Nuclear Free Local Authorities
briefing

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Subject: Nuclear Plant Life Extensions – the Risk of a Lifetime?

i. Overview do report

This report has been prepared by the NFLA Scotland Policy Advisor for the upcoming NFLA Scotland autumn seminar in Glasgow City Chambers on the 26th October. It provides members with an important analysis of the concerns and issues the NFLA has with decisions to extend the plant life of a number of aging nuclear reactors in Scotland and England.

The NFLA Scotland Policy Advisor will be presenting this report at the seminar, along with wider issues over Scottish radioactive waste policy. Registration for the seminar is still open. A flyer can be found on the NFLA website homepage http://www.nuclearpolicy.info and if you would like to attend the seminar please email Cathy Birrell, NFLA Scotland Secretary – cathy.birrell@glasgow.gov.uk – as soon as possible.

1. Introduction

On 16th February 2012 EDF Energy announced that it expects to extend the operating lives of its 14 advanced gas-cooled reactors (AGRs) by an average of seven years — two years longer than its previous estimate of only a year earlier. (1) By 2014, EDF Energy appeared to increase its planned average life extension to eight years. (2) In 2010, EDF Energy also announced it is preparing for a 20-year life extension for its single pressurized water reactor (PWR), Sizewell B. Closure had been planned for 2035 after a 40-year accounting lifespan, but now EDF hopes to keep the reactor open until 2055. (3)

After a series of announcements about life extensions for: Hinkley and Hunterston (4); Dungeness (5); Hartlepool, Heysham and Torness (6), as of September 2017, the expected closure dates for EDF Energy's nuclear stations are now as shown in the table below.

AGR Power Station	Net MWe	Start of Construction	Start of Commercial Operation	Closure date for accounting purposes	Age at closure
Hinkley Point B	955MW	1967	1976	2023	47yrs
Hunterston B	965MW	1968	1976	2023	47yrs
Dungeness B	1050MW	1965	1983	2028	45yrs
Hartlepool	1180MW	1968	1983	2024	41yrs
Heysham 1	1155MW	1970	1983	2024	41yrs
Heysham 2	1230MW	1980	1988	2030	42yrs
Torness	1190MW	1980	1988	2030	42yrs
Sizewell B	1198MW	1988	1995	2035 (2055)	40-60yrs

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2. Regulatory Approval Required

EDF Energy's various announcements about Plant Life Extensions (PLEX) usually make no mention of the Periodic Safety Reviews (PSR) which regulators carry out on old reactors. A PSR is carried out for each operating nuclear power station in the UK every ten years. The review requires an operator to prove that its nuclear power plant is safe and complies with site license conditions. So, theoretically ONR could force closure of a nuclear reactor before EDF's closure date for accounting purposes.

There is no opportunity for public intervention in the PSR process, and the Office for Nuclear Regulation (ONR) is not required to consult the public on issues related to nuclear safety. However, it is worth noting that strong local campaigns for the closure of ageing Magnox stations based on health and safety concerns might well have had an influence on decisions taken by ONR and the nuclear operator in the past, as a number have closed after completion of the PSR process.

ONR says it is working with EDF Energy to extend the life of its nuclear power stations and that it is "*content for the plants to continue to operate*", as long as they complete satisfactory Periodic Safety Reviews (PSRs), and the results from routine maintenance, inspection and testing continue to support the agreed plant safety case. (8)

On 23rd June 2014 Caroline Lucas MP asked the Secretary of State for Energy and Climate Change what the timetable was for the next periodic safety review (PSR) of each of the UK's nuclear power stations. The timetable given was as follows:

Station	Submission to ONR	ONR Decision Date
Hinkley Point B/Hunterston B	January 2016	January 2017
Dungeness B	January 2017	January 2018
Hartlepool/Heysham 1	January 2018	January 2019
Heysham 2/Torness	January 2019	January 2020
Sizewell B	January 2024	January 2025

Since then the PSR process for Hinkley Point B and Hunterston B has been completed (see below), and ONR has confirmed that EDF Energy submitted its third ten yearly periodic review of safety report on Dungeness B to ONR for assessment. ONR's assessment will conclude at the end of January 2018. (9) Fulfilling the requirements of the regulatory process is, of course, no guarantee of safety. The oldest reactor at Fukushima in Japan received a ten year life-extension from regulators just one month before the earthquake and tsunami. (10)

3. Safety of Ageing Reactors

The Union of Concerned Scientists (UCS), based in the US, describes the profile of risk over the lifetime of a reactor as a 'bathtub' curve. New reactors start out as a high-risk as they are 'broken-in'. In the middle of their life, reactors should be in peak health where the risks are at their lowest. Then as reactors get older they enter a 'wear-out' phase with a high risk that components will wear out and fail. (11)

