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Monitored this issue:

Thorium – a better fuel for nuclear technology?

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Thorium is currently described by several nuclear proponents as a better alternative to uranium fuel. Thorium itself is, however, not a fissile material. It can only be transformed into fissile uranium-233 using breeder and reprocessing technology. It is 3 to 4 times more abundant than uranium. Concerning safety and waste disposal there are no convincing arguments in comparison to uranium fuel. A severe disadvantage is that uranium-233 bred from thorium can be used by terror organisations for the construction of simple but high-impact nuclear explosives. Thus development of a thorium fuel cycle without effective denaturation of bred fissile materials is irresponsible.

Introduction

Thorium (Th) is a heavy metal of atomic number 90 (uranium has 92). It belongs to the group of actinides, is around 3 to 4 times more abundant than uranium and is radioactive (half-life of Th-232 as starter of the thorium decay-chain is 14 billion years with alpha-decay). There are currently hardly any technical applications. Distinctive is the highly penetrating gamma radiation from its decay-chain (thallium-208 (Tl-208): 2.6 MeV; compared to gamma radiation from Cs-137: 0.66 MeV). Over the past decade, a group of globally active nuclear proponents is recommending thorium as fuel for a safe and affordable nuclear power technology without larger waste and proliferation problems. These claims should be submitted to a scientific fact check. For that reason, we examine here the claims of thorium proponents.

Claim 1: The use of thorium expands the availability of nuclear fuel by a factor 400

Thorium itself is not a fissile material. It can, however, be transformed in breeder reactors into fissile uranium-233 (U-233), just like non-fissile U-238 (99.3% of natural uranium) can be transformed in a breeder reactor to fissile plutonium. (A breeder reactor is a reactor in which more fissile material can be harvested from spent nuclear fuel than present in the original fresh fuel elements. It may be sometimes confusing that in the nuclear vocabulary every conventional reactor breeds, but less than it uses (and therefore it is not called a breeder reactor).)

For that reason, the use of thorium presupposes the use of breeder and reprocessing technology. Because these technologies have almost globally fallen into disrepute, it cannot be excluded that the more neutral term thorium is currently also used to disguise an intended reintroduction of these problematic techniques.

The claimed factor 400: A factor of 100 is due to the breeder technology. It is also achievable in the uranium-plutonium cycle. Only a factor of 3 to 4 is specific to thorium, just because it is more abundant than uranium by this factor.

Claim 2: Thorium did not get a chance in the nuclear energy development because it is not usable for military purposes

In the early stages of nuclear technology in the USA (from 1944 to the early 1950s), reprocessing technology was not yet well developed. Better developed were graphite moderated reactors that used natural uranium and bred plutonium. For the use of thorium (which, other than uranium, does not contain fissile components), enriched uranium or possibly plutonium would have been indispensable. Initially, neither pathway for thorium development was chosen because it would have automatically reduced the still limited capacity for military fissile materials production. (Thorium has a higher capture cross section for thermal (that means slow) neutrons than U-238. For that reason, it needs as fertile material in reactors a higher fissile density than U-238.)

Only when the US enrichment capacity at about 1950 delivered sufficient enriched uranium, the military and later civil entry into thorium technology started: in 1955 a bomb with U-233 from thorium was exploded, and a strategic U-233 reserve of around 2 metric tons was created. The large head-start of the plutonium bomb could not be overtaken any more, and plutonium remained globally the leading military fission material (although, according to unconfirmed sources, Indian nuclear weapons contain U-233). The US military research concluded in 1966 that U-233 is a very potent nuclear weapon material, but that it offers hardly any advantages over the already established plutonium.[6]

Because light water reactors with low-enriched uranium (LEU) were already too far developed, thorium use remained marginal also in civil nuclear engineering: for instance, the German "thorium reactor" THTR-300 in Hamm operated only for a short time, and in reality it was a uranium reactor (fuel: 10% weapon-grade 93% enriched U-235 and 90% thorium) because the amount of energy produced by thorium did not exceed 25%.

Claim 3: Thorium use has hardly any proliferation risk

The proliferation problem of Th / U-233 needs a differentiated analysis – general answers are easily misleading. First of all, one has to assess the weapon capability of U-233. Criteria for good suitability are a low critical mass and a low rate of spontaneous fission. The critical mass of U-233 is only 40% of that of U-235, the critical mass of plutonium-239 is around 15% smaller than for U-233. A relatively easy to construct nuclear explosive needs around 20 to 25 kg U-233. The spontaneous fission rate is important, because the neutrons from spontaneous fission act as a starter of the chain reaction; for an efficient nuclear explosion, the fissile material needs to have a super-criticality of at least 2.5 (criticality is the amount of new fissions produced by the neutrons of each fission.)

