NUCLEAR MONITOR

May 7, 2015 | No. 803

A PUBLICATION OF WORLD INFORMATION SERVICE ON ENERGY (WISE) AND THE NUCLEAR INFORMATION &RESOURCE SERVICE (NIRS)

Editorial

Dear readers of the WISE/NIRS Nuclear Monitor,

In this issue of the Monitor:

- We write about the demise of Areva's EPR reactor, including the latest problems with flawed pressure vessels.
- Charly Hultén writes about nuclear power's latest setback in Sweden − Vattenfall abandoned plans for new reactors earlier this year and now it has brought forward plans to retire two reactors.
- We summarise a new study on nuclear accidents and the problems with 'probabilistic risk assessments'.
- We summarise a critical report about Generation IV reactors written by the French government's Institute for Radiological Protection and Nuclear Safety.
- We update nuclear debates in Belgium, with the government planning to short-circuit proper consultation and planning processes in order to fast-track lifetime extensions for two reactors.

Feel free to contact us if you have feedback on this issue of the Monitor, or if there are topics you would like to see covered in future issues.

Regards from the editorial team.

Email: monitor@wiseinternational.org

Monitored this issue:

European Pressurized Reactors − a negative learning curve on steroids 1

Sweden: Vattenfall announces early retirement of two reactors 5

Nuclear accidents and risk assessments 7

French government agency sceptical about Gen IV reactors 9

Belgium to postpone closure of Doel 1 and 2? 11

European Pressurized Reactors − a negative learning curve on steroids

Author: *Jim Green − Nuclear Monitor editor*

NM803.4467 The French European Pressurized Reactor (a.k.a. Evolutionary Power Reactor) was the first Generation III design to win orders, first in Finland in 2003 (Olkiluoto 3 − the first reactor order in Western Europe in 15 years), France in 2006 (Flamanville) and China in 2007 (two EPRs at Taishan).

Since then, EPRs have faced one problem after another. All three EPR construction projects have suffered cost blowouts or delays or both.

Since the contract was signed in 2003 for a new EPR in Finland, the estimated cost has risen from €3.2 billion (US$3.6b) to €8.5 billion (US$9.5b). Areva has already made provision for a €2.7 billion (US$3.0b) writedown on the project, with further losses expected.[1] French and Finnish utilities have been locked in legal battles over the cost overruns for several years.[1,2] The project is nine years behind schedule − the start-up date has been pushed back from 2009 to 2018.[3]

The estimated cost of the Flamanville EPR in France has increased from €3.3 billion (US$3.7b) to at least €9 billion (US$10.1b).[4,5] The first concrete was poured in 2007 and commercial operation was expected in 2012, but that timeframe has been pushed back to 2017 (with further delays likely).[6]

The British *Daily Mail* characterised the Flamanville EPR project as one "beset by financial mismanagement with rocketing costs, the deaths of workers, an appalling inability to meet construction deadlines, industrial chaos, and huge environmental concerns", and notes that "it continues to be plagued by delays, soaring costs, and litigation in both the criminal and civil courts."[7]

The two EPRs under construction in China are 13–15 months behind schedule.[8]

Since the Fukushima disaster, a number of countries that might have considered EPRs pulled back from earlier interest in new reactors − the Netherlands, Sweden, and Switzerland, among others.[8] In 2012, new-build tender processes in Finland and the Czech Republic rejected the EPR.

In the US, a total of seven EPRs were planned at six sites.[9] Four EPR construction licence applications were submitted to the Nuclear Regulatory Commission (NRC) − Unistar's Nine Mile Point (New York), Ameren's Callaway (Missouri), PPL's Bell Bend (Pennsylvania) and Constellation's Calvert Cliffs (Maryland). All of those applications have been abandoned or suspended. In February 2015, Areva asked the NRC to suspend work on EPR design certification until further notice.[10]

EPRs were considered at various sites in Canada − including Alberta and Darlington, Ontario − but those plans were shelved and a generic licensing process by the Canadian Nuclear Safety Commission was terminated.[11]

In 2009, Italian utility Enel and EDF planned to build four EPRs but that plan was scrapped after Italy's June 2011 referendum which rejected nuclear power. In 2012, Enel pulled out of the Flamanville EPR project.[12]

The United Arab Emirates chose South Korean reactor technology over EPRs. Reflecting on that decision, former EDF head Francois Roussely concluded that while the EPR is "one of the best" third-generation designs, the complexity of the design is a "handicap". Likewise, Cambridge University nuclear engineer Tony Roulstone said in an October 2014 lecture that the EPR design is very safe but extraordinarily difficult to build − he described it as "unconstructable".[13]

According to the US NRC, EPRs have four sets of active safety systems, each capable of cooling the reactor on its own, and other safety features including a double-walled containment and a "core catcher" for holding melted reactor core materials after a severe accident.[14] But the safety of some EPR design choices has been questioned by the French government's Institute for Radiological Protection and Nuclear Safety[15], and the EPR licensing process in the UK has been criticised.[16]

Pressure vessel problems

On 7 April 2015, the French Nuclear Safety Authority (ASN) announced that fabrication defects had been found in the reactor pressure vessel of the Flamanville EPR. Tests revealed areas with high carbon concentration resulting in "lower than expected mechanical toughness values".[17,18]

Pierre-Franck Chevet, head of ASN, said: "It is a serious fault, even a very serious fault, because it involves a crucial part of the nuclear reactor."[19]

The results of further tests are expected by October 2015. In one scenario, ASN will not require any remedial action and there will be minimal consequences for Areva. But if remedial action is required, it could be extremely expensive and problematic for Areva, all the more so because the pressure vessel has already been installed in the Flamanville EPR. Asked what would happen if tests were negative, Chevet said: "Either EDF abandons the project or it takes out the vessel and starts building a new one ... this would be a very heavy operation in terms of cost and delay."[20]

In a worst-case scenario for Areva, the pressure vessel problem would kill the Flamanville reactor project. A former senior nuclear safety official told *Le Parisien*: "If the weakness of the steel is proved, I don't hold out much hope for the survival of the [Flamanville] EPR project."[19]

