Plant Life-Time Extensions for Scotland's Ageing Reactors the Lack of Public Participation in the Decision-Making Process

A report for the Green MSPs by Pete Roche

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Contents

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Introduction

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 ageing 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. [1]

The Implementation Committee of the Espoo Convention concluded that - regarding the plant life time extension of the Rivne nuclear power station in Ukraine in its twenty-third [2] and twenty-fifth sessions, [3] - the extension of the life-time of a nuclear power plant, even in absence of any works, was to be considered as a major change to an activity and consequently subject to the provisions of the Espoo Convention. As such an Environmental Impact Assessment (EIA) should have been carried out. [4] The Implementation Committee urged Ukraine to provide an EIA and public participation as soon as possible, but no later than the next periodic safety review in 2020. [5]

In June 2014, a Meeting of the Parties to the Convention endorsed the Implementation Committee's decision and agreed that because Ukraine hadn't carried out an EIA it was in breach of the Convention. [6] An EIA should compare the potential impact of extending the life of an old reactor with supplying energy from alternative sources of energy. [7]

Most European countries extend the lifetimes of their ageing nuclear reactors by looking only at whether prescribed safety standards are met. Normally, there is no consideration of whether the risk of a severe accident and associated environmental impacts is justified at an ageing power station in comparison with other ways of generating the same electricity. And the public is not consulted. According to Greenpeace this now has to change. [8]

In addition, when a decision is taken which involves an extension of activities which can have potentially severe effects on the environment, the public should be given a chance to participate according to article 6 of the Aarhus Convention. [9]

Hunterston's life extended 7 years to 2023

On 4th December 2012 EDF Energy announced that it would extend the operating life of its two oldest nuclear power stations - Hunterston B and Hinkley Point B - by seven years. Both plants, commissioned in 1976, are now expected to remain operational until at least 2023 by which time they will be 47 years old. [10] EDF Energy said the decision came after extensive reviews of the plants' safety cases and continuing work with the independent nuclear regulator – the Office for Nuclear Regulation (ONR).

ONR said it was content for the plants to continue to operate as long as the Periodic Safety Reviews (PSRs) are carried out satisfactorily and the next PSR for Hinkley Point B and Hunterston B was due to be submitted to ONR in 2015 with a decision on whether to grant EDF Energy a renewed license in 2016. [11] 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 Hunterston's closure in 2016, but as EDF Energy and ONR appear to be working quite closely together this seems unlikely.

More recently it was announced in Parliament that EDF Energy would submit its PSR for Hinkley Point B and Hunterston B to ONR in January 2016, and that ONR would announce its decision in January 2017. The Government was asked by Caroline Lucas MP whether an EIA is required as part of the periodic safety review procedure; and what opportunities exist for public involvement in such reviews. The Government responded by saying that:

"An environmental impact assessment is undertaken by each licensee covering the radiological impact of routine discharges. Such assessments are carried out separate to the PSR submitted to ONR … and are regulated by the appropriate UK environmental agency … While there is no legal requirement for public involvement in PSRs, the decision of whether to include public involvement is taken at the discretion of each station licensee." [12]

So there has been no EIA carried out prior to the ONR making a decision on the PSR and there has been no opportunity for public intervention in the process. ONR has not been required to consult the public on issues related to nuclear safety.

Torness's Life Extended 7 years to 2030

On 16th February 2016 EDF Energy announced that the scheduled closure date for Torness and (its sister station Heysham 2) had been extended by 7 years to 2030 (by which time they would be 41 and 42 years old respectively). The next PSR for the two stations is due to be submitted in January 2019. [13]

In response to a question at the Torness Local Liaison Committee meeting on 7th April 2016, about whether an EIA had been carried out under the Espoo Convention before announcing the Torness Life Extension, EDF Energy wrote to members of the Committee (which includes local councillors) saying:

"The life extension decision did not require EDF Energy to request any material change to the authorisation or the limits within which the station operates. With regards to the Espoo Convention, it applies to projects that are likely to cause a significant adverse trans-boundary impact, so across national boundaries. Life extension at Torness is not covered by this requirement. There is no similar UK or Scottish legislation that requires an EIA for a nuclear plant life extension." [14]