When, because of spontaneous fissions, a noticeable chain reaction already starts during the initial conventional explosion trigger mechanism in the criticality phase between 1 and 2.5, undesired weak nuclear explosions would end the super-criticality before a significant part of the fissile material has reacted. This largely depends on how fast the criticality phase of 1 to 2.5 is passed. Weapon plutonium (largely Pu-239) and moreover reactor plutonium have – different from the mentioned uranium fission materials U-235 and U-233 – a high spontaneous fission rate, which excludes their use in easy to build bombs.

More specifically, plutonium cannot be caused to explode in a so-called gun-type fission weapon, but both uranium isotopes can. Plutonium needs the far more complex implosion bomb design, which we will not go into further here. A gun-type fission weapon was used in Hiroshima – a cannon barrel set-up, in which a fission projectile is shot into a fission block of a suitable form so that they together form a highly super-critical arrangement (see the picture in sheet 7 in reference #1). Here, the criticality phase from 1 to 2.5 is in the order of magnitude of milliseconds – a relatively long time, in which a plutonium explosive would destroy itself with weak nuclear explosions caused by spontaneous fission. One cannot find such uranium gun-type fission weapons in modern weapon arsenals any longer (South Africa's apartheid regime built 7 gun-type fission weapons using uranium-235): their efficiency (at most a few percent) is rather low, they are bulky (the Hiroshima bomb: 3.6 metric tons, 3.2 meters long), inflexible, and not really suitable for carriers like intercontinental rockets.

On the other hand, gun-type designs are highly reliable and relatively easy to build. Also, the International Atomic Energy Agency (IAEA) reckons that larger terror groups would be capable of constructing a nuclear explosive on the basis of the gun-type fission design provided they got hold of a sufficient amount of suitable fissile material.[1] Bombs with a force of at most 2 to 2.5 times that of the Hiroshima bomb (13 kt TNT) are conceivable. For that reason, the USA and Russia have tried intensively for decades to repatriate their world-wide delivered highly enriched uranium (HEU).

A draw-back of U-233 in weapon technology is that – when it is produced only for energy generation purposes – it is contaminated with maximally 250 parts per million (ppm) U-232 (half-life 70 years).[2] That does not impair the nuclear explosion capability, but the uranium-232 turns in the thorium decay chain, which means – as mentioned above – emission of the highly penetrating radiation of Tl-208. A strongly radiating bomb is undesirable in a military environment – from the point of view of handling, and because the radiation intervenes with the bomb's electronics. In the USA, there exists a limit of 50 ppm U-232 above which U-233 is no longer considered suitable for weapons.

Nevertheless, U-232 does not really diminish all proliferation problems around U-233. First of all, simple gun-type designs do not need any electronics; furthermore, radiation safety arguments during bomb construction will hardly play a role for terrorist organisations that use suicide bombers. Besides that, Tl-208 only appears in the end of the decay chain of U-232: freshly produced or purified U-233/U-232 will radiate little for weeks and is easier to handle.[2] It is also possible to suppress the build-up of uranium-232 to a large extent, when during the breeding process of U-233 fast neutrons with energies larger than 0.5 MeV are filtered out (for instance by arranging the thorium in the reactor behind a moderating layer) and thorium is used from ore that contains as little uranium as possible.

A very elegant way to harvest highly pure U-233 is offered by the proposed molten salt reactors with integrated reprocessing (MSR): During the breeding of U-233 from thorium, the intermediate protactinium-233 (Pa-233) is produced, which has a half-life of around one month. When this intermediate is isolated – as is intended in some molten salt reactors – and let decay outside the reactor, pure U-233 is obtained that is optimally suited for nuclear weapons.

An advantage of U-233 in comparison with Pu-239 in military use is that under neutron irradiation during the production in the reactor, it tends to turn a lot less into nuclides that negatively influence the explosion capability. U-233 can (like U-235) be made unsuitable for use in weapons by adding U-238: When depleted uranium is already mixed with thorium during the feed-in into the reactor, the resulting mix of nuclides is virtually unusable for weapons. However, for MSRs with integrated reprocessing this is not a sufficient remedy. One would have to prevent separation of protactinium-233.[9]

The conclusion has to be that the use of thorium contains severe proliferation risks. These are less in the risk that highly developed states would find it easier to lay their hands on high-tech weapons, than that the bar for the construction of simple but highly effective nuclear explosives for terror organisations or unstable states will be a lot lower.