Actually there are even worse scenarios for Areva − the latest problems could hasten the demise of EPR projects altogether, and might even tip Areva into bankruptcy. Areva posted a €4.83 billion (US$5.4b) loss for 2014 and is negotiating a rescue package with the French government. Areva's CEO Philippe Knoche said in response to the 2014 financial loss: "The scale of the net loss for 2014 illustrates the two-fold challenge confronting Areva: continuing stagnation of the nuclear operations, lack of competitiveness and difficulties in managing the risks inherent in large projects. The group understands how serious the situation is."[21]

Energy specialist Thomas Olivier Leautier from the Toulouse School of Economics said: "Areva's financial situation is critical, the EPR is as crucial to them as the iPhone was to Apple. Their failure in Finland and now the problem in Flamanville could prove fatal."[21]

French environmental minister Ségolène Royal congratulated ASN on its speedy reaction to the pressure vessel problem.[4] Others are asking why the problem was not discovered before the vessel was installed. It is believed the problem involved an inaccurate material inspection device used between 2009 and 2014.[22]

ASN's Pierre-Franck Chevet acknowledged that "mistakes had been made". He said: "It is more than 15 years since the last nuclear power stations were constructed in France. The expertise in some trades has not been sufficiently passed on from one generation to the next."[19]

Chevet said the two planned EPRs planned for Hinkley Point in the UK could be affected as identical safety casings have already been manufactured for those reactors using the same manufacturing techniques.[19]

The two EPRs under construction in China might also be affected since the pressure vessels for those reactors were forged by Areva subsidiary Creusot Forge, as was the Flamanville vessel.[23] China will not load fuel at the Taishan EPRs until safety issues have been resolved, China's environment ministry said.[24]

A senior manager of a Chinese nuclear company, speaking anonymously to the *South China Morning Post,* said: "The people responsible for this need to be sacked. It shouldn't have happened. All materials must be checked thoroughly before use − that's a basic requirement. The urgent task is to launch a quality inspection in Taishan as soon as possible. Each batch of materials varies slightly. We will cross our fingers and pray for the best."[25]

It is unlikely that the EPR under construction in Finland is at risk of a defective pressure vessel, as the vessel was forged by Japan Steel Works. Nevertheless, the Finnish Radiation and Nuclear Safety Authority (STUK) has instructed energy utility TVO carry out new tests of the durability of the pressure vessel.[26]

A future for EPRs?

An immediate priority for Areva is to keep the UK Hinkley Point EPR project moving ahead. That project faces a legal challenge under EU regulations against the massive subsidies being offered by the UK government. Areva also has to sort out unresolved issues with its Chinese project partners. And it needs to find additional partners to cover capital costs.

Ironically, Areva itself may not have the resources for its expected 10% stake in Hinkley Point. Chief executive Philippe Knoche recently declined to commit to the 10% figure, and the head of Areva's reactors and services division said: "Our current financial situation obviously will make things more difficult."

Bloomberg noted in an April 16 article that Areva's EPR export ambitions are now in "tatters". Bloomberg quoted former World Nuclear Association executive Steve Kidd, who said "everyone was laughing" at Areva's projections for EPR sales. Kidd blames the EPR saga in part on the French government's 80% ownership of Areva: "Everyone in the know could tell the chickens were going to come home to roost. I don't think that would have happened in a private business."[5]

According to trade union sources, Philippe Knoche said in February that the utility was likely to sell only about a dozen EPRs in the years up to 2030, down from 25 predicted previously.[27]

If Areva is to secure a dozen orders by 2030, it will need further orders from China − which seems increasingly unlikely. Steve Thomas from Greenwich University says reactors built by Areva and Westinghouse "are just too expensive for the Chinese."[5]

Philippe Knoche says Areva will emphasise growth in China, which he described as the "new frontier" of global nuclear power.[10] The two EPRs under construction at Taishan will likely be completed (unless the pressure vessel problem becomes a major obstacle). It is doubtful whether two additional EPRs planned for the same site will proceed, and still more doubtful that EPRs will be built at other sites.

An agreement (but not a binding contract) to build two EPRs at India's Jaitapur site was signed in 2010. The project has moved at snail's pace. Construction was to start in 2013 but unresolved issues (including financial arrangements) continue to delay the project.[28]

Perhaps Areva will secure further orders in France. That will depend in part on debates over future reliance on nuclear power and other electricity sources, and a debate over permitted lifetimes for the current fleet of reactors.

Areva is involved in developing a 1.1 gigawatt pressurized water reactor called ATMEA. But in March 2015 Areva recognized an €80 million (US$89m) impairment for its share of ATMEA development costs "following the downward revision in the number and schedule of potential sales of this reactor outside Turkey, in the absence of tangible progress in the selection processes of the countries involved at the end of 2014."

The *World Nuclear Industry Status Report 2014* states:

"The smaller PWR design, ATMEA, developed in collaboration with Mitsubishi, has been mentioned as an option for Jordan, Hungary, Argentina, and Turkey for the Sinop project. However, these are all, at best, long shots and unless ATMEA attracts interest in more prestigious markets and get comprehensive safety approval from a highly experienced regulator, it appears to have little future."[8]

Lessons from the EPR saga

What to make of the EPR saga? Areva is backing the wrong horse − the outcome of current political debates will result in a declining role for nuclear power in France, coupled to the growth of renewables.

Areva has also backed the wrong-sized wrong horse: a giant reactor with a giant price-tag.

Areva has backed the wrong-sized wrong horse at the wrong time − the Global Financial Crisis and its aftermath, stagnant energy demand, the liberalization of energy markets, the political fallout from the Fukushima disaster and other factors have dampened demand for new reactors and made it more difficult to secure finance (or government subsidies) for huge projects.

The EPR saga undermines the rhetoric of standardised, simplified reactors designs ushering in a new era of nuclear growth.

The EPR might have demonstrated the potential for mass production to drive down costs − but in reality it is demonstrating the opposite.