Further Life Extensions Possible

EDF Energy is now saying that it is looking at the possibility of extending the life of Torness and Hunterston B even further. Paul Winkle, EDF's Scottish Business Director, speaking at an EDF fringe meeting at the SNP 2016 Party conference, suggested that their life span could be extended even further:

"The current life for Hunterston is 2023 and Torness is 2030, and that is based on our assessment of ageing mechanisms in those plants and being absolutely sure that when they are shut down they are still safe to operate. But to go beyond that we will do assessments and ***it may be possible to make some small***

further extensions, *but we will not operate them beyond when we are confident they are safe to operate. Our current estimate is, with Hunterston, we get to a point where, if we go beyond 2023 there will be uncertainty. We will do more analysis in due course. Those dates are based on our best judgement.* (Emphasis added)" [15]

A spokeswoman for the Scottish Government said that ministers would welcome any extensions, as long as these could be done safely: "*We support life extensions for existing nuclear power stations where the environmental and safety requirements continue to be met. Extending the operating life of Scotland's existing nuclear stations can help to maintain security of supply while the transition to renewables and cleaner thermal generation takes place*." [16]

Scottish Government position

In response to a question about whether an EIA should be required under the Espoo Convention as part of the PSR process, the Scottish Government said:

"The Convention applies to transboundary consultation where a project is likely to have a significant effect on the territory of another party to the Convention. Signatories to the Convention agreed to the text of a nuclear declaration at a Meeting of Parties in June 2014. This includes the following:

'Consider that if an activity needs upgrade works during its lifecycle that might have significant adverse environmental impacts, this should be considered as a major change to the activity in question and be subject to the provisions of the Convention.'"

The Scottish Government continued: *"This is consistent with the rulings of the European Court on the application of the EIA Directive.* ***The extension of an operating permit does not fall within the scope of the Directive unless there are also works or interventions involving alterations to the physical aspect of the site****. It is currently UK practice that where there are significant changes to a site, or a request to have an extension of the lifetime of a site, the regulators have to be content that safety and the impact on the environment have been properly considered. Only if the regulators are content will the operator be able to continue to operate the site."* [emphasis added] [17]

In other words the Scottish Government appears to be claiming that unless there are works or interventions involving alterations to the physical aspect of the site, an EIA is not required. But Espoo says that a lifetime extension is a major change, even in the absence of any works, and therefore it is subject to the Convention. The Espoo Implementation Commission agreed that the extension of the life of a nuclear power station originally expected to run for 30 years for a further 20 years is an activity which requires an EIA and under Article 6 of the Aarhus Convention public participation is required in Environmental Impact Assessments.

Alison Johnstone, Green MSP for Lothian raised this issue on 7th October 2014 in the Scottish Parliament. She asked Energy Minister Fergus Ewing if the Scottish Government would support the case for having full environmental impact assessments when licence extensions for plants such as Hunterston and Torness are considered. Mr Ewing responded that:

"...the environmental case was considered when Hunterson B's life was extended to 2023. That extension was made two years ago, and it has already been fully discussed and reported in the Parliament. In addition to that and the life extension case, it is my understanding of the process [that] *the next periodic safety assessment is due to be carried out in 2016".* [18]

Alison Johnstone MSP said: "*In light of the Hunterston cracks* [see above] *it is important we challenge the fact that the public has no say in the Periodic Safety Reviews and lifetime extensions granted to our nuclear plants. International law says extensions require public consultation and must compare the potential impact of extending an old reactor with supplying energy from alternative sources such as renewable energy.*" [19]

Ageing Advanced Gas-cooled Reactors – the Graphite Problem

One of the reasons why people in Scotland are beginning to demand a say in whether or not ageing reactors have their lives extended is because of the recent discovery of cracked graphite bricks in the core of some of these reactors and the questions this raises about whether it is safe to keep running these reactors long past their expected lifespan of about 30 years. Hunterston B and its sister station at Hinkley Point B in England and are already 40 years old but EDF energy wants them to continue operating for at least another 7 years.