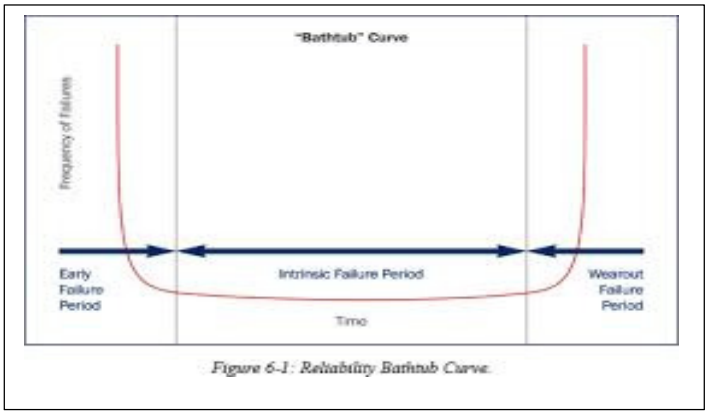

Figure 6-1: Reliability Bathtub Curve.

A major study of reactor hazards by two leading scientists and an international energy specialist, published by Greenpeace in April 2005, concluded that risks from ageing reactors are higher as age related degradation mechanisms are not well understood and are difficult to predict. AGRs do not have a secondary containment, so there is a possibility of large radioactive releases should something go wrong. (12)

Hinkley Point B and Hunterston B opened in 1976 which makes them older, or the same age as, all but one of the eight reactors which Germany has already shut down. A report published in 2006 by Large Associates – an independent nuclear engineering consultancy – on problems at Hinkley Point B (which are also likely to apply to its sister station – Hunterston B) analysed a bundle of documents received under the Freedom of Information Act. It concluded that there are:

"…*significant uncertainties over the structural integrity and residual strength of the moderator cores in … AGR plants … in view of the increased risk presented by continued operation of these nuclear plants, the reactors should be immediately shut down and remain so until a robust nuclear safety case free of such uncertainties has been established*." (13)

John Large said it was "*gambling with public safety*" to allow Hinkley Point B and Hunterston B to continue operating. (14) The documents, written by the former Nuclear Installations Inspectorate, (now ONR) reveal that AGRs are structurally defective and their continued operation is increasing the risk of a radioactive accident. The graphite bricks which make up the reactor cores of the AGRs are cracked. These bricks help to control the nuclear reaction by influencing the speed of neutrons. Channels also run through the bricks which enable key safety mechanisms, such as the entry of control rods designed to shut-down the reactor in an emergency. However, the cracked graphite bricks could cause safety mechanisms to fail in a severe event and the nuclear fuel to overheat, potentially resulting in a radiological release. (15)

4. Graphite Core

In 2016, BBC Radio Four's Costing the Earth programme (16) investigated whether it is safe to keep running the AGRs long past their expected lifespan of about 30 years. Five of Britain's seven AGRs are already older (Torness and Heysham 2 are 29 years old).

In 2005 the Nuclear Installations Inspectorate (now the Office for Nuclear Regulation -ONR) expressed concern about the structure of the reactor core. The core is made up of 6,000 graphite blocks. Around half of these are 1 metre tall with a bore or channel running through each block. Around 200 of these channels contain rods of nuclear fuel. If anything goes wrong control rods are inserted between the channels to dampen the nuclear reaction and shut down the reactor.

Nuclear Engineering consultant John Large explains that graphite is not elastic, it doesn't bend, and it is not particularly strong. And now the graphite bricks are cracking. The core is an assembly of several thousand bricks, loosely stacked together and the expectation was that the core would never fail, so there was no facility to replace any individual blocks if they did become damaged. But now there are physical changes occurring in the core, in the individual bricks – cracking and fracturing – that must result in some loss of strength – not only of the individual bricks, but of the core as a whole.

The BBC used a Freedom of Information request to obtain a number of documents. One paper from ONR reveals that one third of the channels inspected at Hinkley Point B and Hunterston B contain what they describe as significant cracks. EDF says the cracks were anticipated at this stage in the reactors' life and it is safe to operate for years to come. It says evidence suggests that its predictions about cracking are accurate. Brian Cowell, director of nuclear operations, says: "*in fact we are looking to extend life further (than 2023) if we can*." The analysis suggests that we can have more than 1,000 axial cracked bricks and still operate with massive margins of safety.

1,000 cracked bricks would exceed the current safety limit set by ONR, but the regulator is considering changing that limit. Mark Foy – Deputy Chief Nuclear Inspector says the percentage of cracked bricks ONR is currently happy to accept is 10%, but they are considering increasing that to 20%. Foy says that the original safety case provided by EDF was on the basis of 10%

cracking. As experience is gained and analysis and research is undertaken it allows EDF and ONR to gain a more informed and accurate view of what is acceptable and what isn't. EDF has now provided ONR with a safety case for allowing 20% cracking. This is based on the analysis EDF has undertaken; samples they've taken and the inspections they've carried out. The focus has been to look at the likelihood of core disruption after an earthquake which could prevent the control rods being inserted. ONR told 'Costing the Earth' that it was considering the new safety case to allow 20% cracking.