The EPR saga shows that developing modified versions of conventional reactors (in this case pressurized water reactors) can be complicated and protracted and can end in failure. How much more difficult will it be to develop radically new types of reactors?

The EPR saga shows that even countries with extensive nuclear expertise and experience can mess things up.

Even before the EPR fiasco, the large-scale, standardised French nuclear power program was subject to a negative economic learning curve − costs were increasing over time.[29] The EPR represents a negative learning curve on steroids. That point is emphasised by construction cost estimates of £16−24.5 billion (US$24.3−37.2b; €21.7−33.2b) for two planned EPRs (with combined capacity of 3.2 gigawatts) in the UK.[30] In the mid- to late-2000s, the estimated construction cost for an EPR was £2 billion[31]; current estimates are 4−6 times higher.

Private companies have pulled out of EPR projects in several countries (Italy, the US, the UK, etc.). Thus the EPR fiasco reinforces points made in the International Energy Agency's *World Economic Outlook 2014* report − that nuclear growth will be "concentrated in markets where electricity is supplied at regulated prices, utilities have state backing or governments act to facilitate private investment," and conversely, "nuclear power faces major challenges in competitive markets where there are significant market and regulatory risks".[32]

References:

1. World Nuclear Association, April 2015, 'Nuclear Power in Finland', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/
2. World Nuclear News, 6 July 2012, 'Partial ruling on Olkiluoto 3', www.world-nuclear-news.org/-Arbitration_court_rules_on_Olkiluoto_3-0607124.html
3. Reuters, 1 Sept 2014, 'Finland's nuclear plant start delayed again; Areva, TVO trade blame', www.reuters.com/article/2014/09/01/finland-nuclear-olkiluoto-idUSL5N0R20CV20140901
4. 21 Apr 2015, France's nuclear calamity has UK worried, www.thelocal.fr/20150421/flamanville-frances-own-nuclear-nightmare
5. Carol Matlack, 16 April 2015, 'Areva Is Costing France Plenty', www.bloomberg.com/news/articles/2015-04-16/france-s-areva-falters-in-reactor-business-leaks-cash
6. World Nuclear Association, March 2015, 'Nuclear Power in France', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/
7. Steve Bird, 26 Oct 2013, 'Deaths, chilling safety lapses, lawsuits, huge cost over-runs and delays: Why we can't trust the French with Britain's nuclear future', www.dailymail.co.uk/news/article-2477202/Deaths-chilling-safety-lapses-lawsuits-huge-cost-runs-delays-Why-trust-French-Britains-nuclear-future.html
8. World Nuclear Industry Status Report 2014, www.worldnuclearreport.org/-2014-.html
9. Beyond Nuclear, Feb 2015, 'Epic Fail: Électricité de France and the "Evolutionary Power Reactor"', http://static1.1.sqspcdn.com/static/f/356082/25937356/1423508130603/Epic+Fail-+the+EPR.pdf
10. World Nuclear News, 6 March 2015, 'US EPR plans suspended', www.world-nuclear-news.org/RS-US-EPR-plans-suspended-0603157.html
11. World Nuclear Association, Feb 2015, 'Nuclear Power in Canada', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Canada--Nuclear-Power/
12. World Nuclear Association, Nov 2014, 'Nuclear Power in Italy', www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Italy/
13. Carbon Commentary, 22 Oct 2014, 'Cambridge nuclear engineer casts doubt on whether Hinkley Point EPR nuclear plant can be constructed', www.carboncommentary.com/blog/2014/10/22/cambridge-nuclear-engineer-casts-doubt-on-whether-hinkley-point-epr-nuclear-plant-can-be-constructed/
14. US NRC, Aug 2014, 'New Nuclear Plant Designs', www.nrc.gov/reading-rm/doc-collections/fact-sheets/new-nuc-plant-des-bg.pdf
15. Louis Germain and Martin Leers, 21 Jan 2015, 'EDF's chaotic approach of French EPR reactor safety', http://journaldelenergie.com/nucleaire/edfs-chaotic-approach-french-epr-reactor-safety/
16. Emma Bateman, 26 Dec 2013, 'Hinkley C: the Generic Design Assessment has failed', www.theecologist.org/blogs_and_comments/commentators/2209776/hinkley_c_the_generic_design_assessment_has_failed.html
17. Yves Marignac, WISE-Paris, April 2015, 'Fabrication Flaws in the Pressure Vessel of the EPR Flamanville-3', http://bit.ly/EPR_WISE-Paris Summary posted at: http://safeenergy.org/2015/04/13/the-epr-anamoly/
18. WNN, 20 April 2015, 'Flamanville construction continues while vessel tests due', www.world-nuclear-news.org/RS-Flamanville-construction-continues-while-vessel-tests-due-2004155.html
19. John Lichfield, 18 April 2015, 'UK nuclear strategy faces meltdown as faults are found in identical French project', www.independent.co.uk/news/uk/home-news/uk-nuclear-strategy-faces-meltdown-as-faults-are-found-in-identical-french-project-10186163.html
20. Reuters, 17 April 2015, http://uk.reuters.com/article/2015/04/17/areva-nuclear-idUKL5N0XE11320150417
21. Liza Malykhina, 17 April 2015, 'France's nuclear power giant beset by setbacks', www.france24.com/en/20150417-french-nuclear-company-faces-major-setbacks/
22. Nadya Masidlover, 22 April 2015, 'Areva reassures on nuclear-reactor components', www.marketwatch.com/story/areva-reassures-on-nuclear-reactor-components-2015-04-22
23. World Nuclear News, 22 April 2015, 'Areva reviews forging inspections', www.world-nuclear-news.org/C-Areva-reviews-forging-inspections-2204156.html
24. Reuters, 16 April 2015, 'China says no fuel loading at Areva-designed reactor until safety issues cleared', http://in.reuters.com/article/2015/04/16/china-nuclear-areva-idINL4N0XD3AU20150416
25. Stephen Chen, 10 April 2015, 'French warning on nuclear reactors being built in China's Guangdong', www.scmp.com/news/china/article/1762861/french-warning-nuclear-reactors-being-built-guangdong
26. YLE, 18 April 2015, 'Nuclear watchdog seeks re-check of Olkiluoto 3 reactor', http://yle.fi/uutiset/nuclear_watchdog_seeks_re-check_of_olkiluoto_3_reactor/7937448
27. Reuters, 27 Feb 2015, www.reuters.com/article/2015/02/27/us-areva-strategy-idUSKBN0LV1IA20150227
28. World Nuclear Association, 17 April 2015, 'Nuclear Power in India', www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/
29. Arnulf Grubler, September 2010, 'The costs of the French nuclear scale-up: A case of negative learning by doing', Energy Policy, Vol.38, Issue 9, pp.5174–5188, www.sciencedirect.com/science/article/pii/S0301421510003526
30. The higher estimate is from the European Commission and includes finance costs. European Commission, 8 Oct 2014, http://europa.eu/rapid/press-release_IP-14-1093_en.htm
31. Steve Thomas, Mycle Schneider, and Antony Froggatt, 21 Aug 2014, 'The saga of Hinkley Point C: Europe's key nuclear decision', www.energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/
32. International Energy Agency, 2014, 'World Economic Outlook 2014', www.worldenergyoutlook.org

