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CONTACTS

WISE

info@wiseinternational.org
www.wiseinternational.org

NIRS

nirs@nirs.org
www.nirs.org

Nuclear Monitor

monitor@wiseinternational.org
www.wiseinternational.org/nuclear-monitor

Monitored this issue:

Thanks to Peer de Rijk for 20 years with WISE

Author: Jan Haverkamp

On May 1, Peer de Rijk, for 20 years the director of WISE International and WISE Netherlands, stepped down from his position. Peer always saw himself as someone who is good in starting up things – real feet-on-the-ground initiatives that change the world for the better. On that basis he moved in 1998 from the Dutch Friends of the Earth member Milieudefensie to WISE: he wanted to give a new push to the anti-nuclear movement and combine it with working on alternatives.

In order to strengthen WISE's work, he helped in 2000 to organise a close affiliation between WISE and the US based Nuclear Information and Resource Service (NIRS). With him, WISE continued to play its key role as a quality information provider for the anti-nuclear movement, with *Nuclear Monitor* being one example of this work.

Peer also used WISE to set up the first and most reliable clean energy ranking site in the Netherlands, including the possibility to change energy providers.[1] He pushed for Carbonkiller – an initiative to buy out carbon emission rights from the European ETS system and destroy it.[2] He talked me into the GammaSense 2.0 initiative to develop citizens radiation monitoring, with Dutch citizens' innovation group de Waag and the Dutch technical support organisation RIVM.[3] Peer motivated people to challenge the impossible and supported them to make it work.

After 20 years, Peer feels it's time for look around for new challenges. He continues his engagement in the establishment of the first zero-carbon fully sustainable boat-house complex in Amsterdam, Schoonschip.[4] We hope he will continue his involvement in the anti-nuclear movement.

Being born in Surinam as son of a Dutch parents, a social worker and a lepra doctor, growing up in Kenya on the border with Uganda, his family finally settled in the Netherlands. What drove Peer in the end to WISE cannot be better expressed than in his own words:[5]

"More or less by coincidence, we landed in Deventer, the beautiful little town on the IJssel River. A large house was bought and we went living in co-housing. A special co-living group, because the entire family was part of it. Not easy for all those others, who for a short or long time lived in Woongroep Springbalsemien; run-away youth without shelter, illegal Moroccans, activists from in and outside the country, lovers from my sisters.

"It looked like a chaotic world, but one where there was every week a 'house meeting', where we shared what occupied us and what we were going to do the next week. My father was active in peace organisations like IKV and the NVMP (the Dutch branch of IPPNW); my mother was active in the Wereldwinkel fair trade shop, women's organisations, helping illegal immigrants, women's sanctuaries; my sisters were active in the first group organising direct actions against nuclear power (Breek Atoomketen Nederland)[6]; and other housemates were just as engaged and actively fighting injustice.

"It did not come as a surprise when I joined one of Deventer's basic groups against nuclear power at the age of 13.[7] Meetings, doing actions; super-cool and interesting. A pressure cooker in which you learn to listen, analyse, debate, agitate, but also learn to compromise. My first demonstration was in 1978 against the extension of the uranium enrichment plant Urenco in Almelo, the first direct action in which I participated was the blockade of the nuclear power station Dodewaard in 1980. I remember above all rain, a lot of mud, the music of Vuile Mong en zijn Vieze Gasten (Filthy Mong and his Dirty Guests), the enormous pots of action kitchen Rampenplan and that I had to run a port-a-phone duty on the dike for half a night during the blockades. After that, you don't want to stop doing actions."

With Peer's departure, WISE continues under the leadership of a new generation. Kirsten Sleven and Kim van de Sparrentak are now co-directors. They are dedicated to continuing WISE's role in the anti-nuclear movement and in the innovation of the clean energy movement. Kirsten led the Carbonkiller project, Kim was the first new-era Dutch crowd-funded campaigner against the Belgian nuclear power stations Tihange and Doel. Together with new volunteers, administrative support from Koert Sondorp, and one day a week support from Jan Haverkamp on anti-nuclear work, WISE is moving to a new future. Its niche may change a bit, but its impact will continue.

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Unfinished business: Spotlight grows on Rio Tinto's Kakadu uranium clean-up

Author: Dave Sweeney – nuclear-free campaigner, Australian Conservation Foundation

Four decades of imposed uranium mining by Energy Resources of Australia (ERA) and Rio Tinto is about to end at the Ranger uranium mine in Kakadu in Australia's Northern Territory.

What remains is a heavily impacted site that requires extensive, complex and costly rehabilitation. This must meet both community expectation and the mining company's legal obligation to restore the site to a standard where it can be incorporated into the surrounding Kakadu World Heritage area.

As mineral processing winds down at Ranger ahead of a mandated 2021 end to operations, a new report has found that Kakadu, Australia's largest national park, is at long-term risk unless the clean-up is comprehensive and effective.

Unfinished Business, co-authored by the Sydney Environment Institute (SEI) at the University of Sydney and national environment group the Australian Conservation Foundation (ACF), examines the ERA Mine Closure Plan which outlines the rehabilitation works.

The report identifies significant data deficiencies, a lack of clarity around regulatory and governance frameworks and uncertainty over the adequacy of current and future financing – especially in relation to future monitoring and mitigation works for the mine site.

Mine operator ERA and parent company Rio Tinto are required to clean up the site to a standard suitable for inclusion in the surrounding Kakadu National Park, dual-listed on UNESCO's World Heritage list.

No mine in the world has ever successfully achieved this standard of clean-up and the rehabilitation project is attracting national and international attention. This interest has put increased pressure on the Australian and Northern Territory governments, and on ERA and Rio Tinto, to get this work right.

The outcome at Ranger is of critical importance to Rio Tinto's international reputation as a responsible corporate citizen and the company's wider social license to operate. The report argues that Rio Tinto's future access is directly linked to its efforts to repair past impacts.

Concerns over the adequacy of the rehabilitation plans and the financial capacity needed to deliver a comprehensive clean-up operation have been formally raised with Rio Tinto at the company's annual meetings in both London (April) and Perth (May).

Ranger has been one of the most contested and high-profile resource projects in Australia since the mine was opened in 1981 despite the clear opposition of the Mirarr Traditional Owners and other Aboriginal people of the Kakadu region.

The challenge now facing Rio Tinto is not to simply scrape rocks into holes and plant trees, it is to make sure mine tailings, radioactive slurry and toxic by-products of mining are isolated from the surrounding environment for 10,000 years.

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"Achieving this in a monsoonal environment like Kakadu raises enormous environmental and governance challenges," said report co-author Dr Rebecca Lawrence from the Sydney Environment Institute. "For the rehabilitation process to even have a chance at success, the existing opaque and complex regulatory regime needs an urgent overhaul".

Tailings – the waste material remaining after the processing of finely ground ore – are one of the serious environmental risks at Ranger. The report examines how ERA and Rio Tinto intend to deliver on the federal government's requirement to protect the Kakadu environment by isolating any tailings and making sure contaminants do not result in any detrimental environmental impacts for at least 10,000 years.

Long after the miners have gone, this waste remains a direct human and environmental challenge. This issue is key to the long-term health of Kakadu, but there is insufficient evidence and detail on how this work will be managed and assured in the future. Without this detail there will be a sleeping toxic time bomb deep inside Kakadu. This work is a key test of the commitment and capacity of Northern Territory and Commonwealth regulators as well as the mining companies.