Claim 4: Thorium reactors are safer than conventional uranium reactors

The fission of U-233 results in roughly the same amounts of the safety-relevant nuclides iodine-131, caesium-137 and strontium-90 as that of U-235. Also, the decay heat is virtually the same. The differences in produced actinides (see next claim) are of secondary importance for the risk during operation or in an accident. In this perspective, thorium use does not deliver any recognisable safety advantages.

Of greater safety relevance is the fact that uranium-233 fission produces 60% less so-called delayed neutrons than U-235 fission. Delayed neutrons are not directly created during the fission of uranium, but from some short-lived decay products. Only due to the existence of delayed neutrons, a nuclear reactor can be controlled, and the bigger their share (for instance 0.6% with U-235), the larger is the criticality range in which controllability is given (this is called delayed criticality). Above this controllable area (prompt criticality) a nuclear power excursion can happen, like during the Chernobyl accident. The fact that the delayed super-critical range is with U-233 considerably smaller than with U-235, is from a safety point of view an important technical disadvantage of thorium use.

During the design of thermal molten salt reactors (breeders), the conclusion was that the use of thorium brings problems with criticality safety that do not appear with classical uranium use in this type of reactors. For that reason, it was necessary to turn the attention to fast reactors for the use of thorium in molten salt reactors. Although this conclusion cannot be generalised, it shows that the use of thorium can lead to increased safety problems.

As mentioned, a serious safety problem is the necessity to restart breeder and reprocessing technology with thorium.

Thorium is often advertised in relation to the development of so-called advanced reactors (Generation IV). The safety advantages attributed to thorium in this context are mostly, however, not germane to thorium (the fuel) but rather due to the reactor concept. Whether or not these advanced reactor concepts bring overall increased safety falls outside the scope of this article, but that is certainly not a question with a clear "yes" as the answer.

Claim 5: Thorium decreases the waste problem

Thorium use delivers virtually the same fission products as classical uranium use. That is also true for those isotopes that are important in issues around long-term disposal.[5] Those mobile long-lived fission products (I-129, Tc-99, etc.) determine the risk of a deep geological disposal when water intrusion is the main triggering event for accidents. Thorium therefore does not deliver an improvement for final disposal.

Proponents of thorium argue that thorium use does not produce minor actinides (MA)[5], nor plutonium. They argue that these nuclides are highly toxic (which is correct) and they compare only the pure toxicity by intake into the body for thorium and uranium use, without taking into account that these actinides are hardly mobile in final disposal even in accidents.

It may furthermore be true that thorium use does not deliver MA, but it does produce other actinides, especially protactinium-231 (Pa-231; half-life 33,000 years), with similar features as the MA. The advantage with thorium use is that the amount of the resulting long-lived actinides is smaller than that of MA in the case of uranium use by a factor of 5. On the other hand, the high level of U-233 in the waste is not without problems – its toxicity is comparable with plutonium and its long half-life (160,000 years) is aggravated by the fact that its decay product Th-229 (half-life 8,000 years) is a strong gamma-radiator (besides alpha). The maximum concentration of Th-229 is reached after around 100,000 years.

Taken together, one could argue that concerning actinides, thorium use has a limited advantage in produced waste, but certainly not concerning the safety-relevant long-lived fission products. For that reason, the claim that thorium use would considerably reduce the waste problem cannot be upheld. It also needs deep geological final disposal.

Conclusion

The arguments used by thorium proponents for a move from the use of uranium to thorium are at a closer look not convincing. The use of technology based on thorium would not be able to solve any of the known problems of current nuclear techniques, but it would require an enormous development effort and wide introduction of breeder and reprocessing technology. For those reasons, thorium technology is a dead end.

In my opinion, the proliferation aspect is a vital issue. Here we would see a severe deterioration of the current situation, because the barriers to the construction of feasible nuclear explosives by, for instance, terror groups would be seriously lowered. This aspect deserves more attention. We can hope that the IAEA, the USA and Russia would oppose uncontrolled propagation of thorium technology, when they would see its introduction thwarting their decades-long efforts to reduce the proliferation risk by repatriation of HEU.

On the other hand, the current thorium hype, partially carried by a fanaticism based on limited knowledge, could lead in a populist environment to incalculable developments. For that reason, I think it important that the environment and peace movements should insist that thorium technology without sufficient proliferation control should be outlawed in the same way as currently is the case with efforts to phase out the use of HEU. As a minimum requirement, thorium technology without U-233 denaturation with U-238 should be banned, and online reprocessing in molten salt reactors should be banned.