In 2005 the Nuclear Installations Inspectorate (now the Office for Nuclear Regulation -ONR) expressed concern about the structure of the reactor core. [20] A report by Large Associates – an independent nuclear engineering consultancy – on problems at Hinkley Point B which analysed a bundle of documents received under the Freedom of Information Act, 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.*" [21]

John Large said it was "gambling with public safety" to allow Hinkley Point B and Hunterston B to continue operating. [22] The documents, written by the former Nuclear Installations Inspectorate, reveal that AGRs are structurally defective and their continued operation is increasing the risk of a radioactive accident. The bricks which make up the reactor cores of the AGRs are cracked. These bricks, made of graphite, help control the nuclear reaction by influencing the speed of neutrons. Channels also run through the bricks which enable control rods to be inserted to shut-down the reactor in an emergency. However, the cracked graphite bricks could prevent them from being inserted causing the nuclear fuel to overheat, potentially resulting in a radiological release.

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 to the BBC Radio 4's *Costing the Earth* that graphite is not elastic, it doesn't bend, and is not particularly strong. And now the graphite bricks are cracking. The core is an assembly of several thousand bricks, loosely stacked together, but because the expectation was that the core would never fail, there was no facility built into the design to replace any individual blocks if they did become damaged. 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. [23]

The ONR strictly regulate the state of the bricks and set limits on the amount of weight the graphite bricks can lose. However, in recent years EDF Energy has

applied to ONR, and received permission, to increase the limit in order to continue operating these reactors. Hunterston & Hinkley Point B have an estimated weight loss of 12.8% and a limit set at15%. [24] So the limit will probably need to be raised if Hunterston B is to continue generating until 2023. 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. This level of weight loss was not expected when the reactors were originally designed and it is still not adequately understood. ONR has expressed concern about the methodology being used to calculate weight loss and the small margins between weight loss and the limits. [25]

Steve Thomas, 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.*" [26]

As well as losing weight the graphite blocks are also cracking. Short of decommissioning the reactors it is very difficult to accurately determine the weight loss and cracking in the bricks. *Costing the Earth* 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 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. [27]

Brian Cowell, EDF's Director of nuclear operations, says 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 undertaken. The focus has been to look at the likelihood of core disruption after an earthquake which could prevent the control rods being inserted. ONR is considering the new safety case.

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 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 we can't be certain how many keyway route cracks there are. John Large explains that to examine where the cracks are you 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's 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 the model has already been shown to be flawed.

Paul Bowen says they haven't 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 level 6. John Large says the model relied upon by ONR is not working, so they can't predict the strength of the core. More to the point they can't work out where to put their investigative probes to see where cracking is taking place. So they're in the dark.

If the ONR gives the go-ahead for an increase in the number of cracked bricks from 10 to 20%, it might be difficult for people living near theses reactors to understand why the definition of “safe” seems to be changing.

Environmental Impact of Life Extensions

In May 2014 Greenpeace Netherlands wrote to the Secretary to the Aarhus Convention to complain about a 20 year life extension for the Borssele nuclear power plant. [28] The Dutch nuclear regulator carried out a review of the modified safety report, resulting in a positive decision, but there was no public consultation on issues relating to the environmental impact of the lifetime extension, and there is no consultation on the periodic safety review. Greenpeace listed some of the significant effects that are irreversibly attached to the lifetime extension including:

An increased risk of malfunction by ageing components and increased compatibility problems from the introduction of new replacement components, potentially escalating in a severe accident with emissions of radioactive substances into the environment;

An increase in the time of exposure to potential terrorist attack, sabotage or acts of war;

An increase in the time of exposure to extreme natural events that could alone or in combination with human failure or malevolent human acts lead to emissions of radioactive substances into the environment;

An increased use of uranium and therefore increased environmental impacts from uranium mining, processing and fuel production;

An increased production of radioactive waste;

All of these also apply to Torness and Hunterston B. The increased production of radioactive waste is the most quantifiable. A July 2015 report from Radioactive Waste Management Ltd [29] compares a 2010 radioactive waste inventory with a 2013 inventory after EDF Energy announced its ambition to extend the life of its AGRs by an average of 7 years each. [30]

The quantity of AGR Spent fuel increases by 1,400 tonnes uranium (tU) in the 2013 inventory (see page 14). 500tu of this is attributable to the fact that less AGR spent fuel is assumed to be reprocessed (see table 2). Of the 900tU attributable to AGR life extensions around 260tU will be generated by Torness and Hunterston B.

In this context it is worth noting that the 2006 report of the Committee on Radioactive Waste Management (CoRWM) on Managing Radioactive Waste Safely flagged up the fact that:

"*...political and ethical issues* [are] *raised by the creation of more wastes* [which] *are quite different from those relating to committed – and therefore unavoidable – wastes*."