At its recent twin AGMs, Rio Tinto again committed to make sure ERA has the financial resources to deliver its rehabilitation obligations, but the financial mechanism to do so remains undisclosed and uncertainty persists.

The report makes recommendations to improve the chances of a successful clean-up at Ranger. It calls for increased transparency and community input, the public release of key project documents, a better alignment of research and operations and open review processes for key decision points.

Australia has a long history of sub-standard mine closure and rehabilitation in the uranium and wider mining sector, and there is a clear need for a better approach and outcome at Ranger. The challenge is how to rehabilitate the heavily impacted mine and larger Ranger Project Area in a way that reduces adverse impacts and provides confidence that the living and peopled landscape of Kakadu is best protected, now and into the future.

The full report – Unfinished business: Rehabilitating the Ranger uranium mine – is online at https://www.acf.org.au/unfinished_business_rehabilitating_ranger

Ranger uranium mine in Kakadu National Park.

Uranium mines harm Australia's Indigenous people – so why have we approved a new one?

Author: Jessica Urwin

May 1, 2019: Last week the federal government approved the Yeelirrie uranium mine in Western Australia in the face of vigorous protest from traditional owners.[1] This Cameco-owned uranium mine is the newest instalment in Australia's long tradition of ignoring the dignity and welfare of Aboriginal communities in the pursuit of nuclear fuel.

For decades, Australia's desert regions have experienced uranium prospecting, mining, waste dumping and nuclear weapons testing. Settler-colonial perceptions that these lands were "uninhabited"[2] led to widespread environmental degradation at the hands of the nuclear industry.

As early as 1906, South Australia's Radium Hill was mined for radium.[3] Amateur prospectors mined haphazardly, damaging the lands of Ngadjuri and Wilyakali Traditional Owners. An estimated 100,000 tonnes of toxic mine residue (tailings) remain at Radium Hill with the potential to leach radioactive material into the environment.

Uranium mines across Australia have similar legacies, with decades of activism from the Mirarr people against the Ranger and Jabiluka mine sites in Kakadu National Park.[4] In the 36 years since it began operating, the Ranger mine has produced over 125,000 tonnes of uranium and experienced more than 200 accidents.[5] In 2013, a reported one million litres of contaminated material spilt into the surrounding environment.[6]

Aboriginal communities remain at a disproportionate risk because large uranium deposits exist in lands deemed sacred and significant, while the testing and dumping of nuclear material is rarely undertaken in areas inhabited by settlers.

The federal government's ambivalence toward these impacts has most recently culminated in their decision to give Cameco the go-ahead for the Yeelirrie uranium mine, a blow to the traditional owners of Tjiwarl country.[7]

Native title fails to protect traditional owners from the mining industry

The Tjiwarl people have fought the Yeelirrie mine alongside the Conservation Council of WA for more than two years.[8] They now must grapple with the government's decision to ignore their resistance.

But the Tjiwarl people are not alone. Aboriginal communities across Australia continue to engage with and mobilise against government decisions to ignore native title claimants.

As set out in Australian law, native title is the recognition of Aboriginal and Torres Strait Islander peoples' rights to the land and waters, guided by traditional law and customs.[9]

Aboriginal communities have an opportunity to object to a mining application, 35 days before the outcome of the application is determined.[10] A complex appeals process follows.

Russia›s floating nuclear power plant Akademik Lomonosov.

But even in the face of significant complaints, mining applications are more often than not approved. This has led to people mobilising internationally.

And in 2017, the International Campaign to Abolish Nuclear Weapons (ICAN) negotiated with the United Nations to create a treaty banning nuclear weapons.[11] The treaty, adopted on July 7, 2017, recognised the disproportionate impact nuclear material has on Indigenous communities around the world. It includes the mining and milling of uranium.

The treaty warns that parties should be "mindful of the unacceptable suffering of and harm caused to the victims of the use of nuclear weapons (hibakusha), as well as of those affected by the testing of nuclear weapons, [and recognise] the disproportionate impact of nuclear-weapon activities on indigenous peoples."[12]

Nuclear weapons sourced from Aboriginal lands

The toxic legacy of uranium mining is not isolated to the contamination of ecosystems. Radium Hill provided uranium for weapons for the United Kingdom and United States, including the nuclear weapons tested at Maralinga and Emu Field in South Australia in the 1950s and 1960s.[13] These weapons spread radioactive contamination and dispossessed Aboriginal communities in and around the Anangu Pitjantjatjara Yankunytjatjara (APY) lands.[14]

Uranium from the Ranger mine in Northern Territory found its way into the Fukushima reactors, a reality that plagues the Mirarr people. In 2011, senior Mirarr traditional owner Yvonne Margarula expressed her sorrow for those affected by the Fukushima meltdown: "It is likely that the radiation problems at Fukushima are, at least in part, fuelled by uranium derived from our traditional lands. This makes us feel very sad."[15]

These legacies are felt acutely by those who continue to struggle with the lack of protection from native title and other government policies apparently designed to prevent the exploitation of Aboriginal communities by various industries.

In the 1970s, when the Ranger mine opened, the Mirarr people felt largely powerless in negotiations between mining companies and the federal government. Last week, the Tjiwarl experienced similar disempowerment. Yet both communities are recognised by the government as traditional owners.[16]

Unsurprisingly, Australia is yet to sign the Treaty on the Prohibition of Nuclear Weapons, continuing the persistently toxic legacy of Australia's nuclear industry.

Jessica Urwin is a PhD student in the Australian National University's School of History. Her research focusses upon the toxic legacies of Australia's nuclear history, rooted in imperialism and enacted upon populations across the continent.

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Russia's nuclear power export program

Russian environmental group Ecodefense has released a report titled "Dreams and reality of the Russian reactor export". The report focuses on planned and ongoing construction of Russian-designed nuclear power plants around the world and the amounts Russia is willing to spend to support its reactor export.

Throughout 2018, Rosatom repeatedly stated that it was building 36 new nuclear reactors in a number of countries and estimated the total value of its foreign nuclear orders at over US$130 billion. However, according to Ecodefense's report, as of early 2019, only seven Russian nuclear reactors were under active construction worldwide – one unit in Turkey, two in Bangladesh, two in Belarus, and two in India. The total cost of these reactors is around US$36 billion. As for the rest of the reactors Rosatom claims it is building, those are not under active construction, and several of the deals are not backed by legally binding documents.

The Russian government continues to stimulate nuclear reactor export with state funds. In total, the amount of Russian credits and other means of financial support comes to around US$90 billion. In most of the cases, credits are provided at an interest rate of 3%, which is significantly cheaper than those offered by private banks. Without Russian state funds most of Rosatom projects would never be implemented.

In 2018, Jordan decided to cancel the project of a Russian-designed nuclear power plant as it could not secure sufficient funds for it. Earlier, Vietnam and South Africa abandoned similar projects. Attempts to get additional funding for the Akkuyu project in Turkey have so far failed. In this situation the Russian government may again decide to tap into the National Wealth Fund, a key element of the Russian pension system, to finance its nuclear expansion. Just as it did once in the past to provide funds for a delayed Hanhikivi nuclear project in Finland.

Vladimir Slivyak, author of the report and co-chairman of Ecodefense, said: "Spending $90 billion for nuclear projects in other countries is an absolute historic record. And these funds are flowing mostly to developing countries, which wouldn't be able to order reactors otherwise. Rosatom says it is building 36 new units, but the reality is a bit different – only seven Russian reactors are presently under active construction."