Epilogue: the scale of the international efforts supporting thorium technology

There still exists a large gap between the propaganda of thorium proponents and real activities for the development of thorium technology – at least in western industrialised countries. The brunt of the effort lies with smaller start-up firms. The large corporations remain passive and government support for thorium development remains small. Whereas full development of thorium technology would need investments of several billion euros or dollars, current EU support is in the range of a few million per year. This can be read as a clear sign of scepticism.

This scepticism is fed by extensive studies, for instance by the governments of the UK and Norway, that were rather pessimistic about thorium.[8,10] For that reason, I still think there are good grounds for hope that false developments towards the introduction of thorium technology may be countered with clear information. Take for example the Canadian company Terrestrial Energy, involved in the development of molten salt reactors, which in 2013 dropped thorium technology and online reprocessing for proliferation reasons, and now works on molten salt reactors based on classical uranium use (Integral Molten Salt Reactor – IMSR).

T-shirt design from www.snorgtees.com/thorium

In Germany, work on thorium technology continues. The research centre in Jülich jumped on the thorium hype by evaluating its previous experiences with thorium fuels[7]; and in Karlsruhe, the Joint Research Centre of the European Commission (JRC) and the Karlsruhe Institute of Technology (KIT) work on an EU-supported design for a molten salt fast reactor (MSFR) with thorium use. From the MSFR, 150 kg of U-233 would have to be extracted annually. Without denaturation that would be sufficient for several nuclear explosives. In Freiburg and Karlsruhe, new initiatives were founded against this development. They deserve support.

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Democracy is forgotten for the sake of nuclear power in Turkey

Author: Özgür Gürbüz

NM858.4712

Turkey's nuclear ambition is not limited to the Akkuyu power plant in the south – the north has its own problem. Sinop is the second place where the government of Turkey wants to build a nuclear power plant with the help of Japanese and French firms.

While the Akkuyu project's future gets cloudy after the announcement of the withdrawal of potential Turkish partners, the Sinop project suddenly came on to the agenda with an Environmental Impact Assessment Report and its legal obligation to hold a public participation meeting. The name is misleading though. On 6 February 2018, environmentalists of Sinop, members of the Anti-Nuclear Platform together with MPs and several NGOs gathered to join the public participation meeting only to face fences, police barricades, water cannon vehicles and pepper gas.

That was an unusually tense morning for a city like Sinop, one of Turkey's 'happiest cities' according to the Turkish Statistical Institute. Early birds of Sinop witnessed a strange activity with tens of police officers and plainclothes people jumping on buses. They were soon to fill the conference hall of Sinop University as the "selected public", leaving no room for anti-nuclear activists or even ordinary people wishing to learn and raise questions about the nuclear project. Buses left the city centre as early as 4.30am. Judging by the number-plates, three of them were brought from nearby provinces to Sinop. Some of the people on board were in uniforms and some were not, but they were going to be part of the same play named, "I love nuclear".

All these efforts proved to be effective since the conference hall was full before sunrise. Everybody who could ask serious questions about the project or protest the meeting were left out by police barricades, built as far as one kilometre from the venue. That included the Sinop MP Barış Karadeniz, Sinop's mayor Baki Ergül and other MPs (Orhan Bursalı, Ali Şeker), as well as the representative of the Chamber of Electrical Engineers or lawyers who came on behalf of Turkey's Bar Association. People of Sinop understood that the public participation meeting was only for the "selected public". Although it is very difficult to stage democratic protests in Turkey at the moment due to the State of Emergency, people protesting the project chanted behind the police roadblock to make their voices heard under the pouring rain.

After one hour of waiting, people decided to submit their petition of objection to the office of the Governor where they faced another police barricade. The march through the barricade was stopped by the police with the use of pepper spray. Soon after, the police and the protesters managed

Anti-nuclear protest in Sinop, 6 February 2018.

to reach an agreement and a committee of MPs, lawyers and the members of the anti-nuclear movement saw the Governor of Sinop Hasan İpek, and handed over more than 200 petitions claiming that their right to join the meeting was revoked. While negotiations continued in the governor's office, the crowd outside kept on protesting the nuclear power plant project, which is planned to be built through a Japanese-French consortium between Mitsubishi Heavy Industries and Engie. Together they will hold 51% of the shares and the rest will be controlled by Turkey's Electricity Generation Company EUAS).

