Life Extension of the EDF Energy Nuclear Fleet

Nigel Houlton,
Head of Lifetime Programmes
EDF Energy; Nuclear Generation

October 2013
1. Background – UK nuclear power

Commercial nuclear generation began in the UK in 1956, peaking in 1997 with around a quarter of UK supplies coming from 16 nuclear stations. Since then 7 stations have entered decommissioning leaving just 9 still generating.

EDF Energy owns and operates 8 of the 9 remaining civil nuclear stations in the UK - generating around one sixth of the UK’s electricity. EDF Energy’s nuclear fleet comprises 8 stations in the UK

- 7 AGRs* (Commissioned Between 1976 and 1988) - Unique Designs
- 1 PWR** (Commissioned 1995) - 4 loop 1188MW - Westinghouse design

<table>
<thead>
<tr>
<th>Station</th>
<th>Reactor type</th>
<th>NET capacity in Megawatts (MW)</th>
<th>Year commissioned</th>
<th>Age in years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunterston B</td>
<td>2 AGRs</td>
<td>890</td>
<td>1976</td>
<td>37</td>
</tr>
<tr>
<td>Hinkley Point B</td>
<td>2 AGRs</td>
<td>870</td>
<td>1976</td>
<td>37</td>
</tr>
<tr>
<td>Hartlepool</td>
<td>2 AGRs</td>
<td>1,180</td>
<td>1983</td>
<td>30</td>
</tr>
<tr>
<td>Heysham 1</td>
<td>2 AGRs</td>
<td>1,160</td>
<td>1983</td>
<td>30</td>
</tr>
<tr>
<td>Dungeness B</td>
<td>2 AGRs</td>
<td>1,040</td>
<td>1983</td>
<td>30</td>
</tr>
<tr>
<td>Heysham 2</td>
<td>2 AGRs</td>
<td>1,220</td>
<td>1988</td>
<td>25</td>
</tr>
<tr>
<td>Torness</td>
<td>2 AGRs</td>
<td>1,190</td>
<td>1988</td>
<td>25</td>
</tr>
<tr>
<td>Sizewell B</td>
<td>1 PWR</td>
<td>1,191</td>
<td>1995</td>
<td>18</td>
</tr>
</tbody>
</table>

The AGR is the second generation UK reactor design, following on from the Magnox design. The AGR build programme was dogged with issues due mainly to complexity of design. The lead station, Dungeness B, was ordered in 1965 with a 5 year construction target. It eventually came online 13 years late in 1983. The other 6 AGRs were built in principle as sister pairs but they are far from identical. We also operate a PWR at Sizewell B.

Operating such a diversely designed fleet presents a significant technical challenge.

2. The future of nuclear in the UK

The UK has committed to some very challenging emissions reduction targets - 80% by 2050 - through the Climate Change Act. The power sector will play a pivotal role.

- Not all sectors of UK industry can decarbonise to the same extent, so the power industry is expected to take up the slack and be almost completely decarbonised by 2050
- Some predict demand for electricity could double over the same period in the UK including the effect of switching from other fossil energy sources to electricity, for example petrol to electric cars, gas to electric heating at home
However this challenge is not just about decarbonising electricity. It must also be about achieving a sustainable change and therefore must also be affordable and result in security of supply in the UK.

New nuclear has therefore been recognised as an essential part of the mix. In 2010 the British government gave the go-ahead for up to eight new nuclear power plants. The Scottish National Party (SNP) led Scottish government are opposed to building new nuclear stations in Scotland. EDF Energy have plans to start the next wave of new nuclear build in the UK, starting with two EPR reactors at Hinkley Point C in Somerset.

In the meantime existing nuclear stations will play a key role in achieving UK decarbonisation sustainably.

3. The case for lifetime

The existing nuclear fleet provides the most affordable, large-scale, low-carbon source of electricity in the UK. With construction costs, and expected decommissioning costs already mostly secured, the levelised cost is relatively low and stable. Existing nuclear supports a significant number of skilled UK jobs and spend directly in the UK especially compared to fossil stations where UK jobs are lower and much of the spend is on volatile foreign fuel imports and increasingly on carbon emissions.

The case for life extension is wider again. The UK is leading the nuclear renaissance with an ambition likely to require tens of thousands of additional, mainly highly-skilled jobs. Life extension could provide the crucial initial pipeline for these nuclear skills both in the UK and abroad. EDF Energy has already recognised this opportunity and we are inspiring children, teachers and parents and have launched highly regarded apprentice and graduate schemes. Through our Nuclear Leadership Academy we are also developing UK leaders for the future.