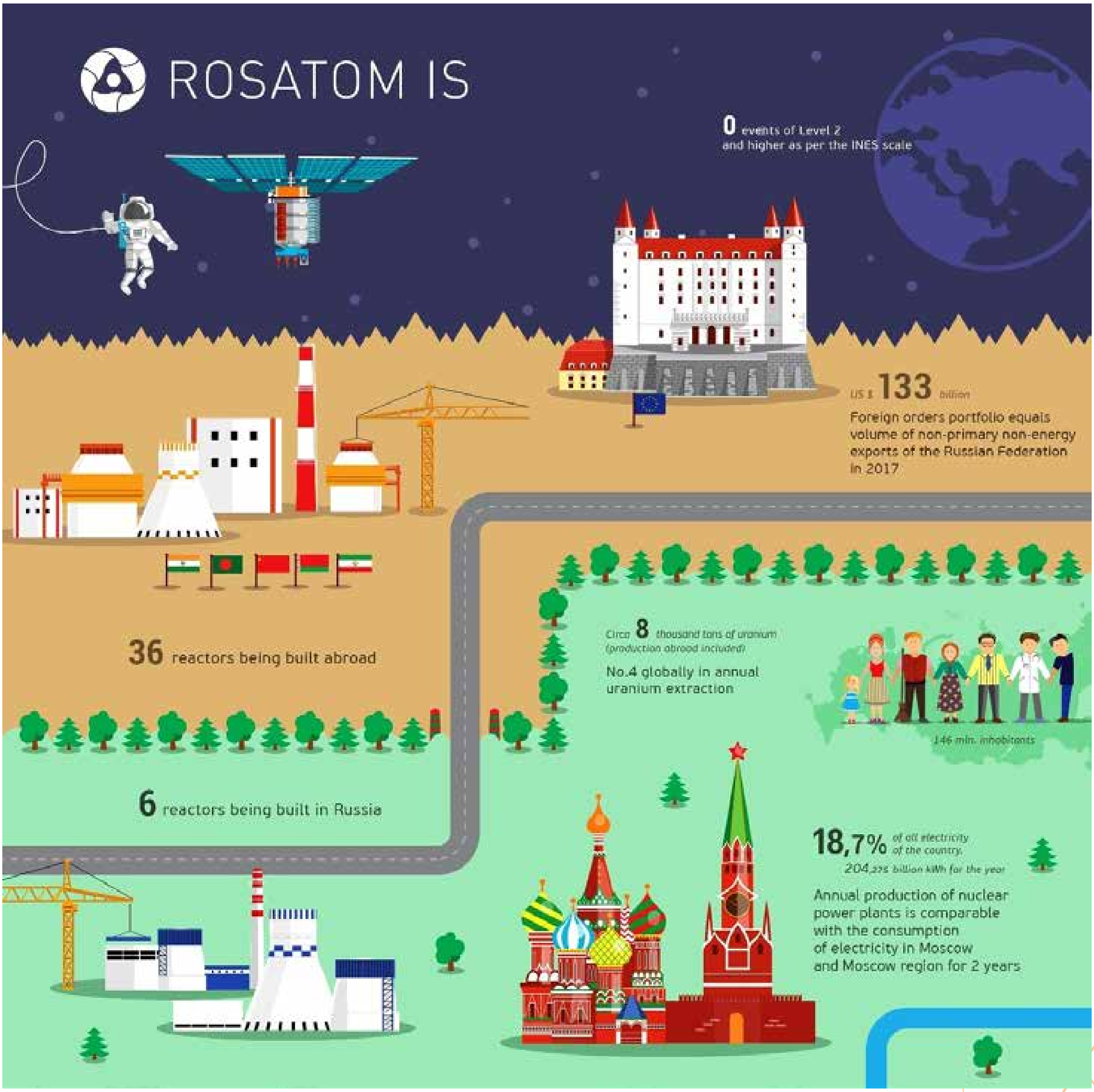
"Nuclear reactors continue to be very expensive and unnecessary as alternative energy is booming around the world. They haven't become safer since Fukushima and they still produce nuclear waste that will be dangerous for many thousands of years ahead. The Russian government should stop its reactor exports to avoid unnecessary expenses and new accidents," Slivyak added.

Vladimir Milov, former Deputy Energy Minister of Russia, writes in his foreword to the report: “Rather than enjoying the much-touted hard currency proceeds from the construction of nuclear power plants abroad, Russia itself pays for many projects. Including with subsidies from the National Wealth Fund (which is designed to finance the country’s beleaguered pension system) or by extending other countries ultracheap credits at interest rates our own citizens and businesses could only dream of. … One hopes this report will help push forward a broad national debate on the merits of the Russian public’s continued sponsorship of a risky nuclear expansion.”

The full report is online: Vladimir Slivyak, 2019, ‘Dreams and reality of the Russian reactor export’, https://ecdru.files.wordpress.com/2019/03/rosatom-report2019.pdf

Ecodefense media release: https://ecodefense.ru/2019/03/07/90billion/

Rosatom propaganda claiming that it is building 36 reactors overseas.



Nuclear Energy: The looming dependency on Rosatom in the EU

Another report written by Jan Haverkamp earlier this year concerns the looming dependency on Rosatom in the EU. Whereas nuclear power is on the decline in most of the world, Central Europe's enthusiasm for the technology appears untouched. Bulgaria, the Czech Republic, Hungary, Slovakia and Ukraine are preparing to prolong the lifetime of their old Soviet reactors. And to enable that, they are closely cooperating with Rosatom.

Belarus and Hungary are, respectively, constructing or preparing construction of new nuclear capacity, in set-ups completely controlled by Rosatom.

Bulgaria, the Czech Republic and Slovakia are positioning their remaining hopes for new nuclear on close cooperation with Russia.

Even Ukraine, with all its tensions with Russia, appears to be bound hand and feet to cooperation with Rosatom to upkeep and potentially expand its own nuclear fleet.

And Finland appears to be stuck in a nuclear bear-hug with its Loviisa nuclear plant, its plans for the Hanhikivi new build reactor, and in having to tolerate the expansion of the Leningradskaya nuclear plant near Sosnovy Bor on its borders.

Rosatom tries to expand its presence in the European electricity market. It has been argued extensively in recent years that this is driven not by a sense to service a traditional market, but rather by a political agenda in which nuclear power partially replaces the receding political influence of gas. This hypothesis only makes sense when we can also see an increase in dependency on Rosatom as a result of its nuclear cooperation with EU and surrounding countries. Haverkamp's report sketches the contours of that debate. It concludes that the dependency on Rosatom is indeed growing and that in some cases Rosatom is instrumental to political goals beyond the company's realm.

Full report: Jan Haverkamp for The Greens/EFA in the European Parliament, 2019, 'Nuclear Energy: The looming dependency on Rosatom in the EU', http://extranet.greens-efa-service.eu/public/media/file/1/5898

Media release: https://europa.groenlinks.nl/nuclearenergy?no-cache=1

Denmark: Parliament calls for EURATOM reform

In April, all 10 parties represented in the Danish *Folketing* announced their support for reform of the Euratom Treaty of 1957, one of the founding treaties in what was then the European Common Market. Like many institutions of that era, the treaty promotes the development of nuclear energy, but not other energy sources. Unlike the other founding treaties of the EU, Euratom has never been updated or amended.