A man managed to get inside the conference hall and criticize the nuclear project. The news and videos showed that he was attacked by the crowd, and then he was taken into custody by the police. This is a clear indication that EUAS International ICC has no intention to have an open and democratic debate regarding the nuclear project. What they say is simple: "Either you love it or you have to love it". That raises a question. Would there be any such anti-democratic treatment if that project was in France or Japan?

Regardless of the excess capacity of Turkey's electricity market and high purchase guarantees extended to nuclear power plants, the government of Turkey is still keen to realize deadly nuclear projects. They still do not admit it but they have chosen the wrong path to solve the country's energy problem.

'Pro-nuclear environmentalists' in denial about power/weapons connections

Author: Jim Green – Nuclear Monitor editor

NM858.4713

It takes a moment to tell a lie but it can take much longer to deconstruct one. So it is with this deconstruction of claims by pro-nuclear propagandists that "nuclear energy prevents the spread of nuclear weapons" and that "peace is furthered when a nation embraces nuclear power".

As discussed in Nuclear Monitor #850, nuclear industry bodies (such as the US Nuclear Energy Institute) and supporters (such as former US energy secretary Ernest Moniz) are openly acknowledging the connections between nuclear power and weapons – connections they have denied for decades.[1] Those connections are evident in almost all of the weapons states, in numerous countries that have pursued but not built weapons, and in potential future weapons states such as Saudi Arabia.[2]

Ideally, acknowledgement of power/weapons connections would lead to redoubled efforts to build a firewall between civilian and military nuclear programs – strengthened safeguards, curbs on enrichment and reprocessing, and so on. But that's not how this debate in playing out. Industry insiders and supporters drawing attention to the connections are quite comfortable about them – they just want increased subsidies and support for their domestic civilian nuclear industry lest 'national security' and 'national defense' be undermined.

Some continue to deny the power/weapons connections even though the connections are plain for all to see and are now being acknowledged by a growing number of nuclear insiders and supporters. The silliest of the deniers are those who self-describe as 'pro-nuclear environmentalists'. One such person is Ben Heard – a paid nuclear lobbyist in Australia whose so-called environment group 'Bright New World' accepts secret corporate donations.[3,4]

An article by Heard attacks the Australian Conservation Foundation for its failure to acknowledge the "obvious distinction" between nuclear power and weapons and for "co-opting disarmament … toward their ideological campaigns against peaceful science and technology".[5]

The Australian Conservation Foundation has actively supported the Nobel Peace Prize-winning International Campaign to Abolish Nuclear Weapons since ICAN was formed in Australia in 2007. ACF's nuclear-free campaigner Dave Sweeney was involved in the foundation of ICAN and has been on the ICAN Australia Board from 2007 to the present.

Heard's response is to note that the Nobel Committee "is well aware of the role of technology in driving peace" and that the International Atomic Energy Agency (IAEA) was awarded the Nobel Peace Prize in 2005. But the Nobel Committee's 2005 citation says nothing about nuclear power "driving peace" – whatever that means – and it doesn't endorse or criticize nuclear power.[6]

The citation singled out then IAEA Director General Dr. Mohamed ElBaradei – the Peace Prize was awarded "in two equal parts" to the IAEA and ElBaradei. The citation noted that ElBaradei "has stood out as an unafraid advocate of new measures to strengthen" the non-proliferation regime. During his tenure as IAEA Director General, ElBaradei was strikingly honest about the limitations of the so-called safeguards system. He noted that the IAEA'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 ".[7]

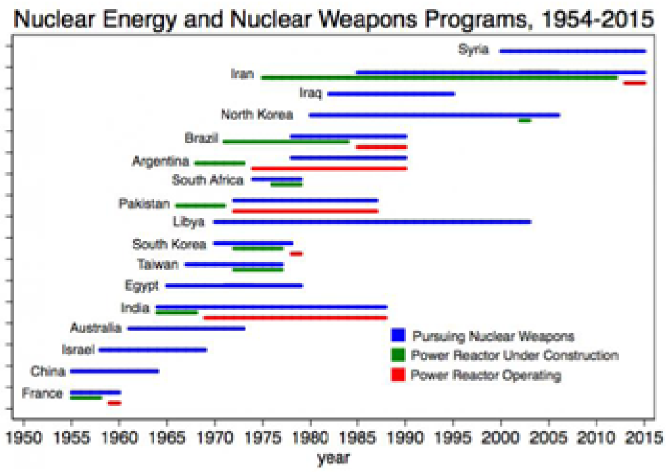
In his Nobel Lecture, ElBaradei said: "We must ... strengthen the verification system. IAEA inspections are the heart and soul of the nuclear non-proliferation regime. To be effective, it is essential that we are provided with the necessary authority, information, advanced technology, and resources. And our inspections must be backed by the UN Security Council, to be called on in cases of non-compliance."[6]

There's nothing about the limitations of safeguards in Heard's article. He has never said anything about the limitations let alone made the slightest contribution towards resolving them.