The nuclear fleet generates around a sixth of the UK’s electricity in the form of reliable baseload generation. With a number of the UKs older and higher emitting coal stations expected to close in the next few years, capacity is expected to fall in the medium term. The current scheduled closure dates of our AGR fleet (2018-2023) coincide with this potential capacity crunch. The recent capacity adequacy report published by OFGEM implies a much heightened risk of capacity shortfalls in the next few years without nuclear life extension.

Extending the lives of our nuclear power stations makes absolute sense in terms of filling a short-term energy need while the country rightly continues towards aggressive decarbonisation targets. Life extension helps with the short-term risk but does not change the need or urgency of the new nuclear programme. The fundamental need for new capacity remains given the inability of old coal stations to meet tighter emissions limits being a prominent factor.

Therefore the UK faces significant affordability and security of supply challenges on its drive to decarbonisation. Decarbonisation offers challenges and opportunities to the wider UK economy. It is crucial that EDF Energy ensures the existing nuclear fleet is able to continue to provide this value to UK consumers as long as it is safe and viable and also to provide opportunities for the UK to play a key role in the nuclear renaissance. In summary nuclear life extensions could play a significant role in both keeping the lights on and keeping us on track for the 2050 targets. A new approach to lifetime planning is needed to support this.
4. A new approach to lifetime planning

Following acquisition of British Energy in Jan ‘09, EDF Energy implemented a Lifetime Programme to support the strategy to ‘seek life extensions for all its nuclear power stations where it is safe and commercially viable’.

The previous approach to lifetime planning was short-term and incremental, borne out of a contractual requirement from government – to effectively make a commercial decision on life extension 2-3 years before scheduled closure date to allow sufficient time to plan for decommissioning. There have been 17 separate life extensions to date, the majority in 5 year tranches. Until recently there was no clear long-term forecast about the potential of the fleet.

In contrast the process in place to make decisions on safety covers all timescales:
- Short-term - continuous requirement to satisfy ourselves and ultimately the independent regulator the ONR that we are safe to continue operating day to day
- Medium-term - every 3yrs we need consent from the ONR to re-start following each statutory outage
- Longer-term - every 10yrs the ONR provides a statement for safety of continued operation following the Periodic Safety Review (PSR)

This incremental approach to life extension was acceptable when our nuclear fleet was still in mid-life and before the UK faced a potential cliff-edge around its future capacity. However as our stations approach end of life and the UK firms up its pathway for decarbonisation, this process is not sufficient. EDF Energy has recognised the need for longer-term planning to realistic dates:
- Safe and reliable plant is best served by taking a realistic view of the expected lifetime and planning accordingly
- We need to plan our resources optimally to realistic planning dates given increasing retirements and competition due to the nuclear renaissance
- Openness and clarity to all about our expectations - including to support the UK’s plans through a challenging period of decarbonisation
- UK infrastructure supporting nuclear e.g. Sellafield, National Grid etc needs to plan
- Supply Chain needs to plan and gear up to meet the demands of new build and support existing nuclear

5. What determines technical lifetime

We established a lifetime programme in 2009 to assess the lifetime potential of the fleet. The potential lifetimes of our AGRs are ultimately limited by the two key non-replaceable components; their graphite core and boilers. Making predictions about the degradation mechanisms of these components is complex and with AGRs being of unique design, data is limited. The key lifetime drivers for each are summarised below.
- Graphite - weight loss or loss of structural integrity leading to inability to perform their intended function. High level of uncertainty on timing
- Boilers - tube degradation leading to unacceptable frequency of leaks
The key to predicting lifetime is modelling and validation through plant inspections. The key to actual lifetime is real plant condition as measured through inspection.

We conducted an extensive review of the potential lifetimes of the AGRs using all available information and our predictive models of degradation. This allowed the relevant experts to provide a judgement on the appropriate planning dates for the fleet. This acknowledged the inherent uncertainty due to the uniqueness of issues and an annual process has been established to ensure these planning dates are continuously reviewed.

Being keen to ensure these important dates were shared openly, we issued a stock exchange announcement in Feb ’12 with the following extract:

“EDF Energy has completed a further technical review of the potential life limiting plant areas. Subject to the necessary formal reviews and approvals in due course, EDF Energy is now expecting an average life extension of seven years across the AGR fleet. The strategic target for Sizewell B remains at 20 years.”