France's renewable energy potential

A report by ADEME, a French government agency under the Ministries of Ecology and Research, shows that a 100% renewable electricity supply by 2050 in France is feasible and would cost hardly any more than a mix of 50% nuclear, 40% renewables, and 10% fossil fuels (primarily gas).

The 119-page report is the result of 14 months of detailed research, and examines the feasibility and costs of several different models ranging from a 40% reliance on renewables by 2050 up to 100% reliance.

For an all-renewables scenario, the report proposes an ideal electricity mix: 63% from wind, 17% from solar, 13% from hydro and 7% from renewable thermal sources (including geothermal energy).

To match supply and demand (and deal with intermittency), the report proposes demand management (electric cars, for example, charging and discharging), import/export, short-term storage (batteries and compressed air installations, for example), pumped-storage hydro, and power-to-gas-to-power technologies (hydrogen/methane).

The report estimates that the electricity production cost would be 119 euros per megawatt-hour in the all-renewables scenario, compared with a near-identical figure of 117 euros per MWh with a mix of 50% nuclear, 40% renewables, and 10% fossil fuels. The current average cost is 91 euros per MWh.

Damien Siess, ADEME's deputy director for production and sustainable energy, noted that renewable energy sources are currently more expensive than nuclear, but the cost of renewables is falling while the cost of nuclear is increasing, mainly because of the safety standards required for new reactors such as the EPR.

The full report (in French):

L'Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME), 2015, 'Vers un mix électrique 100% renouvelable en 2050',

www.ademe.fr/sites/default/files/assets/documents/rapport100enr_comite.pdf

http://fr.scribd.com/doc/261245927/le-rapport-100-energies-renouvelables

English language summary:

Terje Osmundsen, 20 April 2015, www.energypost.eu/french-government-study-95-renewable-power-mix-cheaper-nuclear-gas/

Meanwhile, a new report by the China National Renewable Energy Centre finds that China could generate 85% of its electricity and 60% of total energy from renewables by 2050.

Article: www.rtcc.org/2015/04/22/chinas-electricity-could-go-85-renewable-by-2050-study/

Report: 'China high renewables 2050 roadmap − summary', www.scribd.com/doc/262740831/China-high-renewables-2050-roadmap-summary

Sweden: Vattenfall announces early retirement of two reactors

Author: *Charly Hultén, WISE Sweden*

NM803.4468 On 28 April, Vattenfall CEO Magnus Hall announced that the company will shut down Ringhals 1 (a boiling water reactor that came online in 1976), and Ringhals 2 (pressurized water reactor, 1975) between 2018 and 2020. This is instead of sometime between 2020 and 2025, as previously planned. The announcement follows on the heels of Vattenfall's decision to close its R&D unit devoted to 'new build' (as reported in Nuclear Monitor #797).

The move will bring Vattenfall's remaining fleet down to five reactors, all of which, the company claims, can continue to produce electricity into the 2040s – a planned lifetime of 60 years. (Another three reactors are operated by OKG, a consortium owned by E.ON Sverige and Fortum.)

R1 and R2 are Sweden's oldest reactors, aged 40 and 39 years, respectively. Both reactors are relatively small and currently operate at a loss, due to a sustained fall in electricity prices on the Nord Pool exchange (www.nordpoolspot.com). Actually, R2 has not produced electricity since August 2014, when a routine inspection found corrosion on the bottom of the containment vessel. The reactor is expected to be out of commission until this coming Fall, at the earliest.

Some compensation for the problems in R2 and the early decommissioning of both R1 and R2 will be provided by an increase in the output of R4 (see box below).

Magnus Hall noted that Vattenfall will be shifting its focus toward sectors of the energy market that are less sensitive to the price of electricity. Alongside a stronger emphasis on renewables, Vattenfall will get more involved in district heating and consultancy in the field of energy efficiency.

Is it the market or political directive?

Vattenfall has been explicit in explaining why the company is making the move: ”Electricity prices are on the way down, our costs are going in the opposite direction,” Hall told Sveriges Radio in an interview after the announcement. ”Market prices are too low, and we see no other way out,” he continued.

Vattenfall's press release is equally unequivocal, noting that the company anticipates ”continued low electricity prices in coming years”, that it faces ”increasing production costs”, and that the decision on R1 and R2 was ”business driven”.

The Government, for its part, flatly denies that political pressure has been brought to bear.

In most countries, that would be convincing enough. But Sweden is into its third decade of bitter squabbles over the outcome of an advisory referendum on nuclear energy in 1980 that divided the political spectrum as well as individual parties. Positions taken back then have become entrenched in some quarters.