The announcement just happened to coincide with a communiqué from the EU Commission proposing democratization of EU energy policy. Although it falls short of instructing the government to take any specific measures, the unanimous statement of sentiment will surely guide national policy. Sweden, Germany, Austria, Luxembourg, Ireland and Hungary, plus international environmental organizations and industrial organizations in the energy sector are already pushing for reform.

Many Danes have objected to the Euratom Treaty, even before Denmark joined the Union. Criticism has increased with Denmark's growing commitment to renewable energy sources – particularly wind power. The Danes' principal complaint concerns the Union's subsidization of nuclear energy under the treaty – a policy that stands in stark contrast to the EU's overall ban on state support to market actors. Putting nuclear energy on the same footing as other energy sources is the prime reform goal.

Denmark chose not to rely on domestic nuclear power from the start. Yet, as a Member State, Denmark is currently required to contribute about €27,000 each year to the Euratom budget, a good share of which supports the ITER fusion reactor project. Participation in Euratom is mandatory for all Member States.

From Denmark's point of view, levelling the playing field for energy sources would have two main advantages. As Niels Henrik Hooge of NOAH/Friends of the Earth Denmark puts it: "Although the Commission's proposal does not go far enough, a reform of the Treaty to give renewable energy fair terms can boost the expansion of renewable energy technologies in Europe, to the benefit of both the environment and Danish export interests."

The European Commission communiqué – titled 'A more efficient and democratic decision making in EU energy and climate policy' – is posted at: http://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-177-F1-EN-MAIN-PART-1.PDF

Whatever happened to the 'integral fast reactor'?

Author: Jim Green – Nuclear Monitor editor

A decade ago, nuclear lobbyists – including prominent champions such as climate scientist James Hansen and entrepreneur Richard Branson[1] – were furiously promoting 'integral fast reactors' (IFRs).

IFRs would, if they existed, share features of other fast neutron reactors along with some less common or distinctive features including metallic fuel and the coupling of the reactor to pyroprocessing. The fuel would sit in a pool of liquid metal sodium coolant, at atmospheric pressure. Pyroprocessing would not separate plutonium alone; it would instead separate plutonium mixed with other actinides, thus reducing proliferation risks compared to conventional PUREX reprocessing.

IFRs would (according to their advocates) solve all of nuclear power's problems, providing cheap power, proliferation-resistance, a dramatic reduction in the volume and longevity of radioactive waste, and the ability to use troublesome nuclear waste streams (actinides) and weapons material as fuel.

IFRs would (according to their advocates) end global warming. GE Hitachi's Eric Loewen was described as "the man who could end global warming" in *Esquire* magazine in 2009.[2]

Indeed IFRs would (according to their advocates) go a long way to solving all of the world's problems. *Esquire* magazine implored readers to consider the magnitude of the problems that Loewen was solving: "a looming series of biblical disasters that include global warming, mass starvation, financial collapse, resource wars, and a long-term energy crisis that's much more desperate than most of us realize."[2]

These days, not much is heard about IFRs, and small modular reactors are the non-existent reactor type most heavily hyped by nuclear lobbyists. (More precisely, other types of SMRs – in particular small PWRs such as NuScale's concept – are heavily hyped.)

So, what has happened with IFRs? In short, not much:

- The Canadian Nuclear Safety Commission is involved in pre-licensing vendor design reviews for numerous reactor concepts including the ARC-100 design, which is based on IFR technology.
- GE Hitachi is moving ahead at snail's pace in the US with its version of IFR technology, which it calls PRISM (Power Reactor Innovative Small Module), but no license application has been submitted to the US Nuclear Regulatory Commission (NRC).
- The US Department of Energy (DOE) is considering a bizarre and improbable plan to fund a PRISM reactor to be used as a test reactor to advance fast neutron reactor technology.
- The UK has formally abandoned consideration of IFR technology for plutonium disposition, and there is no longer any serious discussion about the potential use of IFRs for plutonium disposition in the US (see the article in this issue of *Nuclear Monitor*: 'Integral fast reactors rejected for plutonium disposition in the UK and the US').

IFR technology in Canada

Advanced Reactor Concepts (ARC) and New Brunswick Power have agreed to collaborate on the future deployment of an ARC-100 reactor at NB Power's Point Lepreau site in Canada.[3-5] ARC signed an agreement with GE Hitachi in 2017 to collaborate on development and licensing, and the ARC-100 design uses proprietary technology from GE Hitachi's PRISM design.[5] Whereas the PRISM design envisages twin 311 MW reactors feeding a single turbine, the ARC design is 100 MW, and another distinctive feature is that ARC-100 reactors would operate for up to 20 years without the need for refueling.

ARC is a company founded in 2006 and involves a number of people who were previously involved in the EBR-II reactor project – IFR R&D carried out at Argonne National Laboratory from the 1960s until the demonstration reactor was defunded and shut down in 1994 (with pyroprocessing work continuing to this day to address the legacy of nuclear waste … and probably continuing for decades into the future given that it has been a troubled and much-delayed project).

The Canadian Nuclear Safety Commission is currently involved in pre-licensing vendor design reviews for numerous small-reactor concepts including ARC-100. A Phase 1 assessment of the ARC-100 design has been ongoing since September 2017.[6]

The hope is that Point Lepreau will become a hub for a nuclear export industry. But no decision has been taken to build a demonstration reactor at Point Lepreau and any such decision is years away.[6] Construction of a demonstration reactor is no more than a "long-term vision" according to New Brunswick's energy minister Rick Doucet.[7]

Norman Sawyer, president of ARC Nuclear Canada, hopes that a single ARC-100 reactor could be built for C$1–1.5 billion.[6] But no-one is offering to stump up that sort of money. The Union of Concerned Scientists said the economics simply won't work: "The problem is that there is not sufficient private capital around to finance the development of even a single new non-light-water reactor, much less many different types. When you shrink the size of a nuclear reactor, you increase the unit cost of electricity because of those economies of scale."[6]

Current funding – C$10 million from the New Brunswick provincial government (not all of it for ARC's project) and C$5 million from ARC – will only cover the vendor design review process. That process might (or might not) be followed by a much more exhaustive, expensive and time-consuming process to obtain a license to construct and operate an ARC-100 reactor.[6]

Brett Plummer, NB Power's vice-president for nuclear operations, said that there have only been preliminary talks about how a first reactor at Point Lepreau could be paid

A research scientist at Idaho National Laboratory has built a Lego representation of the EBR-I IFR prototype. Seventy years after the EBR-I project began, efforts to commercialize IFR technology continue to flounder.

A Lego representation of the partial fuel meltdown of the EBR-I reactor core in 1955.

for, and he suggested the possibility of a public–private partnership.[6] In other words, vendors such as ARC have received government funding for preliminary regulatory design assessment, no doubt they will seek government funding to prepare a license to construct and operate a demonstration reactor, and they want government funding for reactor construction.

ARC has also received a grant from the UK government "to provide documentation intended to demonstrate the technical and business feasibility of the ARC-100 … and its licensability under U.K. nuclear safety regulations."[8] Perhaps the UK government should also provide the Union of Concerned Scientists with a grant to provide documentation making the case that nuclear vendors should provide documentation at their own expense?

