NFLA Policy Briefing No.205

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Subject: The future of the AGR nuclear reactor fleet – to be closed sooner than expected by EDF?

i. Overview of report

This NFLA Policy Briefing has been requested by the NFLA Scotland Forum and drafted by the NFLA Scotland / Steering Committee Policy Advisor. The NFLA has taken a real interest in whether the Hunterston B Reactors 3 and 4 will be restarted. They have been closed for some considerable time in the past year due primarily to issues over keyway root cracking of the graphite bricks that surround the reactor. The issues that relate to Hunterston B though have parallels for the entire existing fleet of Advanced Gas Reactors (AGRs) that were built in the 1970s and early 1980s. This report considers whether this fleet of aging reactors run by EDF are failing, and considers what the consequences of such issues means for the nuclear industry in the UK.

1. Introduction

In 2004, British Energy, owners of the UK's Advanced Gas-cooled Reactor fleet at the time, revealed that cracking of the graphite bricks in the core of the reactors could potentially mean that currently assumed nuclear power station lifetimes may not be achieved, particularly at Hinkley Point B, Hunterston B, Heysham 2 and Torness. (1) In addition, between 2006 and 2008, Hunterston B, Hinkley Point B, Hartlepool and Heysham 1 all had problem with their boilers.

All of the AGRs are scheduled to close permanently between 2023 and 2030, but all also have graphite cores that bring their lifespans into doubt. All 14 of the AGRs will eventually exhibit some form of cracking towards the end of life, according to Chief Technical Officer for Generation at EDF Richard Bradfield: "There are two irreplaceable components on an advanced gas-cooled reactor: the graphite and the boilers." (2)

In theory most of an AGR plant can be replaced, except for key components within the reactor pressure vessel such as the boilers and the graphite core. The boilers -- or steam generators -- are subject to thermal creep because of the high temperatures to which they are exposed (~600℃). At Hinkley Point B and Hunterston, core temperatures have been lowered over the last decade or so to reduce this problem. That strategy seems to have proved to be successful. But there is no similar treatment for the problems that graphite poses. "Graphite, across the AGR fleet, in most cases, will be the lead component in ending lifetime for our fleet," according to EDF. The two main graphite risk factors are weight loss and brick cracking. Weight loss is caused by radiolytic oxidation due to gamma irradiation in a CO2 environment, and is a problem because it steadily reduces the core's neutron moderation capability. Cracking is caused by changes to the properties of the bricks themselves caused by radiation. (3)

2. Boiler Problems

Over the winter of 2006/7 all four reactors at Hunterston B and Hinkley Point B were closed for more than six months because of cracked boiler tubes. After repairs the reactor were operated at about 60-70% of capacity until further checks from February 2008. (4) In October 2007 Hartlepool Reactor 2 and Heysham 1 Reactor 1, were closed as a precautionary safety measure after corr-

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-sion of a wire winding, which helps to hold the water-cooling system together, was discovered during a planned inspection Hartlepool Reactor 1.The fourth reactor, Heysham 1 Reactor 2, was already on a refuelling outage, so its return to service was delayed because of the wiring problems. (5) Then in 2014, Heysham 1 and Hartlepool had to be shut because of unexpected cracking in the boiler spine - a forged metal tube which supports the weight of boiler tubes coiled around it. (6) The ageing reactors were restarted at just 75-80% of their usual output in order to prevent high temperatures causing further cracks. EDF Energy said at the time, it may take two years to bring them back up to full power. (7)

3. Graphite Weight Loss

In June 2014 the loss of weight in the graphite bricks of several AGRs became an issue, with concern expressed by a number of independent nuclear consultants that the Office for Nuclear Regulation (ONR) was switching its guidelines to suit the needs of EDF. The regulator approved a request by EDF Energy to increase the limit of graphite weight loss from 6.2% to 8%, at Dungeness B. (8) Subsequently EDF Energy published more information about graphite loss across the AGR fleet. Hunterston & Hinkley Point B had an estimated weight loss of 12.8% and a limit set at 15%. (9) So, the limit would probably need to be raised if Hunterston B is to continue generating until 2023. The 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. (10)

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.” (11)

4. Graphite Cracking

In 2006, Large Associates – an independent nuclear engineering consultancy – published a report on problems at Hinkley Point B (and other AGRs). This 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.” (12)

In 2016, the late John Large said it was “gambling with public safety” to allow Hinkley Point B and Hunterston B to continue operating. (13)

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.