CoRWM was discussing waste from new reactors. However, given that the UK is still searching for a solution to the problem of what to do with nuclear waste, the Committee's point should also be applied to AGR life extensions which should, therefore *"require a quite separate process to test and validate proposals for the management of the wastes arising."* [31]

Alternatives to Scottish Plant Life Extensions

During 2015 Torness generated 8.7TWh (terawatt hours) [32] and Hunterston B generated about 7.5TWh [33]

Scotland is in the enviable position of having fantastic renewable energy potential. The Scottish Government has a target to meet 100% of the country's electricity demand from renewables by 2020. It is well on track to hitting this. At last count Scotland generated the equivalent of 57% of its electricity consumption from renewables and had reduced climate emissions by 39.5% since 1990. Once the 100% target is reached, closure of Hunterston B and Torness would mean there would be less electricity to export, but it would be feasible provided there was enough capacity in grid connections, demand management and storage to provide flexible back-up at times when renewable generation is low.

A 2016 Independent analysis by Ricardo Energy & Environment [34] and commissioned by WWF Scotland, FoE Scotland and RSPB Scotland, shows that to deliver Scotland's climate targets at lowest cost and maximum benefit, a minimum of 50% of our energy across the electricity, heat and transport sectors will need to come from renewables by 2030. The current trajectory suggests less than 30% will be achieved, and climate targets will be missed.

To achieve this, a scenario developed by Ricardo shows Scotland generating the equivalent of 143% of electricity demand from renewables, with substantial exports to the rest of the UK. An additional 7 - 8 GW of new renewable capacity is built to replace retiring nuclear stations and meet increasing demand from the heat and transport sectors, security of supply is maintained by enhanced grid flexibility, energy storage and connection to wider UK and European electricity grids, and up to 14,000 new jobs are created.

An earlier 2015 study by international energy consultancy DNV GL commissioned by WWF Scotland concluded that a renewables-based, efficient, flexible, electricity system for Scotland is perfectly feasible by 2030. An almost entirely renewables-based Scottish system is possible with moderate efforts to reduce demand for electricity and ongoing work to reinforce the grid. [35]

Both of these reports show it is not necessary to extend the life of Scotland's two nuclear stations Hunterston B and Torness beyond 2023 and 2030 respectively. However, if a full environmental impact assessment was carried out at the same time as the Periodic Safety Reviews for these two stations it would most likely show that it would be perfectly feasible to replace them with renewables and energy efficiency earlier.

For instance, the RSPB's 2050 Energy Vision for the UK shows that between 5,558 and 6,277 TWh/year could be generated with low ecological risk by renewable energy technologies in the UK. The UK's final energy consumption in 2014 was 1661TWh, suggesting that, if appropriately sited, approximately four times the UK's current final energy (not just electricity) consumption could be generated from renewables, with low ecological risk. [36]

Scotland's consumed 144TWh/yr of energy (not just electricity) in 2013. [37] The RSPB research shows that more than three times the current level of onshore wind in Scotland could be achieved with low risk for wildlife - up to 41TWh/year.

RSPB says there is vast potential for floating wind in deeper waters, and there are also large areas potentially suitable for wave energy generation at low ecological risk, if the industry is supported to enable commercialisation.

Scotland could also boost solar deployment over the next decade. At the last count solar capacity in the UK as a whole had reached around 10GW, but in Scotland it is only around 250MW. If Scotland had a proportionate share of UK solar capacity it should be closer to 1GW by now. [38] The Solar Trade Association (STA) estimates that 2GW would be a reasonable target to aim for in 2020. [39] The Scottish Government has a target of 100% renewable electricity by 2020 – and it is currently about half way towards achieving that target. Solar PV could potentially provide a sizeable amount of the rest of that target. [40] The STA wants to see solar panels installed on all new public buildings, and retrospectively a roll-out of solar panels across the Scottish public estate, including installations on schools, leisure facilities, police stations, prisons and local authority offices. And it wants the Scottish Government to say that solar should be explored with all new builds and refurbishments in the public sector. [41] STA Scotland estimates that there are 25,000 hectares of south-facing commercial rooftops in Scotland that could be put to use to generate clean, home-grown electricity. There are currently just a handful of large-scale ground-mounted solar farm installations in Scotland. Examples are the Solar Meadow at Edinburgh College was completed in 2013, and the Mackies Ice Cream solar farm in Aberdeenshire, a 1.8MW site that was opened in August 2015. It has been estimated that Scotland needs to build 25,000 new homes a year to keep up with population growth. If all suitable houses were built with solar PV integrated on their roofs, this could represent a solar PV market of 60MW per year.