Far from endorsing Heard's claim about the "obvious" distinctions between nuclear power and weapons, ElBaradei noted in his Nobel Lecture that under the current system, any country has the right to develop operations for producing nuclear materials for civilian uses "but in doing so, it also masters the most difficult steps in making a nuclear bomb."[8]

Consumption and production of fissile material

Heard says the anti-nuclear movement "simply ignore that the US nuclear power sector was integral in the destruction of no less than 16,000 former Soviet nuclear warheads under a program known as 'Megatons to Megawatts'."[5] That's another lie – the anti-nuclear movement hasn't ignored the program.



Source: Nicholas Miller, www.eurekalert.org/pub_releases/2017-11/dc-nep110317.php

Heard ignores the production of fissile material in civilian nuclear programs:

- The amount of civilian plutonium (almost all of it produced in power reactors) grows at a rate of about 70 tonnes per year.[9] That amount of reactor-grade, weapons-usable plutonium[10] would suffice to build about 7,000 weapons.
- As of January 2017, the global stockpile of separated civilian plutonium (i.e. separated from spent fuel by reprocessing) was about 290 tonnes (enough for about 29,000 weapons).[11]
- A May 2015 report written for the International Panel on Fissile Materials found that as of the end of 2013, civilian stockpiles of highly enriched uranium and separated plutonium amounted to over 50,000 weapons-equivalents.[12] The weapons-equivalents figure jumps dramatically (to several hundred thousand) if plutonium in spent fuel is included.[13]

Nuclear power promotes peace?

Heard claims that nuclear power promotes peace and uses the two Koreas to illustrate his argument: "The South is a user and exporter of nuclear power, signatory to the non-proliferation treaty, and possesses zero nuclear warheads. The North has zero nuclear power reactors, is not a signatory to the non-proliferation treaty, and is developing and testing nuclear weapons."[5]

Likewise, Michael Shellenberger from the pro-nuclear lobby group 'Environmental Progress' claims that: "One of FOE-Greenpeace's biggest lies about nuclear energy is that it leads to weapons. Korea demonstrates that the opposite is true: North Korea has a nuclear bomb and no nuclear energy, while South Korea has nuclear energy and no bomb."[14]

Heard and Shellenberger ignore the fact that North Korea uses what is calls an 'experimental power reactor' (based on the UK Magnox power reactor design) to produce plutonium for weapons.[15] They ignore the fact that North Korea acquired enrichment technology from Pakistan's A.Q. Khan network, who stole the blueprints from URENCO, the consortium that provides enrichment services for the nuclear power industry.[15] They ignore the fact that North Korea's reprocessing plant is based on the design of the Eurochemic plant in Belgium, which provided reprocessing services for the nuclear power industry.[15]

Heard and Shellenberger also ignore South Korea's history of covertly pursuing nuclear weapons, a history entwined with the country's development of nuclear power. For example, the nuclear power program provided (and still provides) a rationale for South Korea's pursuit of reprocessing technology.[16]

Nicholas Miller's article in *International Security*

Echoing Shellenberger's claim that "nuclear energy prevents the spread of nuclear weapons"[17], Heard writes: "Peace is furthered when a nation embraces nuclear power, because it makes that nation empirically less likely to embark on a nuclear weapons program. That is the finding of a 2017 study published in the peer-reviewed journal *International Security*."[5] That's a lie twice over. Firstly, it isn't true. Secondly, Heard's assertion isn't supported by the *International Security* journal article, written by Nicholas Miller from Dartmouth College.[18]

Miller's article does however downplay the power/weapons connections. He writes: "In contrast to the conventional wisdom, this article argues that the link between nuclear energy programs and proliferation is overstated. Although such programs increase the technical capacity of a state to build nuclear weapons, they also have important countervailing political effects that limit the odds of proliferation. Specifically, nuclear energy programs (1) increase the likelihood that a parallel nuclear weapons program is detected and attracts outside non-proliferation pressures, and (2) increase the costliness of nonproliferation sanctions."