John Large explained at the time to the BBC Radio 4’s ‘Costing the Earth’ programme that graphite is not elastic, it does not bend, and is not particularly strong. He argued that the graphite bricks are cracking and starting to lose weight due to decades of bombardment by radiation and the effects of the CO2 gas coolant on the material. The bricks are crucial to the structural integrity of the reactor cores and also act to moderate the nuclear reaction; it will not function without them. The cracking and fracturing must result in some loss of strength – not only of the individual bricks, but of the core as a whole. (14)

Up until the most recent Periodic Safety Review for Hinkley Point B and Hunterston B was approved in January 2017, the limit on the percentage of cracked bricks the ONR would accept was set at 10%. This was then increased to 20%. ONR’s Chief Nuclear Inspector Mark Foy told

‘Costing the Earth’ that the original safety case provided by EDF was on the basis of 10% cracking. As experience is gained and analysis and research are undertaken, he said, it allows EDF and ONR to gain a more informed and accurate view of what is acceptable and what isn’t. EDF provided ONR with a safety case for allowing 20% cracking, and this was agreed in early 2017. The focus of EDF’s case was on the likelihood of core disruption after an earthquake which could prevent the control rods being inserted.

The ONR is also concerned about a very specific form of cracking – keyway route cracking (KWC). The keyway is a slot that holds each 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 pointed out that this will make the graphite blocks a very loose set of bricks. He said the presence of keyway cracks casts doubt on the safety of the reactor in the event of an emergency like an earthquake. 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 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. (15)

At the time of the Periodic Safety Review, seven KWRCs had been found at Hunterston. (16) Reactor 3 was turned off for a ‘Graphite Inspection Outage’ on 9th March 2018 which was expected to last only until the end of the month. But EDF found a total of 39 KWRCs in the reactor. EDF said they are "happening at a slightly higher rate than modelled". (17)

Reactor 4 joined reactor 3 for a graphite inspection outage in October 2018.

In December 2018 EDF announced that, after inspecting around a quarter of Reactor 3, it had observed around 100 keyway root cracks “Using modelling to project the number of cracks across the whole reactor our best estimate of the current number of cracks is around 370. This takes the core over the operational limit of 350 contained in the existing safety case for that period of operation." (18)

30 KWRCs were observed in Reactor 4 which suggests around 200 over the reactor as a whole. A safety case for re-starting Reactor 4 was submitted to ONR in November 2018. But ONR requested further information from EDF in respect of multiply cracked bricks. A revised safety case was then presented in March 2019. (19)

Nuclear policy consultant, Dr Ian Fairlie, argued that the increasing number of cracks in the ageing reactors spelled their end. “There is only one thing you can do and that is close them, as they cannot be repaired,” he told The Ferret. “Although the risks of a major adverse event at Hunterston are relatively small, one has to take into account what the worst case scenario could be, and that is pretty serious indeed – the radioactive contamination and evacuation of both Glasgow and Edinburgh.” (20)

If an untoward incident were to occur – for example an earth tremor, gas excursion, steam surge, sudden outage, or sudden depressurisation, the barrels (or graphite bricks) could become dislodged and/or misaligned. According to John Large, the late independent nuclear engineer, this could in turn result in the following happening:

(a) control rods could be blocked from dropping into the reactor core by the resulting displaced graphite barrels. (Only 12 of the 81 control rods in R3 are articulated).
(b) coolant gas channels could become partly blocked by misaligned barrels, and

(c) fuel assemblies could become stuck and not be able to be withdrawn.