The long, slow march of IFR technology in the US

Enthusiasts argue that IFR/PRISM reactor technology is ready to go on the basis of the EBR-II project at Argonne National Laboratory. But it isn't. A 1994 pre-application safety evaluation report by the NRC stated:[8]

"Although all major problems are currently being addressed, much research remains to be performed in order to establish the safety and reliability of the specific fuel concept to the burnups planned. The data base to support the metal-fuel system to be used in the PRISM design needs to be developed. …

"The PRISM fuel system … is a new concept. Many of the basic design principles have been developed from EBR-II metal-fuel experience. However, because of differences in material, geometry, and exposure conditions, this experience must be extrapolated to the PRISM design through the use of analytical tools that characterize the operational history and transient responses of the fuel system. Experimental data must be obtained both to support the model development efforts and to verify the integrated computer codes. …

"Although no new major safety-related problems in the proposed PRISM fuel system design were identified, many phenomenological uncertainties must be resolved in order to develop a set of analytical tools and a supporting experimental data base necessary for licensing."

Plans to apply to the NRC for a construction and operation license have been floated periodically since 1994. GE Hitachi has completed the NRC's 'preapplication review process'[9], but no license application has been submitted.

In a March 2009 letter to the NRC, GE Hitachi indicated that it intended to submit a design application in mid-2011.[10] In 2011, Tom Blees, president of an IFR/PRISM lobby group called the Science Council for Global Initiatives, wrote: "The suggestion … that fast reactors are thirty years away is far from accurate. GE-Hitachi plans to submit the PRISM design to the Nuclear Regulatory Commission (NRC) next year for certification."[11] But GE Hitachi hasn't progressed beyond the pre-application review process.

Blees also claimed in 2011 that China was building a copy of the EBR-II IFR prototype.[11] That claim was false. If he was referring to the China Experimental Fast Reactor, it isn't an IFR clone, it took over a decade to build the 20 MW reactor, and it has been a failure.[12,13]

Blees said in 2011 that work was in train to "facilitate a cooperative effort between GE-Hitachi and Rosatom to build the first PRISM reactor in Russia as soon as possible" and that "if the United States moves ahead with supporting a GE-Rosatom partnership, the first PRISM reactor could well be built within the space of the next five years".[11] Nothing came of that initiative.

Blees said in 2011 that the "Science Council for Global Initiatives is currently working on arranging for the building of the first commercial-scale facility in the USA for conversion of spent LWR fuel into metal fuel for fast reactors."[11] Nothing has come of that initiative.

In July 2017, Blees reported the 'good news' that GE Hitachi "finally is applying for a commercial license for the PRISM."[14] But there was no such application.

In October 2010, GE Hitachi signed a memorandum of understanding with the operators of the US DOE's Savannah River site to consider the construction of a demonstration PRISM reactor. It would be possible to construct a prototype without having completed the NRC's usual licensing procedures, as Savannah River is a federally-owned site.[15,16] But nothing came of that initiative.

In October 2016, GE Hitachi and US company Southern Nuclear announced their intention to collaborate on the development and licensing of PRISM reactor technology.[17] But little seems to have come from that initiative – the websites of GE Hitachi and Southern Nuclear have no information other than the October 2016 announcement. Pro-nuclear commentator Dan Yurman suggested that the companies "may be anticipating future grant programs".[18]

In June 2017, GE Hitachi said that a nuclear industry team was "collaborating to potentially seek a regulatory license to deploy GEH's advanced PRISM sodium-cooled fast reactor design."[19] The companies planned to pursue DOE advanced reactor projects based on public–private partnerships. In other words, they have their hands out for taxpayer subsidies.

To sum up … progress has been extraordinarily slow. One might have expected more interest if, as advocates claim, IFRs can solve all of nuclear power's problems and many of the world's most pressing problems. Interest in IFRs would have died altogether if not for a drip-feed of government funding stretching back decades:[20]

- The EBR-II R&D project was government funded, and ongoing work on pyroprocessing is DOE funded.
- 1985–87: US$30 million from the DOE to study liquid metal reactor concepts.
- 1988: US$5 million from the DOE for 'continuing trade studies'.
- 1989–95: US$42 million from the DOE for the Advanced Liquid Metal Reactor program.
- A multi-million-dollar grant from the DOE, announced in 2014, for GE Hitachi to carry out a PRISM safety assessment.[21,22]

The most recent development is that the NRC has been working with industry on the Licensing Modernization Project to develop "regulatory guidance for licensing non-LWRs for the NRC's consideration and possible endorsement". On the basis of that work, the NRC hopes to issue a final regulatory guide in late 2019.[23]

But wait!

But wait … the Science Council for Global Initiatives continues with its bluff and bluster. Tom Blees claimed in November 2018 that:[24]

"SCGI is now deeply involved with expediting some of the most promising projects that we have been nurturing for several years. We would like to share all the details, but we are required to keep much of it confidential. What we can say is that our efforts to promote rapid construction of commercial-scale prototypes of three systems that could power the planet now involve the US, China, South Korea and others. The three systems are metal-fueled fast reactors, molten salt reactors, and the spent fuel recycling system called pyroprocessing."

Don't hold your breath.

'Versatile Test Reactor'

In 2018, Idaho National Laboratory (INL) subcontracted GE Hitachi to work with Bechtel to advance design and cost estimates for a Versatile Test Reactor (VTR) based on PRISM technology.[25] According to INL, the reactor would facilitate the development of innovative nuclear fuels, materials, instrumentation and sensors.[26] The DOE plans to decide in 2020 whether or not to proceed with (and fund or part-fund) the project.

The proposal is bizarre – and improbable – for several reasons.

Firstly, fast reactor technology has failed in the US as it has in many other countries.[27,28] Why attempt a revival, especially in light of the hefty price-tag for the VTR – an estimated US$3.9–6.0 billion?[29]

Secondly, it makes little sense to choose a largely untested, experimental reactor type. The experimental reactor will itself be an experiment.

Thirdly, even if it was agreed that a fast-neutron test capability was needed, a new reactor isn't required. Ed Lyman from the Union of Concerned Scientists states:[29]

"In fact, there are ways to simulate the range of neutron speeds typical of a fast reactor in an already existing test reactor, such as the Advanced Test Reactor at Idaho National Laboratory or the High Flux Isotope Reactor at Oak Ridge National Laboratory. This could be accomplished by using neutron filters and possibly a different type of fuel. Going that route would be significantly cheaper: A 2009 DOE assessment suggests that this approach could achieve the minimum requirements necessary and would cost some $100 million to develop (in 2019 dollars), considerably less than the VTR project's projected price tag. Equally important, using one of the two currently operating test reactors could likely provide developers with fast neutrons more quickly than the VTR project."

Fourthly, if built the VTR would likely use plutonium driver fuel that is not only weapons-usable but weapons-grade.[30]

The VTR will most likely go the way of the 'Next Generation Nuclear Plant Project'. The DOE planned to build a prototype 'next generation' reactor to generate electricity, produce hydrogen, or both, by the end of fiscal year 2021. The project was initiated in 2005 but the DOE decided not to proceed with it in 2011, citing an impasse between the DOE and the NGNP Industry Alliance regarding cost-sharing arrangements.[31]

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Integral fast reactors rejected for plutonium disposition in the UK and the US

Author: Jim Green – Nuclear Monitor editor

Plutonium disposition in the UK

As Cumbrians Opposed to a Radioactive Environment (CORE) recently noted, it was in 2008 that the UK Nuclear Decommissioning Authority (NDA) released a Comment Paper on the options for managing the plutonium stockpile accumulating from the reprocessing of spent fuel at Sellafield – a stockpile estimated by the NDA to reach 140+ tonnes (in the form of plutonium oxide powder) when all reprocessing at Sellafield has ceased.[1]

The NDA is years away from making a decision about how to dispose of the plutonium stockpile and/or to use it as reactor fuel. But the use of IFR/PRISM technology has been formally rejected. The NDA said in a March 2019 report:[2]

"The NDA considered a proposal by GE Hitachi Nuclear Energy (GEH) to build a fuel fabrication plant and two PRISM reactors to irradiate a plutonium alloy fuel. No PRISM reactors or fuel plants have ever been built, and the proposal considered by NDA therefore envisaged both the reactors and fuel plant being first of a kind.