In assuming that the non-replaceable graphite and boiler systems will determine lifetime, we have thereby also assumed that all other aspects of the nuclear business are successfully managed to enable these new lifetime planning dates to be achieved. Therefore the next stage of our journey is underway; to align all aspects of our business internally and externally to these new dates.

\(^1\) The seven year average expectation for the AGRs includes the 5 year extension of Heysham 1 and Hartlepool announced in December 2010 and the 7 year extension of Hinkley Point B and Hunterston announced in December 2012.
6. Aligning our business

We developed a suite of through-life plans at all levels (system, station, fleet) during 2012. We engaged early with our key supply chain partners with original equipment manufacture (OEM) knowledge in creating our key underpinning strategies and plans. These are embodied in the through-life management strategies (TLMSs) we have developed for our 20 key systems. These TLMSs summarise the strategy for lifetime management including investment requirements, personnel and supply chain issues. These TLMSs have enabled us to identify the key risks and investments required to reach the revised planning dates (‘+7yrs’) safely and reliably and as of the end of 2012 these are embedded in our business plan.

A lifetime resource planning framework has also been developed in parallel to try and help us understand what resources the business will need to operate to the revised planning dates. It recognises our obligation to decommission our stations and key decision points at both a fleet and station level. The output has been incorporated into the fleet lifetime plans and a resourcing review.

This work underpinned our announcement in December 2012 of a 7 year life extension of Hinkley Point B and Hunterston to keep them operating to 2023.

7. Engaging the nuclear community

The UK stands out in Europe as one of the few countries pursuing life extension. The UK Government is demonstrating the value it places on nuclear by supporting EDF Energy’s decision to extend the lives of the current fleet to bridge the gap until new nuclear comes on stream. The Scottish Government, despite its anti new-nuclear position, has said publically that it will not oppose life extension of existing nuclear stations meaning this will be an important part of Scotland’s low carbon ambitions.

We engaged with our key external stakeholders including government, the regulators, the NDA, and our key supply chain partners and our approach has been widely welcomed.

This is especially important following the events in Fukushima. The subsequent ONR report (‘The Weightman Report’) concluded that the UK plants are robust to design basis events and safe to continue operations. However as an organisation committed to continuous improvement, we established a programme to use learnings to further our current robust position.

There are several key external enablers focussed around the supply chain and key supporting infrastructure including fuel supply, grid infrastructure, waste and used fuel management, reprocessing facilities, original equipment manufacturers, key component suppliers, as well as suppliers of outage management capability and engineering support. We are therefore leading a different approach with the owners of all these capabilities to ensure our fleet is supported through life. This involves the following steps:-

- Openly sharing our best view of the operating lives of the stations
- Working with all parties to identify the best strategy for the each capability
- Ensuring the key risks from all the above capabilities are managed on an ongoing basis

We have formed a Strategic Partnership for Lifetime with four key suppliers to our fleet, Amec, Atkins, Babcock International and Doosan Power Systems.

We believe our revised approach to the whole supply chain is creating a strong sense of leadership and shared responsibility to the needs of the country.
8. Conclusion

- Achieving the full potential of the existing nuclear fleet is good for the country and good for EDF Energy.
- The previous shorter-term planning approach is no longer sufficient
- Longer-term planning, based on a reasonable expectation of lifetime, is appropriate and our approach has received strong support
- We have reviewed our lifetime potential and updated our guidance to the market around an expectation of an average life extension of 7 years for AGRs and 20 years for Sizewell B
- We announced a 7 year life extension for Hinkley Point B and Hunterston in December 2012 in line with this expectation.
- Alignment of plans is underway. Firstly to robustly underpin this expectation and then seek opportunities to further increase it

Notes
*AGR = Advanced gas-cooled reactor - second generation of UK reactors after the Magnox design. It followed on from the British Magnox design first generation reactor. All AGRs have graphite cores and carbon dioxide as coolant. Gas cooling allows high temperatures (640 °C at outlet) and therefore high thermal efficiency (41% compared with around 34% for PWR). However the core needs to be much larger in AGRs than PWRs and fuel (enriched) efficiency is lower. AGR are refuelled at part load or when shut down.
**PWR = Pressurised Water Reactor – water cooled reactor whereby water is pumped under pressure.