As a consequence, the Liberal Party leader, the Confederation of Swedish Enterprise and the political editors at leading Conservative newspaper, *Svenska Dagbladet,* were all quick to conclude that government pressure lay behind the decision. The current Social Democratic and Green Party Government has made it hard for Vattenfall to turn a profit, they argue, pointing to a recently announced Bill that would raise the tax on reactor capacity (not actual production) as the culprit.

The capacity tax was introduced in 2000 by a Social Democratic Government. In 2008 a Conservative-led Government more than doubled it. A current Bill that proposes to raise the tax again (by 17%) will be debated in Parliament later this month. If passed, it will take effect in August.

Neither Vattenfall's press release nor the CEO's remarks made any reference to the tax.

The consensus view is this: The market is achieving the phase-out that Sweden's politicians have been unable to agree on. The Liberal Party and the Conservatives complain, but only the Sweden Democrats – a nationalist-populist party that received 17% of the vote in last year's election, but remains a pariah in the eyes of all established parties – advocate state subsidization of nuclear energy.

”The other parties are willing to let the phase-out happen,” said Tomas Ramberg, a political commentator with the (publicly-funded) Sveriges Radio, in a roundtable discussion. No-one at the table objected.

Another participant in the roundtable discussion was Per Lindvall, economic analyst for *Svenska Dagbladet,* whose political editors are so eager to blame the Government. Mr Lindvall sees Vattenfall's decision as simply an effective means to cut the company's losses. It is also a ”wise” strategy from the company's point of view to reduce overall electricity output, he said.

What are the consequences?

Is this 'the beginning of the end' of nuclear energy in Sweden? Yes and no. More and more Swedes are recognizing that nuclear energy can be a costly habit. Finland's fifth reactor, under construction at Olkiluoto, now at about 270% of the original budget, and the massive subsidies being offered by the British Government to French utility EDF to build new reactors in the UK, have cooled most parties' enthusiasm for 'new build', and subsidization is out. But, as Sweden will still have eight reactors in operation, and the owners envisage reactor lifetimes of up to 60 years, reliance on some amount of nuclear energy will probably be in the picture through the 2030s.

Will the country's energy supply suffer? Not immediately, perhaps not at all. The dominant assessment sees a risk of shortages in the south of Sweden, but only if Sweden's next two oldest reactors, O1 and O2 at Oskarshamn, are taken offline, as well. OKG, the reactors' owner, has complained of operating losses for the same reasons Vattenfall puts forward in relation to the Ringhals 1 and 2. Whether Vattenfall's decision will have any effect on OKG's strategic thinking remains to be seen.

Energy experts caution that the current price-cost ratio may lead to additional phase-outs. As a preparedness measure, Minister of Energy Ibrahim Baylan proposes to extend the maintenance of prepaid capacity reserves managed by Svenska Kraftnät, which operates the national grid. These reserves lie idle until they are needed, for example, under extreme climate conditions when industry is producing at full capacity.

Nuclear owners' decisions to reduce output may, some commentators predict, make it easier for the parties and interest groups to get past the issue of ”nuclear energy, for or against” and reach agreement on how to secure the country's power needs. If so, it would definitely facilitate the work of the Energy Commission that the Prime Minister plans to convene.

Will electricity prices rise? Yes, but only moderately in the short term. The only estimate put forward in connection with Vattenfall's latest announcement puts the price rise at +0.01 SEK in 2018, an increase of 3.7%. Predictions for the longer term are uncertain – mainly due to the impact of renewable energy sources and the addition of a fifth Finnish reactor in the region.

Higher prices would not be an unmixed evil. Should prices show a sustained upward trend, it would provide an inducement to Swedish industry to start using currently unexploited in-house energy reserves such as process heat, back pressure, and energy-rich chemical by-products and wastes.

Sources:

English:

Vattenfall: Vattenfall changes direction for operational lifetime of Ringhals 1 and 2, press release, 28 April 2015, http://corporate.vattenfall.com/news-and-media/press-releases/2015/vattenfall-changes-direction-for-operational-lifetimes-of-ringhals-1-and-2/

Swedish:

Ringhals reaktorer stängs tidigare (TT/Ny Teknik 28 April 2015), www.nyteknik.se/nyheter/energi_miljo/karnkraft/article3904252.ece

Monica Kleja: Ringhals 4 får höja effekten (Ny Teknik 4 February 2015), www.nyteknik.se/nyheter/energi_miljo/karnkraft/article3881618.ece

Sveriges Radio/P1 Studio Ett, 28 April 2015, http://sverigesradio.se/sida/artikel.aspx?programid=1637&artikel=6152756

Björn Dickson, Anna De Lima Fagerlind: Olönsam kärnkraft stängs i förtid (Svenska Dagbladet Näringsliv, 29 April 2015, www.pressreader.com/sweden/svenska-dagbladet/20150429/.../TextView

Peter Akinder: Vattenfall stänger reaktorer (op ed piece, Östra Småland/Nyheterna, 29 April 2015), www.ostrasmaland.se/ledare/vattenfall-stanger-reaktorer/

Ökad press på politikerna (Östra Småland/Nyheterna, 29 April 2015)

More power from Ringhals 4

The decision to raise the productivity of a 'middle-aged' reactor like R4 by 18% was long in the making. Vattenfall applied for permission in 2007; the regulator gave permission in February of this year. Whereas the past government was favorable all along, several members of the engineering community and the regulatory authority expressed some concern about possibly damaging stress to aging reactor components (valves, etc.).

In the interval, R4's steam generators and pressurizer have been replaced. *Ny Teknik*, the leading Swedish technical newspaper, reports that roughly 20 billion SEK (€2.1b, US$2.4b) have been invested in modernizing the four reactors at Ringhals over the past 10 years.

If R4 passes all the tests, to be conducted this year, sometime in 2016 it will start to contribute an extra 1.3 terrawatt-hours per annum, assuming trouble-free operation.

In this context it might be mentioned that Oskarshamn 3 (BWR, 1985) has just completed a similar test period and came online in January. Capacity there is now 1450 MW.