These events could in turn lead to large emissions of radioactive gases. Further, if hot spots were to occur and if nuclear fuel were to react with the graphite moderator they could lead to explosions inside the reactor core. ***In the very worst case, the hot graphite core could become exposed to air and ignite leading to radioactive contamination of large areas of central Scotland, including the metropolitan areas of Glasgow and Edinburgh.*** (21)

Reactor 4 was eventually re-started on 25th August 2019 after EDF's safety case was approved by ONR but it was given permission to operate for about four months (a core burn up of 16.025TWd). The "operational allowance" for cracks per reactor was doubled from 350 to 700. But ONR stressed that after four months EDF would again have to prove that it was safe to carry on running the reactor. (22) Reactor 4 was closed again on 10th December 2019.

In July 2019, while ONR was still considering the R4 safety case, the widening of some of the cracks in graphite blocks emerged as a new issue. This prompted the need for further analysis of the significance of crack openings greater than 1.2 cm wide (i.e. around ½ inch), a small number of which are predicted to occur in the next period of operation.

After permitting reactor four to restart for four months ONR posted five detailed technical reports online. One assessing "structural integrity" disclosed for the first time that some of the graphite bricks in reactors three and four have begun to disintegrate. (23) The graphite cores of the two Hunterston B reactors were beginning to crumble as cracks spread. ONR revealed that at least 58 fragments and pieces of debris have broken off the graphite bricks that make up the reactor cores. According to ONR there is "significant uncertainty" about the risks of debris blocking channels for cooling the reactor and causing fuel cladding to melt.

ONR warned that it will require "more robust arguments" before it agrees to allow the two reactors to restart in 2020. It also highlights concerns about the risk of "fuel snagging" from "multiply cracked bricks" and says that previous predictions have underestimated cracking. But EDF Energy insists that graphite debris does not "pose a risk to nuclear safety". ONR's additional requirements are about "theoretical risks which are extremely unlikely to develop", it says. (24)

4. Hunterston in 2020

Hunterston B has operated since 1976, and is due to be closed for good in 2023, which currently makes it 44 years old. It is older than, for example, Fessenheim, which was France's oldest nuclear power station but has just been switched off. (25) Reactor 3 has been offline for more than two years. Reactor 4 was first shutdown on 2nd October 2018 but was allowed a trial operation between August 2019 and 10th December 2019.

The estimated date for the return to service of the two reactors at Hunterston B in Ayrshire has been delayed yet again. Reactor 3 was previously expected, by EDF Energy, to return to service on July 13, but now won't be back in service until at least August 20th. Reactor 4 was previously due back on July 27th, but now won't return before September 17th. The return date of Reactor 3 has been postponed more than 10 times since it was first shut in March 2018. (26)

The safety case for restarting Reactor 3 was finally submitted to the Office for Nuclear Regulation (ONR) for its assessment on 15th April 2020 and for Reactor 4 on 29th May. (27)

Engineers from EDF have been trying to prove to nuclear inspectors at the ONR that it is safe to restart the two reactors and that with careful supervision, a cracked graphite core should be nothing to worry about. EDF may be hoping to restart the two reactors in August and September, but there are increasing concerns regarding revelations the graphite cores have begun to crumble as cracks spread. At least 58 fragments and pieces of debris have broken off the graphite bricks that make up the reactor cores. According to the Office for Nuclear Regulation (ONR) there is "significant uncertainty" about the risks of debris blocking channels for cooling the reactor and causing fuel cladding to melt. Such a disaster could result in a radiation leak and contamination right across the central belt of Scotland. Small wonder then that many local residents are pressing ONR to refuse EDF permission to restart these decrepit 44-year old reactors. (28)

EDF says it has spent more than £200 million on tests, inspections and creating quarter-scale models of the reactor cores that are shaken to mimic an earthquake to try to prove that the graphite is safe. EDF hopes the new safety cases will be approved soon to allow for six months of operation. That may pave the way for approval for Hinkley Point B with "pretty much the same safety case".