5. Keyway Route Cracking

The ONR is also investigating a very specific and more concerning form of cracking. The keyway is a slot that holds each graphite brick to the adjacent brick, the bricks underneath and the bricks on top. These keyways, which are acknowledged to be the limiting factor in the life of these reactors, are beginning to fracture.

John Large points out that this will make the graphite blocks a very loose set of bricks. Prof Paul Bowen of Birmingham University sits on the graphite technical advisory committee for ONR. He says the keyway cracks could potentially prevent the entry of the control rods. If the core distorts too much, it's easy to see how trying to feed anything in could become very difficult. Seven of the keyways have been discovered to have cracks at Hunterston B.

John Large believes the presence of keyway cracks casts doubt on the safety of the reactor in the event of an emergency like an earthquake. We have a cracked and deteriorating core that's lost its residual strength and we don't know by how much. Some of the design case accidents will test the core – one of these would be a seismic shake where the whole core is wobbled. If the core becomes misaligned, and the fuel modules get stuck in the core, the fuel temperature will get raised and could undergo a melt. If the radioactivity gets into the gas stream and the reactor is venting because it's over pressurised then you have a release to the atmosphere and you have dispersion and a contamination problem.

ONR agrees keyway cracks could compromise safety. One of the documents the BBC obtained said the discovery of keyway route cracks at Hunterston invalidates the previous safety case. EDF had to consider what information to present to ONR to satisfy them that the reactor was still safe to operate. EDF brought in articulated control rods and nitrogen injection systems to address the extra risks posed by the keyway route cracking. The new rods are bendy making them easier to insert into a distorted core and an injection of nitrogen could buy several hours of invaluable time in the event of an accident.

However, concern remains because it is not certain how many keyway route cracks there are. John Large explains that to examine where the cracks are the operator would have to take the fuel out of the reactor and put a camera down to inspect the inside of the bore, but these keyway cracks are on the outside of the bricks so you can't actually see them. It is very hard to inspect the channels in which the fuel sits. Around 10% are inspected each time the reactor is shutdown. So there may be keyway route cracks that have never been seen at Hunterston and Hinkley. In the absence of a full visual inspection a mathematical model is used to work out the likelihood of cracks in particular parts of the reactor.

The trouble is that the model has already been shown to be flawed. Professor Paul Bowen says they have not been able to get the exact timing of the cracks right. The industry argued that cracks would appear first in layers 4 and 5, but they actually appeared in layer 6. John Large says the model relied upon by ONR is not working, so they cannot predict the strength of the core. More to the point they cannot work out where to put their investigative probes to see where cracking is taking place. So they are in the dark, which is of real concern to the NFLA.

6. Strict Regulation?

ONR claims that it strictly regulates the state of the graphite bricks. However, in June 2014, it approved a request by EDF Energy to increase the limit of graphite weight loss from 6.2% to 8%, at Dungeness B. (17) Subsequently EDF Energy published more information about graphite loss across the AGR fleet. Hunterston & Hinkley Point B had an estimate weight loss of 12.8% and a limit set at 15%. (18) So the limit will probably need to be raised if Hunterston B is to continue generating until 2023. Independent nuclear commentator, Peter Lux, points out that the 12.8% figure is for the core as a whole. Some areas might have over 40% weight loss. Short of decommissioning the reactors it is very difficult to accurately determine the weight loss and cracking in the bricks. This level of weight loss was not expected when the reactors were originally designed and the weight loss and cracking is still not adequately understood. (19)

Steve Thomas, Emeritus Professor of Energy Policy at the University of Greenwich, said that the company had given average weight loss figures, but this masked the fact that some parts of the graphite core had lost up to 40% of their weight. "*It just smells bad when you hit the limit and then you try to change it and then you change it again,*" he said. "*It looks a little bit compliant that the nuclear industry asks for it and the regulator says 'OK yes, you can have that'. The [regulator] looks a bit captured to me*." (20)

7. Hunterston & Hinkley PSR

In February 2017, ONR published its assessment of the Periodic Safety Review (PSR) for Hunterston B (HNB) and Hinkley Point B (HPB). It also accepted EDF's revised graphite core safety case for both sites, but included a number of recommendations as part of this acceptance. Acceptance of the safety case is reliant on a revised inspection and monitoring strategy. (21)

In November 2015, EDF Energy said it had found cracks in three of the graphite bricks in one of the Hunterston B reactors. Similar cracks were found in October 2014 in two of the graphite bricks of the other reactor. Costing the Earth revealed that the ONR was considering doubling the limit it had set on the percentage of cracked bricks it is willing to accept from 10% to 20%. This has been a particularly controversial part of this process with people living near these reactors finding it difficult to understand why the definition of "safe" seems to be changing.