Source: 4 Feb 2015, www.nyteknik.se/nyheter/energi_miljo/karnkraft/article3881618.ece

Nuclear accidents and risk assessments

NM803.4469 A new study published in *Physics and Society* analyses 174 nuclear accidents between 1946 and 2014 that resulted in loss of human life and/or more than US$50,000 of property damage (in 2013 dollars). The accidents involved nuclear energy at the production/generation, transmission, and distribution phase (nuclear power plants, uranium mines, enrichment/reprocessing/MOX plants, manufacturing plants, transportation by truck or pipeline, etc.)[1]

The authors − academics Spencer Wheatley, Benjamin Sovacool and Didier Sornette − state that the rate of nuclear accidents meeting their criteria decreased from the late 1970s, decreased further after Chernobyl (April 1986), and since then has been fairly stable at around 0.002 to 0.003 events per plant per year (roughly one accident per year worldwide meeting their criteria). The distribution of damage size dropped after the Three Mile Island accident (March 1979) − the median damage size became approximately 3.5 times smaller.

The worst accidents do not show any clear patterns. The authors note that "the term "dragon-king" has been introduced to refer the situation where extreme events appear that do not belong to the same distribution as their smaller siblings."

Based on their statistical calculations, the authors estimate a 50% chance of a Fukushima event (or larger) in the next 50 years, a Chernobyl event (or larger) in the next 27 years, and a Three Mile Island event (or larger) in the next 10 years. However they note that "there is tremendous estimation uncertainty associated with these estimations."

A more detailed version of the research, along with the list of 174 accidents, will be published at a later date.

Probabilistic risk assessment

Wheatley, Sovacool and Sornette question the accuracy of probabilistic risk assessment (PRA), which requires the definition of failure scenarios to which probabilities and damage values are assigned. They note that statistical/empirical analyses of nuclear accidents have “almost universally” found that PRA “dramatically underestimates the risk of accidents”, and they point to research demonstrating that PRAs are “fraught with unrealistic assumptions, severely underestimating the probability of accidents”.

Likewise, Princeton University physicist M.V. Ramana challenges “misleading” PRAs such as Areva’s estimate for its EPR of one core-damage incident per reactor in 1.6 million years, and Westinghouse’s claim that for its AP1000 reactors the core melt frequency is roughly one incident per reactor in two million years.[2]

Ramana writes:

“There are both empirical and theoretical reasons to doubt these numbers. A 2003 study on the future of nuclear power carried out by the Massachusetts Institute of Technology points out that “uncertainties in PRA methods and data bases make it prudent to keep actual historical risk experience in mind when making judgments about safety.” What does history tell us? Globally, there have been close to 15,000 reactor-years of experience, with well-known severe accidents at five commercial power reactors − three of them in Fukushima.

“However, as Thomas Cochran of the Natural Resources Defense Council explained in his recent testimony to the US Senate, depending on how core damage is defined, there are other accidents that should be included. The actuarial frequency of severe accidents may be as high as 1 in 1,400 reactor-years. At that rate, we can expect an accident involving core damage every 1.4 years if nuclear power expands from today’s 440 commercial power reactors to the 1,000-reactor scenario laid out in the MIT study. In either case, though, our experience is too limited to make any reliable predictions.

“Theoretically, the probabilistic risk assessment method suffers from a number of problems. Nancy Leveson of MIT and her collaborators have argued that the chain-of-event conception of accidents typically used for such risk assessments cannot account for the indirect, non-linear, and feedback relationships that characterize many accidents in complex systems. These risk assessments do a poor job of modeling human actions and their impact on known, let alone unknown, failure modes.”

Ramana notes that conclusions about overall accident probabilities derived from PRAs are “far from dependable”. He notes that before the Chernobyl accident, B.A. Semenov, the head of the International Atomic Energy Agency’s safety division, said that “a serious loss-of-coolant accident is practically impossible” with Chernobyl-type reactors.

Ramana concludes:

“The lesson from the Fukushima, Chernobyl, and Three Mile Island accidents is simply that nuclear power comes with the inevitability of catastrophic accidents. While these may not be frequent in an absolute sense, there are good reasons to believe that they will be far more frequent than quantitative tools such as probabilistic risk assessments predict. Any discussion about the future of nuclear power ought to start with that realization.”

The Fukushima disaster illustrated one of the weaknesses of PRAs − the difficulty of modeling common-cause failures. Fukushima illustrated another problem − PRAs do not account for complacency, corruption, slack regulation etc.

He Zuoxiu, a member of the Chinese Academy of Sciences and researcher at the CAS Institute of Theoretical Physics, wrote in a 2013 article:

“The world’s 443 nuclear power plants have been running for a total of 14,767 reactor-years, during which time there have been 23 accidents involving a reactor core melting. That’s one major accident every 642 reactor years. But according to the design requirements, an accident of that scale should only happen once every 20,000 reactor years. The actual incidence is 32 times higher than the theory allows.

“Some argue this criticism is unfair. After all, 17 of those 23 accidents were caused by human error − something hard to account for in calculations. But human error is impossible to eliminate, and cannot be ignored when making major policy decisions.

“Even if we set aside the accidents attributed to human error, technical failings have caused core melting once every 2,461 reactor-years. That’s still more than eight times the theoretical calculation.”

References:

1. Spencer Wheatley, Benjamin Sovacool and Didier Sornette, April 2015, ‘Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents & Accidents’, Physics and Society, http://arxiv.org/abs/1504.02380
2. M. V. Ramana, 19 April 2011, ‘Beyond our imagination: Fukushima and the problem of assessing risk’, Bulletin of the Atomic Scientists, http://thebulletin.org/web-edition/features/beyond-our-imagination-fukushima-and-the-problem-of-assessing-risk
3. He Zuoxiu, 25 Oct 2013, ‘Chinese nuclear disaster ‘highly probable’ by 2030’, www.chinadialogue.net/article/show/single/en/5808-Chinese-nuclear-disaster-highly-probable-by-2-3-

French government agency sceptical about Gen IV reactors

NM803.4470 The French Institute for Radiological Protection and Nuclear Safety (IRSN) has produced an important critique of Generation IV nuclear power concepts.[1] IRSN is a government authority with 1,790 staff under the joint authority of the Ministries of Defense, the Environment, Industry, Research, and Health.