"This approach had some theoretical benefits compared to the MOX options. PRISM fast reactors were put forward by GEH as commercially viable, "ready to deploy" and capable of quickly

dispositioning the complete plutonium stockpile. However, the studies undertaken by NDA with GEH over the past few years have shown that a major research and development programme would be required, indicating a low level of technical maturity for the option with no guarantee of success.

"Whilst these R&D requirements are extensive, they are also reasonably well understood. However, the work needed for the fuel fabrication facility is considered preliminary and the proposal was based on not requiring further plutonium-active testing prior to scale-up and industrialisation. This major technical risk, based on GEH's proposal, would also be borne by the NDA. In addition, the regulatory review by the ONR and EA highlighted this approach as carrying significant licensing risks in all areas. Implementation scenarios were assessed as economically unfavourable compared to other options reflecting, in part, the technical and licensing uncertainties in the proposal.

"At this time, it is noted that the cost, scope and extent of work required to progress Fast Reactor options, such as the GEH PRISM, as well as the timeframe for these options to become available, means it is not credible for the NDA to develop these options, or have them available for implementation within the next 20 years. Therefore no further work with GEH has been funded by NDA. However, given the very long-term nature of any disposition programme, the NDA will continue to monitor Fast Reactor developments world-wide and assess levels of maturity and potential benefits."

Thus the NDA has reaffirmed views expressed in internal 2011 emails, released under Freedom of Information laws, that its "high-level assessment" of PRISM reactors for plutonium disposition found that "the technology maturity for the fuel, reactor and recycling plant are considered to all be low".[3]

The use of plutonium in MOX fuel for conventional light-water reactors or CANMOX fuel for CANDU EC-6 reactors remain under consideration by the NDA, but the prospects are not good. The use of plutonium in MOX fuel is the NDA's preferred option, but as the NDA's recent report states, "this [MOX] option carries significant risks and uncertainties since it is fundamentally dependent on the availability of suitable new reactors in the UK and the operators' willingness to use MOX fuel. As the overall design of a MOX plant depends on a number of reactor-specific factors, commitments from operators under suitable terms would be a pre-requisite to reaching a decision on this option."[2]

The previous MOX plant at Sellafield suffered "many years of disappointing performance" according to the NDA's chief executive, and the decision to close the plant was announced in August 2011 as there were no longer any customers in the aftermath of the Fukushima disaster in Japan.[4]

As for the CANMOX option – the building of a CANMOX fuel plant and at least two CANDU EC-6 reactors – the NDA report states that this is a "credible" option but "no discernible evidence was offered that this approach would be significantly simpler or more cost-effective than reuse as MOX in LWRs." The NDA notes "greater technical and implementation risks" with CANMOX compared to MOX "largely due to the fact that production of CANMOX fuel has not been demonstrated on an industrial-scale. In addition, there are currently no CANDU reactors in operation which achieve the levels of fuel irradiation proposed by SNC Lavalin for this option."[2]

Given the poor prospects for using plutonium as reactor fuel, immobilization followed by disposal may become the NDA's favoured option. Three immobilization options are being studied: hot isostatic pressing to produce a monolithic ceramic product; a pressing and sintering process similar to MOX manufacturing to produce pellets; and encapsulation in cement-based matrices as used in the UK for Intermediate Level Wastes.[2]

Plutonium disposition in the US

IFR/PRISM technology has also been rejected for plutonium disposition in the US. MOX has also been rejected – in part because of significant delays and cost overruns with a partially constructed and now abandoned MOX fuel fabrication plant in South Carolina. The US government favors a "dilute and dispose" option for disposing of 34 tonnes of plutonium: the Savannah River Site facility will be used to dilute plutonium and it will be disposed of at the WIPP repository in New Mexico.[5]

The US Department of Energy's (DOE) Plutonium Disposition Working Group released a report in 2014 which considered the use of Advanced Disposition Reactors (ADR) for plutonium disposition.[6] The ADR concept was similar to GE Hitachi's PRISM according to the DOE. The DOE's cost estimates for the use of ADRs for the processing of 34 tonnes of plutonium were as follows: 'capital project point estimate' US$9.4 billion; operating cost estimate US$33.4 billion; and other program costs US$7.6 billion. Thus the total would be "more than $58 billion life cycle cost when sunk costs cost are included." That was twice as much as the next most expensive option for plutonium management considered in the 2014 report.

The DOE report estimated that it would take 18 years to construct an ADR and associated facilities – despite claims from GE Hitachi and others that IFR/PRISM technology could be operational in as little as five years. The DOE report stated: "Final design of a commercial fast reactor would require significant engineering and licensing and as such carries uncertainties in being able to complete within the assumed duration."[6]

On the technical challenges, the DOE report said:[6]

"Irradiation of plutonium fuel in fast reactors ... faces two major technical challenges: the first involves the design, construction, start-up, and licensing of a multi-billion dollar prototype modular, pool-type advanced fast-spectrum burner reactor; and the second involves the design and construction of the metal fuel fabrication in an existing facility. As with any initial design and construction of a first-of-a-kind prototype, significant challenges are endemic to the endeavor, however DOE has thirty years of experience with metal fuel fabrication and irradiation. The metal fuel fabrication facility challenges include: scale-up of the metal fuel fabrication process that has been operated only at a pilot scale, and performing modifications to an existing, aging, secure facility ... Potential new problems also may arise during the engineering and procurement of the fuel fabrication process to meet NRC's stringent Quality Assurance requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

In short, the ADR option was associated with "significant technical risk" according to the DOE report, and metal fuel fabrication faces "significant technical challenges".

A review of the 2014 report, commissioned by the National Nuclear Security Administration and carried out by Aerospace, reached similar conclusions.[7] Commenting on its own assessment and the 2014 DOE report, Aerospace said:

"Both reports acknowledge the high technical and programmatic risks inherent in the necessary research and development, technology demonstration, full-scale design, construction, and startup of an advanced fast spectrum burner sodium cooled reactor. Both reports acknowledge that additional new facilities for metal fabrication will be required, incurring additional technical and programmatic risk. It is expected in both reports that the NRC licensing process and fuel qualification process will be lengthy.

"ADR is the most complex and technically challenging option. The Aerospace assessment notes significant issues with the industrial base, including the adequacy of the workforce, fast reactor knowledge base, and the need for a significant R&D and technology development and demonstration phase ...

"Long term storage of spent plutonium metal fuel rods may require a different approach than that used for spent commercial uranium fuel rods, and may require the development of a new facility.

"The ADR project is more technically challenging and complex than the MOX Fuel option. New facilities are needed for plutonium metal processing, fuel fabrication, and spent fuel storage. Execution of design and construction in an NRC licensing environment is new for advanced liquid metal reactors and will require hundreds of nuclear qualified suppliers and construction workers over a decade or more."