However, much of the information in Miller's article undermines his argument. In Miller's own words, "more countries pursued nuclear weapons in the presence of a nuclear energy program than without one", "the annual probability of starting a weapons program is more than twice as high in countries with nuclear energy programs, if one defines an energy program as having an operating power reactor or one under construction", and countries that pursued nuclear weapons while they had a nuclear energy program were "marginally more likely" to acquire nuclear weapons (almost twice as likely if North Korea is considered to have had a nuclear energy program while it pursued weapons).

Miller notes that France, South Africa, India, and Pakistan all acquired nuclear weapons while their energy programs were ongoing, and he notes that Argentina, Brazil, India, Iran and Pakistan began pursuing nuclear weapons after a nuclear energy program had already been initiated.

Miller cites recent studies that find that "states are more likely to pursue or acquire nuclear weapons when they have greater numbers of peaceful nuclear cooperation agreements with other states (including agreements related to nuclear energy production), receive sensitive nuclear assistance, are recipients of technical aid on the fuel cycle from the International Atomic Energy Agency (IAEA), or have greater latent nuclear capacity (e.g., uranium deposits, nuclear scientists, and chemical engineers)."

Leaving aside some of Miller's questionable arguments, his article is a reasonable primer on the manifold and repeatedly-demonstrated connections between nuclear power and weapons.

Miller's focus is on the pursuit of nuclear weapons so he is silent about the ongoing connections between power and weapons in existing weapons states – connections such as those loudly trumpeted by nuclear advocates in the US and the UK in their recent efforts to secure further support for ailing civilian nuclear industries[1]; or India's refusal to put much of its 'civilian' nuclear industry under IAEA safeguards.

Miller also has little to say about research reactor programs and their connections to both nuclear power and weapons.[19] Yet that is an important part of the story. To give one example: India's first nuclear weapon test used plutonium produced in the CIRUS (Canada–India-Reactor-United-States) research reactor and that plutonium was ostensibly separated for India's fast breeder power program.[20]

Downplaying the connections

Miller's article includes a reasonable account of the troubling connections between nuclear power and weapons – so how does he downplay the connections? He conducts a quantitative analysis concerning nuclear energy programs (reactors under construction or operating) and the pursuit of weapons. In so doing, much relevant information is cast overboard, such as real or feigned interest in nuclear power facilitating the pursuit of weapons even if construction of power reactors never began.

Even so, much of his data contradicts his conclusions. His simple count of countries pursuing weapons with or without a nuclear energy program from 1954 to the present yields these results:

- Nuclear energy program during pursuit of weapons: 10 countries (59%)
- No nuclear energy program during pursuit of weapons: 7 countries (41%)

As discussed below, at least two countries listed in Miller's 'no nuclear energy program' category – Australia and Iraq – could be included in the other category in which case the 59:41 ratio becomes 71:29, a ratio of more than 2:1.

Another difficulty with Miller's quantitative analysis is that it yields contradictory and inexplicable results such as these:

1. The annual probability of starting a weapons program is more than twice as high in countries with an operating power reactor or one under construction (a statistically-significant finding).
2. The annual probability of starting a weapons program is somewhat lower in countries with operating power reactors compared to countries without them (a statistically non-significant finding).

So why does Miller conclude that "nuclear energy programs do not significantly increase the likelihood of proliferation"? Why does he privilege the second of those findings when only the first is statistically significant? Why privilege the finding that excludes countries with power reactors under construction (but not in operation) when the inclusion of such countries provides a fuller, more accurate assessment of the power/weapons connections? It seems he bases his conclusions on the findings he likes and downplays those he dislikes.

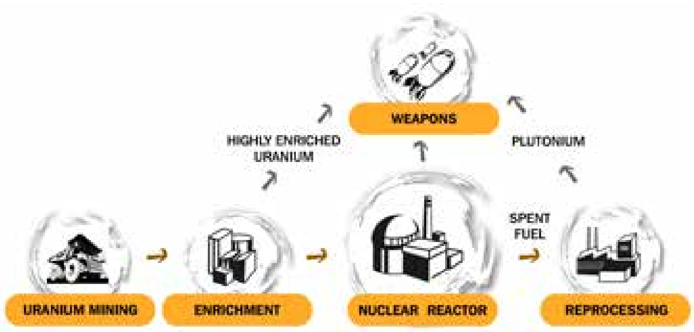
Miller produces a series of 'logistic regression models' to map the raw data against potentially confounding variables such as economic and industrial capacity. He concludes that "although statistical power may be an issue, the data at hand do not make a strong case for a large, positive effect of nuclear energy programs, as the conventional wisdom would predict." But within the findings, conventional wisdom can be found. The only statistically-significant finding arising from the models is a positive link between nuclear energy programs and the pursuit of weapons – a problem Miller circumvents by momentarily adopting a stricter definition of statistical significance!