There are numerous critical analyses of Generation IV concepts by independent experts[2], but the IRSN critique is the first from the government of a country with an extensive nuclear industry.

The IRSN report focuses on the six Generation IV concepts prioritised by the Generation IV International Forum (GIF), which brings together 12 countries with an interest in new reactor types, plus Euratom. France is itself one of the countries involved in the GIF.

The six concepts prioritised by the GIF are:

- Sodium cooled Fast Reactors (SFR);
- Very High Temperature Reactors, with thermal neutron spectrum (VHTR);
- Gas-cooled Fast Reactors (GFR);
- Lead-cooled Fast Reactors (LFR) or Lead-Bismuth (LB) cooled Fast Reactors;
- Molten Salt Reactors (MSR), with fast or thermal neutron spectrum; and
- SuperCritical Water Reactors (SCWR), with fast or thermal neutron spectrum.

The report states: “There is still much R&D to be done to develop the Generation IV nuclear reactors, as well as for the fuel cycle and the associated waste management which depends on the system chosen.”

IRSN considers the SFR system to be the only one to have reached a degree of maturity compatible with the construction of a reactor prototype during the first half of this century − and even the development of an SFR prototype would require further preliminary studies and technological developments.

Only SFR and VHTR systems can boast operating experience. IRSN states: “No operating experience feedback from the other four systems studied can be put to direct use. The technological difficulties involved rule out any industrial deployment of these systems within the time frame considered [mid century].”

The report says that for LFR and GFR systems, small prototypes might be built by mid-century. For MSR and SCWR systems, there “is no likelihood of even an experimental or prototype MSR or SCWR being built during the first half of this century” and “it seems hard to imagine any reactor being built before the end of the century”.

IRSN notes that it is difficult to thoroughly evaluate safety and radiation protection standards of Generation IV systems as some concepts have already been partially tried and tested, while others are still in the early stages of development.

IRSN is sceptical about safety claims: “At the present stage of development, IRSN does not notice evidence that leads to conclude that the systems under review are likely to offer a significantly improved level of safety compared with Generation III reactors, except perhaps for the VHTR ...” Moreover the VHTR system could bring about significant safety improvements “but only by significantly limiting unit power”.

The report notes that the safety of fast reactors can be problematic because of high operating temperatures and the toxicity and corrosive nature of most coolants considered. It says that issues arising from the Fukushima disaster require detailed examination, such as: choice of coolant; operating temperatures and power densities (which are generally higher for Generation IV concepts); and in some cases, fuel reprocessing facilities that present the risk of toxic releases.

The report is unenthusiastic about research into transmutation of minor actinides (long-lived waste products in spent fuel), saying that “this option offers only a very slight advantage in terms of inventory reduction and geological waste repository volume when set against the induced safety and radiation protection constraints for fuel cycle facilities, reactors and transport.” It notes that ASN, the French nuclear safety authority, has recently announced that minor actinide transmutation would not be a deciding factor in the choice of a future reactor system.

The reports findings on the six GIF concepts are briefly summarised here:

Sodium-cooled Fast Reactors (SFR)

The main safety advantage is the use of low-pressure liquid coolant. The normal operating temperature of this coolant is significantly lower than its boiling point, allowing a grace period of several hours during loss-of-cooling events. The advantage gained from the high boiling point of sodium, however, must be weighed against the fact that the structural integrity of the reactor cannot be guaranteed near this temperature.

The use of sodium also comes with a number of drawbacks due to its high reactivity not only with water and air, but also with MOX fuel.

It seems possible for SFR technology to reach a safety level at least equivalent to that of Generation III pressurised water reactors, but IRSN is unable to determine whether it could significantly exceed this level, in view of design differences and the current state of knowledge and research.

Very High Temperature Reactors (VHTR)

The VHTR benefits from the operating experience feedback obtained from High Temperature Reactors (HTR).

This technology is intrinsically safe with respect to loss of cooling, which means that it could be used to design a reactor that does not require an active decay heat removal system. The VHTR system could therefore bring about significant safety improvements compared with Generation III reactors, especially regarding core melt prevention.

VHTR safety performance can only be guaranteed by significantly limiting unit power.

The feasibility of the system has yet to be determined and will chiefly depend on the development of fuels and materials capable of withstanding high temperatures; the currently considered operating temperature of around 1000°C is close to the transformation temperature of materials commonly used in the nuclear industry.

Lead-cooled Fast Reactors (LFR)

Unlike sodium, lead does not react violently with water or air.

The thermal inertia associated with the large volume of lead used and its very high density results in long grace periods in the event of loss of cooling.

In addition, the high boiling point at atmospheric pressure is a guarantee of high margins under normal operating conditions and rules out the risk of coolant boiling.

The main drawback of lead-cooled (or lead-bismuth cooled) reactors is that the coolant tends to corrode and erode stainless steel structures.

LFR safety is reliant on operating procedures, which does not seem desirable in a Generation IV reactor.

The highly toxic nature of lead and its related products, especially polonium-210, produced when lead-bismuth is used, raises the problem of potential environmental impact.

IRSN is unable to determine whether the LFR system could guarantee a significantly higher safety level than Generation III reactors.

Various technical hurdles need to be overcome before a reactor of this type could be considered.

Gas-cooled Fast Reactors (GFR)

Given the current state of GFR development, construction of an industrial prototype reactor would not be technically feasible. GFR specifications are highly ambitious and raise a number of technological problems that are still a long way from being solved.

From the safety point of view, the GFR does not display any intrinsic quality likely to lead to a significant improvement over Generation III reactors.

Molten Salt Reactors (MSR)

The MSR differs considerably from the other systems proposed by the GIF. The main differences are that the coolant and fuel are mixed in some models and that liquid fuel is used.