£200 million may seem like a lot of money, but it's only about one reactor's income for one year, so if it helps EDF keep its fourteen AGRs generating for longer it will have been well worth it for the Company. (29)

This has led to concerns that Hunterston is being used as a 'guinea pig'. The Conservative councillor for West Kilbride, Todd Ferguson, says: "I'm concerned that Hunterston B is being used as some sort of guinea pig, with the purpose being to supply data on how far you can push EDF's ageing AGR reactor fleet. The station has exceeded its life cycle and the time is right to start winding down operations safely. The safety of the workforce and local communities are paramount." (30)

EDF chose not to enter the two Hunterston B reactors into the capacity market auction in January, which would have offered it payments to guarantee that it would be available to generate in the period October 2022 to September 2023. This probably indicates a lack of confidence at EDF that the two reactors will remain in operation as far as September 2023. (31)

Another signal that suggests EDF are switching from generation to decommissioning is the fact that the generator has announced plans to submit scoping requests to North Ayrshire Council ahead of planning applications for waste facilities to support future decommissioning activities. As part of the preparations for decommissioning, EDF is planning to build a new intermediate level waste (ILW) store and two waste processing facilities on the B site with applications for planning permission submitted by early 2021, following a period of consultation with a range of stakeholders.

A final decision has still to be taken on the best route for storage of ILW from Hunterston B and EDF is still looking at a range of options including the shared use of the Hunterston A ILW store. But to ensure the site can move into de-fuelling with no unnecessary downtime, applications are being lodged now to speed up the process should EDF decide to build a new store.

Discussions are also reported to be underway between BEIS, EDF Energy and the NDA, to examine the future decommissioning of the AGR fleet when it is time for the reactors to come off line. As yet no decisions have been made, and those discussions continue. (32)

EDF Energy's Stations	Reactor Type	Net Capacity	Date Commissioned	Expected Closure Sate	Status July 2020
Hunterston B	AGR	965MW	1976	2023	R3 & R4 closed
Hinkley Point B	AGR	965MW	1976	2023	R3 & R4 closed
Heysham 1	AGR	1155MW	1983	2024	operating
Hartlepool	AGR	1185MW	1983	2024	operating
Dungeness B	AGR	1120MW	1983	2028	R21 & R22 closed
Torness	AGR	1190MW	1988	2030	operating
Heysham 2	AGR	1230MW	1988	2030	operating
Sizewell B	PWR	1198MW	1995	2035	1 turbine operating 1 closed

5. Hinkley Point B

However, it is not just the AGR of Hunterston B which are creating new problems for EDF. The two reactors at Hinkley Point B are arguably also on 'borrowed time' and are also due to shut for good in 2023. Although Hinkley Point B entered into the capacity market auction "it exited above the clearing price and therefore did not get an agreement. The revenues at the clearing price did not provide sufficient reward to take on the risk of penalties arising from non-delivery" (33)

Hinkley Point B's reactor 3 shut down for a graphite inspection outage on 8th June. It is not expected to go back on-line until at least 14th December. Reactor 4 has already been offline for a similar inspection since 21st February and is not expected back until 30th November. (34)

6. Hartlepool and Heysham 1

Hartlepool and Heysham 1 AGRs are both due to shut-down in 2024. Although they were entered into the capacity market auction for October 2023 to September 2024 and EDF says "we are confident they will operate to their scheduled closure date of 2024, they exited above the clearing price and therefore did not secure agreements. The revenues at the clearing price did not provide sufficient reward to take on the risk of penalties arising from non-delivery." (35)

Heysham 1 Power Station was recently served with an improvement notice by ONR after contravening safety regulations regarding the pressure systems of their nuclear reactor. The improvement notice was served on 4th June after shortfalls were discovered in the examination and inspection of the Reactor 1 pressure vessel. Nuclear reactor pressure vessels feature hundreds of sealed penetrations which must be routinely inspected to ensure they are free from defects. Out of the 600 penetrations in one of the reactors ONR found that EDF Energy had failed to examine 11 penetrations within the intervals specified in the written maintenance scheme. EDF must comply with the improvement notice served to them by the ONR and complete the 11 overdue examinations by December 18, 2020. (36)