The great thing about solar is that it can deployed easily and quickly in towns and cities or in places not suitable for wind turbines. Leading solar company Lightsource Renewable Energy has already identified around 70 potential sites for ground-mounted solar PV farms in Scotland, as well as opportunity for commercial and domestic rooftop solar PV systems. [42] Lighthouse Operations Director Mark Turner says the UK's solar industry has the capability to deliver the same energy production as Hinkley Point C (which is expected to generate 25TWh/yr) within 24 months and at comparable cost. [43]

Some 700MW of onshore wind projects on the Scottish islands are waiting for suitable grid connections before construction can begin. [44] Scotland's islands could enjoy a £725m boost to their economies over the next 25 years from renewables, according to a report by energy consultancy Baringa. The report, which was commissioned by the Scottish Government, found if investments were made in grid infrastructure and generating assets, the amount of renewable energy deployed on the islands could be growing rapidly by the early 2020s. At its peak, renewables deployment could provide an extra five per cent boost to local economic output on average across the islands. The economic benefits would include up to £225m in community benefits and revenues of up to £390m for community-owned island generation projects, according to the report, while up to 2,000 jobs would also be created in the peak development phase. [45] Council leaders from the Western Isles, Orkney and Shetland have called on UK ministers to connect their renewable energy projects to the national grid. [46]

The National Grid, in evidence to the Scottish Parliament's Economy, Energy, and Tourism Committee, addressed fears about what might happen when Hunterston B closes in 2023 and perhaps Torness if it cannot secure a life extension. Both National Grid and Ofgem

emphasised to the Scottish Parliamentary Committee that the electricity system is evolving. They stressed that by the mid-2020s there will be more diversity in types of renewables, more demand response, and interconnection, so less need for local generation. Carbon Capture and Storage (CCS) might also be available for baseload. But they also stressed that market signals (including transmission, capacity market etc.) would change if there are genuine risks to security of supply in Scotland. [47]

Conclusion

The Espoo Convention, to which the UK is a signatory, says that all ageing nuclear power stations in Europe should have an environmental impact assessment (EIA) carried out before a licence renewal or the approval of a 10-year-periodic safety review. Such an assessment should compare the potential impact of extending the life of an old reactor with supplying energy from alternative sources such as renewable energy, and involve the public in the decision-making process.

Given the significant problems with cracking in the graphite bricks in the core of Scotland's ageing reactors, the fact that the UK has yet to find a solution to the problem of what to do with nuclear waste, and the progress made with the development of renewable energy in Scotland, it is quite likely that an EIA would conclude that Scotland's reactors should close much sooner rather than is currently anticipated by EDF Energy and the Scottish Government.

References

[1] Haverkamp, J. *Europe's ageing nuclear reactors will have to undergo environmental assessments*, Ecologist 9th June 2014
http://www.theecologist.org/News/news_analysis/2430353/europes_ageing_nuclear_reactors_will_have_to_undergo_environmental_assessments.html

[2] Report of the Implementation Committee on its twenty-third session, ESPOO 5th-7th Dec 2011
http://www.unece.org/fileadmin/DAM/env/documents/2011/eia/ic/ece.mp.eia.ic.2011.8.e.pdf

[3] Report of the Implementation Committee on its twenty-fifth session, ESPOO 11th-13th Sept 2012
http://www.unece.org/fileadmin/DAM/env/documents/2012/eia/ic/ece.mp.eia.ic.2012.4.e.pdf

[4] Haverkamp, J. *Europe's ageing nuclear reactors will have to undergo environmental assessments*, Ecologist 9th June 2014
http://www.theecologist.org/News/news_analysis/2430353/europes_ageing_nuclear_reactors_will_have_to_undergo_environmental_assessments.html