ONR has now agreed to this increased limit. It says:
"*Continued operation of HPB/HNB reactors is now supported by NGL's [EDF's] safety case NP/SC 7716 which sets an operational limit of 20% cracking in the core. The justified period of operation of each reactor at HPB/HNB is therefore dependent upon the findings from the inspections at each outage*."

The ONR is also concerned about Keyway Route Cracking (KWRC) with seven of the keyways discovered to have cracks at Hunterston B. As mentioned above the presence of keyway cracks the core could become misaligned, and the fuel modules could get stuck in the core. If this happened the fuel temperature would rise and could undergo a melt. If the radioactivity gets into the gas stream and the reactor is venting because it's over pressurised then you have a release to the atmosphere and you have dispersion and a contamination problem.

ONR said that EDF had attempted to predict the rate of KWRC. Originally the first cracks were not expected to occur until 2019, but the first KWRC was observed at Hunterston B in 2015. Inspection will "*play a crucial role in supporting the period of safe operation of the reactor in later life*," the regulator said, adding that certain improvements are necessary, such as the development of a capability to measure the condition of control rod channels. EDF Energy should develop improved inspection and monitoring technology; in particular equipment capable of performing visual inspection and dimensional measurements of control rod channels, it said. (22)

8. Environmental Impact Assessment

The discovery of cracked graphite bricks in some of these reactors has raised questions about whether it is safe to keep running them long past their expected lifespan of about 30 years. People living nearby are beginning to demand a say in whether or not ageing reactors with cracked graphite bricks and graphite weight loss should have their lives extended.

Spokesperson for the Stop Hinkley Campaign, Roy Pumfrey, said:
"Hinkley Point B is over 40 years old and well past its sell-by date; its ageing problems are now getting deeply worrying. It is time to shut it down – permanently. EDF is gambling with public safety, but this is a lottery we are not prepared to take part in. Despite the fact that cracks are beginning to appear in the graphite core of these reactors, increasing the risk for us all, ***we haven't been asked once for our opinion about extending their life****."* (23)

Now, an international convention known as the UN Convention on Environmental Impact Assessment (EIA) in a Transboundary Context, or the Espoo Convention has said that all aging nuclear power stations in Europe should have an environmental impact assessment (EIA) before a licence renewal or the approval of a 10-year periodic safety review. An EIA will have to compare the potential impact of extending the life of an old reactor with supplying energy from alternative sources such as renewable energy, as well as involve the public in the decision making process. (24)

Unfortunately, in June 2017, the most recent Meeting of the Parties to the Espoo Convention, failed to endorse draft decisions on non-compliance prepared carefully and over the course of a few years by the Convention's Implementation Committee. Instead the Meeting created a working group to clarify the need for transboundary environmental assessments when extending the life of old reactors. (25)

9. Scotland

Despite their opposition to the construction of new nuclear reactors, Scottish Government Ministers have said they will not block applications by EDF Energy to continue running Torness and Hunterston beyond their current licences. (26) In 2011, Fergus Ewing, Energy Minister at the time, told the Scottish Parliament there was a "*rational case*" for extending the life of Scotland's two nuclear plants, and that the Scottish National party (SNP) government was "perfectly open" to the continued use of Hunterston and Torness power stations, to ensure there was security of supply. He told the Parliament that the two power stations could continue to generate electricity "providing that the case is justified on economic and environmental grounds". He added: "*That case exists, and it exists because of the need for security of supply. We have always acknowledged that, although we are clearly opposed to the building of new nuclear power stations*." (27)

10. Conclusions

EDF Energy's announcement about extending the life of its AGR stations means that some of them could be open for as long as 47 years compared to the original design life of around 30 years. Given the problems of cracking in the graphite bricks in the core of the reactors and particularly the Keyway Route Cracks, and the difficulty of detecting where and when these cracks have occurred or will occur, this has created some public concern.

Whilst the nuclear regulator strictly regulates the state of the graphite bricks in AGRs, there remains concerns from independent experts that lifetime extensions are becoming a more problematical process. NFLA encourages a more in-depth debate between the regulator and such experts.

What is most worrying is that the local communities are being asked to take a risk with these graphite bricks when they have not been asked for their opinion. NFLA recommend local authorities around nuclear sites should consider calling for full environmental impact assessments (EIA) being carried out before a licence renewal or the approval of a 10-year periodic safety review is made, in order to encourage an informed public discussion.

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