7. Dungeness B

On 27th August 2018 Dungeness B shut down Reactor 22 for its planned statutory outage. On 23rd September 2018 Reactor 21 was also shut down for the planned double reactor outage. Both reactors have been shut since. The regular inspections on the reactors in Kent in late summer 2018 identified the need for repairs on steam pipes. The inspections showed that seismic restraints, pipework and storage vessels associated with several systems providing a safety function were found to be "corroded to an unacceptable condition" according to ONR. (37) Measures are being taken to eliminate the corrosion, including the upgrading of more than 300m of pipeline associated with reactor cooling systems and renewal of numerous seismic pipework supports and remediation of carbon dioxide storage vessels. On 26th February 2020 EDF Energy announced further extended outages at the two reactors The Dungeness B21 reactor was due to come back online on April 20 but the outage was extended to July 18. The Dungeness B22 unit was previously due back online on 2nd May but that was extended to 8th July. The dates given now are 21st September and 11th September. (38)

The boiler design at Dungeness was "very different" to the other AGRs and probably would be the life-limiting factor for the plant. However, EDF says the issues are "manageable" and that the company aimed to present a safety case shortly to seek to restart in September. (39)

8. Torness and Heysham 2

The Office for Nuclear Regulation (ONR) published its Project Assessment Report which allows Torness and Heysham 2 to continue operating for the period 2020 – 2030. (40) The Ferret website reported that cracks in the graphite core are now expected to start appearing six years sooner than previously thought (41)

ONR said that the cracking could cause debris to inhibit vital cooling of highly radioactive reactor fuel beginning as soon as 2022 rather than 2028. It said Torness and Heysham 2 will be able to keep operating until 2030 – but only if inspections to check for cracks are intensified. ONR promises to "robustly challenge" the plant's operators, EDF Energy, to ensure that it "remains safe".

Independent campaigners fear that Torness will become increasingly unsafe, and warn it may have to close down sooner than expected. EDF, however, insists that the station will keep generating electricity safely until 2030. NFLA has called on ONR to keep Torness under close scrutiny. “These safety reservations surrounding the Torness periodic safety review need to be cleared up as soon as possible,” said the NFLA Scotland convenor, Councillor Feargal Dalton. “Whilst EDF is having to spend large resources trying to persuade the regulator that it is safe to restart the Hunterston B reactors, this report emphasises that similar issues with ageing are likely to arise at Torness over coming years.” Councils would press ONR “to forensically scrutinise what look like significant weaknesses in the EDF safety case,” Councillor Dalton added. “In the meantime, the Scottish Government should start discussions about a ‘just transition’ for the workers at both Hunterston and Torness so that Scotland can move to a safe, sustainable and non-nuclear economy as quickly as possible.”

ONR made nine recommendations to remedy major “safety shortfalls” at Torness and Heysham 2 and raised 41 minor matters with EDF. These include “weaknesses” in health reviews, as well as issues with “structural integrity”, “corrosion management” and “cyber security”.

Although no cracks have yet been detected, ONR inspectors pointed out there was a significant difference in the design of Torness and Heysham 2 compared to that of Hunterston. The newer stations have seal rings between the graphite bricks that make up the reactor core. ONR quoted EDF saying that there could be “a systematic failure” of the seal rings after cracking. “This could lead to debris with the potential to challenge the ability to move or adequately cool fuel,” said ONR. “If keyway root cracking predictions are realised, then the safety case is unlikely to remain robust for the next ten years periodic safety review period,” observed ONR inspectors.