The MSR has several advantages, including its burning, breeding and actinide-recycling capabilities.

Its intrinsic neutron properties could be put to good use as, in theory, they should allow highly stable reactor operation. The very low thermal inertia of salt and very high operating temperatures of the system, however, call for the use of fuel salt drainage devices. System safety depends mainly on the reliability and performance of these devices.

Salt has some drawbacks − it is corrosive and has a relatively high crystallisation temperature.

The reactor must also be coupled to a salt processing unit and the system safety analysis must take into account the coupling of the two facilities.

Consideration must be given to the high toxicity of some salts and substances generated by the processes used in the salt processing unit.

The feasibility of fuel salt processing remains to be demonstrated.

SuperCritical-Water-cooled Reactors (SCWR)

The SCWR is the only system selected by GIF that uses water as a coolant. The SCWR is seen as a further development of existing water reactors and thus benefits from operating experience feedback, especially from boiling water reactors. Its chief advantage is economic. While the use of supercritical water avoids problems relating to the phase change from liquid to vapour, it does not present any intrinsic advantage in terms of safety.

Thermal inertia is very low, for example, when the reactor is shut down.

The use of supercritical water in a nuclear reactor raises many questions, in particular its behaviour under neutron flux.

At the current stage of development, it is impossible to ascertain whether the system will eventually become significantly safer than Generation III reactors.

References:

1. IRSN, 2015, ‘Review of Generation IV Nuclear Energy Systems’,
www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx
Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf
2. See for example: International Panel on Fissile Materials, 2010, ‘Fast Breeder Reactor Programs: History and Status’, www.ipfmlibrary.org/rr08.pdf
Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, ‘Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century’, www.greenpeace.org/international/press/reports/nuclearreactorhazards

Belgium to postpone closure of Doel 1 and 2?

Author: *Peer de Rijk − Director of WISE Amsterdam*

NM803.4471 Belgium's Parliament is debating legislation put forward by the energy minister which proposes extending the lifetime of the nuclear power reactors Doel 1 and 2 for 10 more years.

According to the phase-out policy agreed upon by earlier governments, the Doel 1 reactor should have been permanently shut down on February 15 of this year (it was shut down in February, but may be restarted). Doel 2 was supposed to close no later than 1 December 2015.

The Council of State, an advisory body to the government, warned the minister that − in order to be legally correct − a decision to extend reactor lifetimes would require a new licensing procedure including an Environmental Impact Assessment (EIA) and a national and trans-boundary public consultation process, as prescribed by the European Directive 2011/92/EU and the Aarhus and Espoo conventions, both signed and ratified by Belgium.

So far Belgium has neglected the advice. Even the independent Federal Agency for Nuclear Control (FANC) − which is supposed to make sure the government follows proper procedures – has published a paper stating that a full EIA would be too complicated and time-consuming given the urgency for Belgium to safeguard energy supply.

The position of the government and the 'independent' FANC has provoked critical responses from a number of organisations including Greenpeace Belgium and the European watchdog organisation Nuclear Transparency Watch (NTW).

NTW warned that the proposal to extend the lifetime of the 40 years old Doel 1 and 2 reactors threatens to break international rules for transparency. If the right of the public to participate in an EIA is not respected, NTW will seek advice on initiating a formal complaint to the Compliance Committee of the Aarhus Convention.

NTW chair and member of the European Parliament Michèle Rivasi sent a letter to the energy minister stressing the importance of respecting international obligations to conduct a full-scale EIA and a cross-border public participation process in advance of any final decision.

NTW is a network founded in 2013 by an initiative of Members of the European Parliament from five different political groups. NTW promotes transparency in nuclear issues and increases the contribution of civil society in the governance of nuclear activities. WISE has been a member since late 2014.

Greenpeace Belgium is trying to prohibit lifetime extensions for the two reactors. In June 2013, the Belgian state was taken to court because of the lack of an adequate nuclear emergency preparedness and response plan (EP&R). The request was to force the Belgian state to update its EP&R plans within six months and to take into account the experiences and lessons from Fukushima. The court was also asked to force the government not to restart the Doel 3 and Tihange 2 reactors before adequate EP&R plans are operational. Doel 3 and Tihange 2 have been offline since March 2014 due to concerns about the integrity of their reactor pressure vessels.

On 19 February 2015, the hearings took place before the tribunal in Brussels and on 1 April the final verdict was published. In a disappointing ruling the judge declared himself incompetent to bring in a verdict. He stated that a ruling would go against the constitutional rule of separation of powers.

WISE/NIRS Nuclear Monitor

The World Information Service on Energy (WISE) was founded in 1978 and is based in Amsterdam, the Netherlands.

The Nuclear Information & Resource Service (NIRS) was set up in the same year and is based in Washington D.C., US.

WISE and NIRS joined forces in the year 2000, creating a worldwide network of information and resource centers for citizens and environmental organizations concerned about nuclear power, radioactive waste, proliferation, uranium, and sustainable energy issues.

The WISE / NIRS Nuclear Monitor publishes information in English 20 times a year. The magazine can be obtained both on paper and as an email (pdf format) version. Old issues are (after 2 months) available through the WISE homepage: www.wiseinternational.org

Subscriptions:

US and Canada based readers should contact NIRS for details on how to receive the Nuclear Monitor (nirsnet@nirs.org).
All others receive the Nuclear Monitor through WISE.

Version	NGO's/ individuals	Institutions/ Industry
Paper 20x	100 Euro	350 Euro
Email/Pdf 20x	50 Euro	200 Euro

Contact us via:

WISE International
PO Box 59636, 1040 LC Amsterdam, The Netherlands

Web: www.wiseinternational.org

Email: info@wiseinternational.org

Phone: +31 20 6126368

ISSN: 1570-4629

TPG Post
Port betaald

PRINTED MATTER
MATIERE IMPRIME

WISE/NIRS NUCLEAR MONITOR

c/o WISE Amsterdam
PO Box 59636
1040 LC Amsterdam
Netherlands

PRIORITY
PRIORITAIRE