of the assumed reactor capacity (1000MW compared to 1258MW for Sizewell B) and the extended life (60 compared to 40 years).

[ix] Tonnes of uranium assuming similar performance of current PWR fuel at around 33MW(th) per metric tonne of heavy metal.

[x] The volume of highly radioactive liquid wastes produced by the UK's existing nuclear power stations is approximately 4,600 m^3. The reprocessed fuel of 10 more reactors running for 60 years would produce around 13,000 m^3.

[xi] 13,000 m^3 of highly active liquid wastes contains around 730 x 10^{18} Bq of $\beta\gamma$ radioactivity. The World Nuclear Association estimates the total release from Chernobyl to be 12 x 10^{18} Bq.

[xii] C.S. MacDonald (1996), Report of the Inspector, Appeal by United Kingdom Nirex Ltd, Proposed Rock Characterisation Facility on Land at and adjoining Longlands Farm, Gosforth, Cumbria, para.8.43.

[xiii] US Department of Energy (2001), Nuclear Energy Research Advisory Committee, "A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010", 31 October 2001.

[xiv] C.W. Forsberg et al. (1989), Oak Ridge National Laboratory, Proposed and Existing Passive and Inherent Safety-Related Structures, Systems, and Components (Building Blocks) for Advanced Light-Water Reactors, ORNL-6554, October 1989, pp. 1-2, as cited in Makhijani & Saleska, "The Nuclear Power Deception", Institute for Energy and Environmental Research, April 1996, http://www.ieer.org/reports/npd7.html

[xv] Leonard Jaffe (1996), "Technical Aspects and Chronology of the Three Mile Island Accident," in The Three Miles Island Nuclear Accident: Lesson and Implications, Annals of the New York Academy of Sciences, Volume 365, pp. 37-47, April 4, 1981 as cited in Makhijani & Saleska, "The Nuclear Power Deception", Institute for Energy and Environmental Research, April 1996, http://www.ieer.org/reports/npd7.html

[xvi] "Westinghouse will rely on Probabilistic Risk Assessment (PRA) calculations combined with data of component failure rates to design the AP1000's equipment for low risk performance. In addition, Westinghouse proposed to use test data developed for the AP600, and similar or identical components, since the U.S. Nuclear Regulatory Commission already approved the safety of the AP600", Nuclear Energy Institute, http://www.nei.org/doc.asp?catnum=3&catid=710

[xvii] Karlheinz Orth, Siemens AG, quoted in "Outlook On Advanced Reactors," Nucleonics Week, March 30, 1989, pp. 1-20.

[xviii] WISE News Communique (1998), "New generation: The AP 600", (492.4881), May 22, 1998, http://www.antenna.nl/wise/492/4881.html