It could, in fact, be cheaper to build new renewable capacity rather than continue to operate these ageing reactors. This could soon be the case with Torness, especially if it has to keep being turned on and off to inspect the graphite core. Scotland clearly needs to be prepared for the possibility that Torness might be forced to close not long after 2022.

9. Flexible Return Dates

Paul Brown asked EDF “At what point do you cut your losses and close the stations permanently?” but failed to get a cogent reply. On Dungeness B EDF said: “For the past two years we have undertaken a major investment programme at Dungeness to secure the station’s longer-term future. Since the start of the year we have made great progress in tackling some of the complex problems our works identified. However, we still have further engineering works to complete, and a detailed safety case to finalise, before we ask for restart approval from our regulator. Our present position for estimated return to service is 11 September for Reactor 22 and 21 September for Reactor 21.”

Professor Stephen Thomas commented on the constantly postponed start-up dates for the ageing reactors: “It is clear, given that shutdowns expected to take two months are now expected to take two years or more, that EDF has found huge unanticipated problems. It is hard to understand why, when the scale of the problems became clear, EDF did not cut its losses and close the reactors, but continues to pour money into plants to get a couple more years of operation out of plants highly likely to be loss-makers. It is depressing that ONR, which has a duty to keep the public informed on such important issues, chooses to hide behind bland statements such as that it will take as long as it takes, and that it will not comment on EDF’s decisions.” (42)

10. Just Transition

After international trade union lobbying, the 2015 Paris Agreement included reference to “a just transition of the workforce and the creation of decent work and quality jobs”. According to the Public and Commercial Services Union most definitions of a ‘just transition’ means “protecting workers jobs and livelihoods when economies are shifting from their dependency upon the burning of fossil fuels to a zero carbon sustainable economic model.” (43)

However, over the next decade we can expect ***all 14 of the UK’s AGRs to close down***. By 2030 only Sizewell B is expected to still be operating and of the proposed new fleet of reactors only Hinkley Point C has started construction. Given that nuclear reactors are generally located in

fairly remote areas there are strong arguments in favour of "social interventions" now to protect workers jobs and livelihoods as these local economies will need to shift from their dependency on nuclear power generation.

After an AGR closes down it will take around 5 years to remove all of the fuel, during which time the reactors' gas and water-cooling systems will still need to be working. And this means jobs.

The current plan would be to then prepare the reactors to enter a period of care and maintenance. This would take around another 5 years. The reactors would then remain in care and maintenance for around 40 years with final dismantling delayed until around 2070. (44) By deferring decommissioning the final dismantlement of a reactor can benefit from radioactive decay, reducing the potential dose to the workforce, enabling dismantling to be undertaken with significant worker access, and changing the categorisation of radioactive wastes. It also avoids the need for interim storage of waste – the Nuclear Decommissioning Authority's (NDA's) current plans are predicated on a Geological Disposal Facility being available for reactor waste from around 2060. Deferral also gives funds set aside for decommissioning the opportunity to accrue interest from investments. (45)

However, the NDA says it is increasingly questioning the deferred reactor dismantling strategy. The lengthy deferral period means there is likely to be a loss of skills, knowledge and capability to carry out final site clearance. And with advances in robotics that have been made in recent years perhaps the lengthy deferral period is no longer necessary. The NDA says:

"…advances in remote decommissioning techniques and international experience demonstrate that nuclear power reactors can be dismantled promptly without the need for significant worker access." (46)

It is not clear, yet, what role the NDA might play in the decommissioning of EDF Energy's AGR nuclear stations. Financially speaking it will be in EDF's interests to delay final dismantling as long as possible so that the money they have set aside for decommissioning can accrue in the bank for half a century. But this might not be the best thing for the local economies. And the fact that EDF Energy and the NDA, are in talks to examine the future decommissioning of the AGR fleet suggests that the NDA is likely to have some role. Accelerated decommissioning would be one way to provide a just transition for the AGR workforce. The development of advanced robotics technology to allow remote access to radioactive areas also has the potential to develop new industries in communities currently dependant on employment at nuclear power stations.