[5] See ESPOO Implementation Committee 30th Session 25-27th Feb 2014
http://www.unece.org/fileadmin/DAM//env/eia/documents/ImplementationCommittee/2011-2014/30th_session/4._INF.3_CI4_Rivne_F_R_rev.pdf and for a full list of the paperwork regarding Rivne see http://www.unece.org/environmental-policy/conventions/environmental-assessment/areas-of-work/review-of-compliance/committee-initiative/eiaicci4-ukraine.html

[6] Economic Commission for Europe Meeting of the Parties to the Convention on Environmental Impact Assessment in a Transboundary Context Sixth session Meeting of the Parties to the Convention on Environmental Impact Assessment in a Transboundary Context serving as the Meeting of the Parties to the Protocol on Strategic Environmental Assessment Second session Geneva, 2–5 June 2014
http://www.unece.org/fileadmin/DAM/env/documents/2014/EIA/MOP/ece.mp.eia.20.e.Add.1-ece.mp.eia.sea.4.e.Add.1_advance_copy.pdf

[7] See Appendix II (b)
https://www.unece.org/fileadmin/DAM/env/eia/documents/legaltexts/Espoo_Convention_authentic_ENG.pdf

[8] Haverkamp, J. *Europe's ageing nuclear reactors will have to undergo environmental assessments*, Ecologist 9th June 2014
http://www.theecologist.org/News/news_analysis/2430353/europes_ageing_nuclear_reactors_will_have_to_undergo_environmental_assessments.html

[9] The Aarhus Convention
https://www.unece.org/fileadmin/DAM/env/pp/documents/cep43e.pdf

[10] EDF Energy 4th Dec 2012 http://media.edfenergy.com/r/334/edf_energy_announces_seven_year_life_extension_to_hinkley

[11] ONR 4th Dec 2012 http://news.onr.org.uk/2012/12/edf-energy-decision-on-lifetime-extension-onr-position-statement/

[12] Hansard, Nuclear Power Stations: Safety: Written question – 200777, answered 23rd June 2014 http://www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Commons/2014-06-16/200777/

[13] EDF Energy 16th February 2016 http://media.edfenergy.com/r/1030/edf_group_results_2015___highlights_for_edf_energy_in_uk

[14] Letter from Paul Winkle, Torness Station Director to LLC Committee Members dated 22nd April 2016.

[15] Holyrood Magazine 17th Oct 2016 http://www.holyrood.com/articles/news/lifetime-scotlands-nuclear-plants-could-be-extended-says-edf

[16] Times 19th Oct 2016 http://www.thetimes.co.uk/edition/scotland/nuclear-closures-could-be-delayed-to-keep-lights-on-mrd9xqj9j

[17] Letter dated 17th September 2014 from Karen Minto, Safer Communities Directorate, Scottish Government to Mandy Meikle.

[18] Scottish Parliament Official Report 7th October 2014 http://www.parliament.scot/parliamentarybusiness/report.aspx?r=9566&i=86767

[19] STV 7th October 2014 http://stv.tv/news/west-central/294983-hunterston-nuclear-plant-no-threat-to-public-safety-says-fergus-ewing/

[20] Greenpeace 5th July 2006 http://www.greenpeace.org.uk/media/press-releases/secret-documents-reveal-government-inspectors-fears-over-defective-nuclear-reactors

[21] Brief Review of the Documentation Relating to the Graphite Moderator Cores at Hinkley Point B and Other Advanced Gas-Cooled Reactors. Large and Associates, June 2006. http://www.greenpeace.org.uk/files/pdfs/migrated/MultimediaFiles/Live/FullReport/7810.pdf

[22] Guardian 5th July 2006 https://www.theguardian.com/science/2006/jul/05/energy.frontpagenews

[23] Costing the Earth. Radio 4 BBC 2nd Nov 2016 http://www.bbc.co.uk/programmes/b080t880

[24] Nuclear Engineering International 11th July 2014 http://www.neimagazine.com/news/newsedf-energy-publishes-agr-graphite-loss-levels-4316310

[25] Peter Lux 7th June 2014 http://www.plux.co.uk/graphite-weight-loss-at-agr-reactors/

[26] Times 11th July 2014
http://www.thetimes.co.uk/tto/business/industries/utilities/article4144448.ece

[27] Costing the Earth. Radio 4 BBC 2nd Nov 2016
http://www.bbc.co.uk/programmes/b080t880