Aerospace commented on problems common to fast reactors:[7]

"Based on experience with existing fast reactors that utilize sodium as the reactor core coolant, fires and steam explosions have been major problems during operations. A number of plants have been shut down for long periods of time in the past as a result of sodium fires. A research report of the International Panel on Fissile Materials on fast reactor programs highlights the maintenance and repair challenges at fast reactors: "The reliability of light-water reactors has increased to the point where, on average, they operate at 80 percent of their generating capacity. By contrast, a large fraction of sodium-cooled demonstration reactors have been shut down most of the time that they should have been generating electric power.""

Aerospace was also unimpressed by GE Hitachi's cost estimates:[7]

"Aerospace finds the quality and completeness of the cost basis of estimate is difficult to assess due to the age of the source data provided ... The ADR estimate also lacks costs associated with program-level risks that are likely to be encountered during development and operations. Therefore, the ADR program cost estimate reported in the 2014 [DOE] PWG report may be low relative to realized actual costs should the program proceed. It is very likely that the ADR program would be subject to funding constraints on capital and construction."

An August 2015 DOE Red Team report didn't even consider IFR/ADR technology worthy of detailed consideration:[8]

"The ADR option involves a capital investment similar in magnitude to the MFFF [Mixed Oxide Fuel Fabrication Facility] but with all of the risks associated with first of-a kind new reactor construction (e.g., liquid metal fast reactor), and this complex nuclear facility construction has not even been proposed yet for a Critical Decision (CD)-0. Choosing the ADR option would be akin to choosing to do the MOX approach all over again, but without a directly relevant and easily accessible reference facility/operation (such as exists for MOX in France) to provide a leg up on experience and design. Consequently, the remainder of this Red Team report focuses exclusively on the MOX approach and the Dilute and Dispose option, and enhancements thereof."

The DOE Red Team report said that the IFR/ADR option has "large uncertainties in siting, licensing, cost, technology demonstration, and other factors" but "could become more viable in the future" if fast reactors were to become part of the overall US nuclear energy strategy.[8]

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Integral fast reactors: fact and fiction

Author: Jim Green – Nuclear Monitor editor

Integral fast reactors (IFR) would, if they existed, share features of other fast neutron reactors along with some less common or distinctive features including metallic fuel and the coupling of the reactor to pyroprocessing (discussed below). The fuel would sit in a pool of liquid metal sodium coolant, at atmospheric pressure.

IFR's have been the subject of endless hype but as Ed Lyman from the Union of Concerned Scientists notes, the interest of these "staunch advocates … has been driven largely by idealized studies on paper and not by facts derived from actual experience."[1]

Actual experience has been limited to the EBR-II prototype that operated at Argonne National Laboratory from the 1960s to 1994. Since then, progress has been glacial (see the article in this issue of *Nuclear Monitor*: 'Whatever happened to the 'integral fast reactor').

For the most part, the claims of IFR advocates don't stand up to scrutiny.

Safety

IFR advocates claim that:

- "Metal fuel expands if it overheats, shutting off the fission reaction and making a meltdown physically implausible."[2]
- "[E]ven a catastrophic situation will not result in a reactor meltdown".[3]
- GE Hitachi claims that: "In the event of a worst-case-scenario accident, the metallic core expands as the temperature rises, and its density decreases slowing the fission reaction. The reactor simply shuts itself down. PRISM's very conductive metal fuel and metal coolant then readily dissipates excess heat … without damaging any of its components. This is what is described as "passive safety" a design feature that relies upon the laws of physics, instead of human, electronic or mechanical intervention, to mitigate the risk of an accident."[4]

In fact, IFR/PRISM reactors would be subject to some of the same risks as other fast-reactor types[5] and other risks associated with pyroprocessing.

According to Argonne National Laboratory: "[T]he metal fuel technology base was developed at Argonne in the 1980s and 1990s; its inherent safety potential was demonstrated in the landmark tests conducted on the Experimental Breeder Reactor-II (EBR-II) in April 1986. They demonstrated the safe shutdown and cooling of the reactor without operator action following a simulated loss-of-cooling accident."[6]

But the 1986 test was a "dog-and-pony show" according to Ed Lyman:[7]

"And what about [Charles] Till's claim that the IFR can't melt down? It's false. "Pandora's Promise" referenced two successful safety tests conducted in 1986 at a small demonstration fast reactor in Idaho called the Experimental Breeder Reactor-II (EBR-II). But EBR-II operators scripted these tests to ensure the desired outcome, a luxury not available in the real world. Meanwhile, the EBR-II's predecessor, the EBR-I, had a partial fuel meltdown in 1955, and a similar reactor, Fermi 1 near Detroit, had a partial fuel meltdown in 1966. Moreover, fast reactors have inherent instabilities that make them far more dangerous than light-water reactors under certain accident conditions, conditions that were studiously avoided in the 1986 dog-and-pony show at EBR-II."

Nuclear weapons proliferation

Climate scientist James Hansen claims that IFR technology "could be inherently free from the risk of proliferation"[8] and another IFR proponent, Barry Brook, claims they "cannot be used to generate weapons-grade material."[9]

In fact, IFRs could be used to produce plutonium for weapons. Dr George Stanford, who worked on the IFR (EBR-II) R&D program in the US, notes that proliferators "could do [with IFRs] what they could do with any other reactor − operate it on a special cycle to produce good quality weapons material."[10] And IFR advocate Tom Blees notes that: "IFRs are certainly not the panacea that removes all threat of proliferation, and extracting plutonium from it would require the same sort of techniques as extracting it from spent fuel from light water reactors."[11]

IFR proponents claim they could help solve proliferation problems by using fissile material (especially plutonium) as reactor fuel. But they could also worsen proliferation problems. To quote from an Argonne National Laboratory report: "The reactor ... could be used for excess plutonium consumption or as a breeder if needed ..."[12]

IFR proponents claim that pyroprocessing does not pose a proliferation risk because the plutonium it separates is mixed with other (non-fissile) actinides. But a 2008 US Department of Energy review concluded that pyroprocessing and similar technologies would "greatly reduce barriers to theft, misuse or further processing, even without separation of pure plutonium."[7]

IFR advocates Barry Brook and Corey Bradshaw claim that nuclear weapons proliferation "is under strong international oversight."[8] Oddly, they cite another IFR advocate, Tom Blees, in support of that statement. But Blees doesn't argue that the nuclear industry *is* subject to strong international oversight − he argues that "fissile material *should* all be subject to rigorous international oversight" (emphasis added).[14]

Blees argues for the establishment of an international strike force on full standby to attend promptly to any detected attempts to misuse or to divert nuclear materials.[15] That is a far cry from the IAEA's safeguards system as it currently exists. In articles and speeches during his tenure as the Director General of the IAEA from 1997−2009, Dr. Mohamed ElBaradei said that the Agency's basic rights of inspection are "fairly limited", that the safeguards system suffers from "vulnerabilities" and "clearly needs reinforcement", that efforts to improve the system have been "half-hearted", and that the safeguards system operates on a "shoestring budget ... comparable to that of a local police department".

IFR proponents indulge in disingenuous comparisons. For example, it's fair to say that pyroprocessing poses less of a proliferation risk compared to conventional PUREX reprocessing … but it poses a greater proliferation risk compared to a once-through, no-reprocessing fuel cycle.