The Nuclear Liabilities Fund (NLF) is worth approximately £9.4bn to meet cost of decommissioning AGRs & the Sizewell PWR. EDF Energy makes regular payments into the fund. It estimates that the cost of decommissioning its 7 AGR stations and one PWR would be around £20.4bn.[1] It currently expects to rely on accrued interest up to 2090-2100 to fund much of these liabilities. (47) Nevertheless, it could well prove to be in the Government's best interests to provide some of the funding for early decommissioning to allow the nuclear skills available at the AGR stations to be made use of now, rather than spending money to prop up the local economies after nuclear stations enter their care and maintenance period, and then having to retrain a whole new generation of nuclear works in 40 years' time to carry out deferred decommissioning.

11. Local Regeneration Projects.

It is worth also looking at other local regeneration projects for examples of successful schemes to generate employment around decommissioning nuclear facilities.

The Caithness and North Sutherland Regeneration Partnership (CNSRP), for instance, is an informal partnership of all the public agencies in the area around Dounreay looking at what will happen to the economy after decommissioning. The Partnership is targeting renewables – offshore wind and tidal, tourism and space, amongst other things. There are potential job

[1] The NLF Annual Report highlights "…*the higher risk of early closure due to technical challenges arising late in life*." It also highlights the "…*risk of the liabilities increasing as EDFE's work programme for decommissioning evolves from provisioning estimates into executable plans. Decisions taken by external bodies such as the Office for Nuclear Regulation and HM Government regarding the timescales or requirements for decommissioning may also affect the liabilities*."

opportunities locally in the renewable energy sector, and at the proposed new spaceport in Sutherland. Infrastructure improvements including to ports and harbours at Wick and Scrabster as well as educational facilities should help. Nearly £20m of inward investment is taking place at Wick Harbour as a result of the Beatrice Offshore Wind Development. (48) CNSRP is confident Beatrice will create 160 new jobs, and it hopes this will be followed up by 250 over the next four years at the Moray offshore wind venture. (49)

The 1,100 Dounreay Site Restoration Limited (DSRL) employees have been offered the chance of a new job once their work at Dounreay is finished with one of Cavendish Dounreay Partnership's firms. Alternatively, employees have been offered training to place them in the "strongest possible position" to take up a role with a local company. (50)

12. The NDA's Socio-Economic Plan

The NDA's Magnox Socio-Economic Plan (2016-19) says the Authority's objective is "to support the creation of dynamic, sustainable local economies for communities living near our sites." (51)

The NDA spent around £705,000 on projects in the area around the closed Hunterston A Magnox station such as re-opening the Marine Studies Centre on the Isle of Cumbrae; funding quayside offices at Ardrossan, and funding the construction of staff toilets at Portencross Castle to ensure that the castle can remain open and keep bringing tourists to the area. There were no applications supported over £10,000 in 2017/18. Largs Organic Gardens received £8,632 for the volunteer run garden at the railway station towards the Viking Longship and tools for the community garden project. £1,500 was supported to purchase an outboard motor for the Maritime Volunteer Service at Ardrossan Harbour to provide maritime training sessions for local groups.

13. Conclusions

With six of the fourteen AGR reactors currently closed and ageing problems beginning to appear in the rest, it is extremely unlikely that they will all make it as far as their currently expected closure dates. Indeed there must be a question-mark, given the consequences of a serious accident, whether it is prudent to keep trying to drag out the lifetimes of these reactors. If the ONR allows the oldest AGRs at Hunterston B and Hinkley Point B to continue operating for much longer serious questions are bound to be asked of its independence from the nuclear industry.

It is clearly time for stakeholders including the local communities, local authorities, the nuclear workforce and the nuclear industry to start discussing how to create a 'Just Transition' for the AGR workforce. This should include whether or not that should involve the UK taxpayer contributing to nuclear decommissioning funds to facilitate early decommissioning of these reactors in order to make the maximum use of existing skills, rather than waiting 50 years to proceed with final decommissioning.

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