[28] Non-appliance with the Aarhus Convention by the Kingdom of the Netherlands in relation to the plant life-time extension of the Borssele nuclear power plant, Greenpeace Netherland, 6th May 2014
https://www.unece.org/fileadmin/DAM/env/pp/compliance/C2014-104/Correspondence_with_communicant/frCommC104_Letter_Greenpeace_18.03.2015.pdf

[29] An overview of the differences between the 2013 Derived Inventory and the 2010 Derived Inventory, NDA 22nd July 2015
http://webarchive.nationalarchives.gov.uk/20150817115932/http://www.nda.gov.uk/publication/differences-between-2013-and-2010-derived-inventory/

[30] Houlton, N. Life Extension of the EDF Energy Nuclear Fleet, EDF Energy October 2013
http://www.nicongress.org/uploads/papers/speaker/Nigel%20Houlton%20NIC_LifetimeManagement_EDFEnergy%20Paper%20Final.pdf

[31] Managing our Radioactive Waste Safely, CoRWM, November 2006
https://www.gov.uk/government/publications/managing-our-radioactive-waste-safely-corwm-doc-700

[32] Torness Local Liaison Committee Meeting 7th April 2016
http://eastlammermuircommunitycouncil.org.uk/files/2016/05/LLC-Minutes-2016.pdf

[33] Largs & Millport News 9th Feb 2016
http://www.largsandmillportnews.com/news/fairlie/14263254.Hunterston_s_40th_anniversary_milestone/

[34] The Energy of Scotland: Heatiung, Moving and Powering our Lives from now until 2030. WWF Scotland, RSPB Scotland, FoE Scotland
2016http://assets.wwf.org.uk/downloads/ricardo_energy_report_web.pdf

[35] Pathways to Power, Scotland's Route to Clean, Renewable, Secure Electricity by 2030 WWF Scotland 2015 http://assets.wwf.org.uk/downloads/pathwaystopower.pdf

[36] The RSPB's 2050 Energy Vision (2016)
http://www.rspb.org.uk/Images/energy_vision_summary_report_tcm9-419580.pdf

[37] Energy in Scotland 2016 http://www.gov.scot/Resource/0050/00501041.pdf

[38] Brodies 28th Sept 2016 http://www.brodies.com/blog/solar-energy-scotland-challenges-and-opportunities-2/

[39] STA Key Facts and Statistics, March 2016 http://www.solar-trade.org.uk/wp-content/uploads/2016/03/Key-facts-and-statistics-Solar-in-Scotland-v8.pdf

[40] Solar Power Portal 11th May 2016 http://www.solarpowerportal.co.uk/news/solar_set_for_growth_in_scotland_says_snp_energy_spokesperso n_7236; Solar Power Portal 9th May 2016 ; http://www.solarpowerportal.co.uk/news/solar_to_hit_the_ground_running_in_scotland_after_snp_election_win 20 key Solar asks for Scottish Government, Solar Trade Association 24th Feb 2016 http://www.solar-trade.org.uk/scottish-solar-industry-publishes-key-asks-for-scottish-government/

[41] Herald 27th Feb 2016 http://www.heraldscotland.com/news/14306977.Solar_panels____should_be_on_new_public_buildings_ in_Scotland___/

[42] WWF Scotland Press Release 29th Dec 2014 http://www.wwf.org.uk/updates/scotlands-solar-power-capacity-almost-third?_io=7429

[43] Click Green 24th Oct 2014 http://reskin-cg.class-media.co.uk/opinion/opinion/123982-renewable-energy-boss-tells-pm-solar-power-could-match-hinkley-in-2-years.html

[44] Scottish Renewables 16th March 2016 https://www.scottishrenewables.com/news/SR-responds-2016-ukgovernment-budget/

[45] Business Green 8th March 2016 http://www.businessgreen.com/bg/news/2449974/renewables-could-givescottish-islands-economies-a-gbp725m-boost

[46] Daily Record 8th March 2016 http://www.dailyrecord.co.uk/business/business-news/national-gridconnection-vital-scottish-7513724#KUASSKwi5i4BWZ7G.97

[47] Scottish Parliament, Economy, Energy and Tourism Committee, 11th March 2015 http://www.scottish.parliament.uk/parliamentarybusiness/28862.aspx?r=9854

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