Economics

GE Hitachi refuses to release estimates of capital and operating costs for its IFR design (which it calls PRISM), saying they are "commercially sensitive".[16]

Other IFR advocates aren't so shy about offering implausible estimates for IFRs. Steve Kirsch states that the first PRISM reactor "will probably cost around [US]$1 to $2 billion" per 1,000 MW.[17] That would make PRISM up to 13 times cheaper (per MW) than the Vogtle AP1000 project in the US.

IFR advocate Tom Blees states that the cost of the first PRISM reactor would be in the range of US$3–4 billion[18] (US$4.8–6.2 billion / 1,000 MW assuming the estimate is for a twin-reactor block with a capacity of 622 MW).

Future (nth-of-a-kind) PRISMs have reportedly been estimated by GE Hitachi to cost about US$1.7 billion / 1,000 MW[18] – radically cheaper than Lazard's latest estimate of US$6.5–12.5 billion / 1,000 MW for new nuclear plants.[19]

James Hansen, Richard Branson and GE Hitachi's Eric Loewen claimed in 2012 that IFRs could generate electricity "at a cost per kW less than coal"[20] (roughly 2–3 times cheaper than Lazard's latest estimate of the cost of electricity from new nuclear plants[19]). Hansen may have been closer to the mark in 2008 when he said: "I do not have the expertise or insight to evaluate the cost and technology readiness estimates" of IFR advocate Tom Blees and the "overwhelming impression that I get ... is that Blees is a great optimist."[21]

Waste

Here are some of the claims made by IFR advocates:

GE Hitachi: "In GEH's view, what is generally considered to be "nuclear waste" these days is not really waste at all. Light Water Reactor (LWR) used nuclear fuel is composed of 95 percent uranium, 1 percent transuranics, and 4 percent fission products. Many of these transuranic isotopes have long half-lives, which can create long-term engineering challenges for geologic disposal. By using electro-metallurgical separations, PRISM is designed to perform the recycling of the 96 percent of the fissionable material (uranium and transuranics) remaining in used nuclear fuel."[4]

George Monbiot: "IFRs, once loaded with nuclear waste, can, in principle, keep recycling it until only a small fraction remains, producing energy as they do so. The remaining waste ... presents much less of a long-term management problem, as its components have half-lives of tens, not millions, of years."[22]

Mark Lynas: "For me, the most compelling reason to look seriously at the PRISM is that it can burn all the long-lived actinides in spent nuclear fuel, leaving only fission products with a roughly 300-year radioactive lifetime. This puts a very different spin on the eventual need for a geological repository – instead of something that will be designed to safeguard radioactive material for a million years (technically a very improbable idea), safeguarding waste for 300 years is a very different, and much less challenging, proposition."[23]

Monbiot, Lynas, Fred Pearce, Stephen Tindale and Michael Hanlon: "The PRISM reactor offered by GE-Hitachi [is] a fourth-generation fast reactor design which can generate zero-carbon power by consuming our plutonium and spent fuel stockpiles, thereby tackling both the nuclear waste and climate problems simultaneously ..."[24]

James Hansen: "Nuclear "waste": it is not waste, it is fuel for 4th generation reactors! … The 4th generation reactors can 'burn' this waste, as well as excess nuclear weapons material, leaving a much smaller waste pile with radioactive half-life measured in decades rather than millennia, thus minimizing the nuclear waste problem. The economic value of current nuclear waste, if used as a fuel for 4th generation reactors, is trillions of dollars."[25]

But even if IFRs worked as hoped, they would still leave residual actinides, and long-lived fission products, and long-lived intermediate-level waste in the form of reactor and reprocessing components ... all of it requiring deep geological disposal. UC Berkeley nuclear engineer Prof. Per Peterson notes in an article published by the pro-nuclear Breakthrough Institute: "Even integral fast reactors (IFRs), which recycle most of their waste, leave behind materials that have been contaminated by transuranic elements and so cannot avoid the need to develop deep geologic disposal."[26]

Pyroprocessing

According to Tom Blees from the Science Council for Global Initiatives, pyroprocessing – a form of spent fuel reprocessing that dissolves metal-based spent fuel in a molten salt bath – is "proven" technology.[27]

But if pyroprocessing has been 'proven', it has proven to be a failure. The IFR (EBR-II) R&D program in the US left a legacy of troublesome waste and pyroprocessing has worsened the situation. This saga is discussed in detail by Ed Lyman, drawing on documents released under the Freedom of Information Act.[1,28]

Lyman states:[1]

"[P]yroprocessing has taken one potentially difficult form of nuclear waste and converted it into multiple challenging forms of nuclear waste. DOE has spent hundreds of millions of dollars only to magnify, rather than simplify, the waste problem. …

"The FOIA documents we obtained have revealed yet another DOE tale of vast sums of public money being wasted on an unproven technology that has fallen far short of the unrealistic projections that DOE used to sell the project …

"Everyone with an interest in pyroprocessing should reassess their views given the real-world problems experienced in implementing the technology over the last 20 years at INL. They should also note that the variant of the process being used to treat the EBR-II spent fuel is less complex than the process that would be needed to extract plutonium and other actinides to produce fresh fuel for fast reactors. In other words, the technology is a long way from being demonstrated as a practical approach for electricity production."

Ready to deploy?

GE Hitachi claims that "after 30 years of development, the technology utilized by PRISM is ready to be commercialized".[16] But government agencies in the US and the UK have reached radically different conclusions (see the article in this issue of *Nuclear Monitor*: 'Integral fast reactors rejected for plutonium disposition in the UK and the US').

GE Hitachi claims: "PRISM has successfully been through detailed regulatory review in the U.S. In its Report, "Pre-application Safety Evaluation: Report for the Power Reactor Innovative Small Module (PRISM) Liquid Metal Reactor," the U.S. Nuclear Regulatory Commission (NRC) stated: "On the basis of the review performed, the staff, with the ACRS in agreement, concludes that no obvious impediments to licensing the PRISM design have been identified.""[16]

In fact, the NRC was much more downbeat, stating that "many … uncertainties must be resolved in order to develop a set of analytical tools and a supporting experimental data base necessary for licensing."[29]

Tom Blees argued in 2011 that the first IFR/PRISM reactor could be built in the US "within the space of the next five years" and that "far from being decades away, a fully-developed fast reactor design is ready to be built."[18] But no such reactors have been built – and GE Hitachi has not even submitted a license application.

British IFR advocate Mark Lynas said in 2012: "GE's executives told me that they could get one up and running in 5 years – the PRISM is fully proven in engineering terms and basically ready to go."[23] If that's what GE executives said, they were lying and Lynas ought to have been more skeptical. The UK Nuclear Decommissioning Authority is no longer considering IFR/PRISM reactors for plutonium disposition, stating in a March 2019 report that "the studies undertaken by NDA with GEH over the past few years have shown that a major research and development programme would be required, indicating a low level of technical maturity for the option with no guarantee of success."[30]

In South Australia, nuclear lobbyists united behind a push to persuade the 2015/16 Nuclear Fuel Cycle Royal Commission of the merits of IFR/PRISM reactors. But the stridently pro-nuclear Royal Commission completely rejected the proposal, stating in its May 2016 report: "Fast reactors or reactors with other innovative designs are unlikely to be feasible or viable in South Australia in the foreseeable future. No licensed and commercially proven design is currently operating. Development to that point would require substantial capital investment. Moreover, the electricity generated has not been demonstrated to be cost-competitive with current light water reactor designs."[31]

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