Countries that have built nuclear weapons

Miller finds that among 17 countries that pursued nuclear weapons from 1954 to the present (others put the number higher[21]), they were more likely to actually build weapons if they had a nuclear energy program (defined as a power reactor in operation or under construction). For countries with a nuclear energy program, 44% developed weapons (4 out of 9 countries); for countries without a nuclear energy program, 37.5% developed weapons (3 out of 8 countries).

Once again, there is a disconnect between Miller's findings and his conclusions. And the disconnect is greater if North Korea is considered to have had a nuclear energy program while it pursued weapons. Miller writes: "If one instead codes North Korea as pursuing nuclear weapons with an energy program, the acquisition rate for countries with energy programs would be 50 percent, versus 28.5 percent for countries without energy programs. This is a substantial difference in success rate, and it is in line with the conventional wisdom."

The Dartmouth College media release announcing the publication of Miller's article asserts that "countries that pursued nuclear weapons under the cover of an energy program have not been significantly more likely to acquire



nuclear weapons, when compared to countries that seek nuclear weapons without an energy program."[22] Yet Miller's own count finds an increase, rising to a near-doubling if North Korea is considered to have had a nuclear energy program. Once again it seems he is basing his conclusions on the findings he likes and downplaying those he doesn't.

Miller goes on to note that using different codings (country categorizations) "there is little support for the conventional wisdom" and he states that "the evidence that a nuclear energy program is associated with a higher success rate is inconsistent and sensitive at best."

All the logistic regression models in the world don't alter the fact that nuclear power/weapons connections are multifaceted, repeatedly demonstrated, disturbing and dangerous:[23]

- Nuclear power programs facilitated the successful pursuit of weapons in four countries (France, India, Pakistan, South Africa) according to Miller (and North Korea could be added to that list) and have provided many other countries with a latest weapons capability.
- Power programs have provided ongoing support for weapons programs to a greater or lesser degree in seven of the nine current weapons states (the exceptions being Israel and North Korea).
- The direct use of power reactors to produce plutonium for weapons in all or all-but-one of the declared weapons states (and possibly other countries, e.g. India and Pakistan).
- The use of power reactors to produce tritium for weapons in the US (and possibly other countries, e.g. India).
- Power programs (or real or feigned interest in nuclear power) legitimizing enrichment and reprocessing programs that have fed proliferation.
- Power programs (or real or feigned interest in nuclear power) legitimizing research (reactor) programs which can lead (and have led) to weapons proliferation.
- And last but not least, the training of experts for nuclear power programs whose expertise can be (and has been) used in weapons programs.

As a counterfactual, how would nuclear weapons proliferation have unfolded if nuclear power had never existed? There would be far less fissile material in existence (several hundred thousand weapons-equivalents). Far fewer nuclear experts. The three pathways to weapons (power, research, or secret programs) would be reduced to two (and the remaining two pathways would be more difficult to pursue). There would be far fewer latent nuclear weapons states. There would be fewer nuclear weapons states. There would be fewer nuclear weapons.

Conversely, let's imagine a significant expansion of nuclear power. Former US Vice President Al Gore said during a 2006 interview: "For eight years in the White House, every weapons-proliferation problem we dealt with was connected to a civilian reactor program. And if we ever got to the point where we wanted to use nuclear reactors to back out a lot of coal … then we'd have to put them in so many places we'd run that proliferation risk right off the reasonability scale. And we'd run short of uranium, unless they went to a breeder cycle or something like it, which would increase the risk of weapons-grade material being available."[24]

Errors and omissions

Miller's downplaying of the power/weapons connections is weaker still when his errors are corrected. He claims that Australia had no nuclear energy program while it pursued nuclear weapons. In fact, Australia's pursuit of weapons was intimately linked to the pursuit of nuclear power.[25] For example, Prime Minister John Gorton pushed for a power reactor in the late 1960s and early '70s and later said: "We were interested in this thing because it could provide electricity to everybody and it could, if you decided later on, it could make an atomic bomb."[26]

If forced to put Iraq's weapons program into just one category, it would undoubtedly be classified as a secret program rather than one pursued under the cover of nuclear power or research. But therein lies a serious problem with Miller's quantitative analysis: numerous weapons programs defy a simple, singular classification. At various stages Iraq pursued all three pathways to weapons: a research reactor program (disrupted by repeated military strikes on its research reactors to prevent weapons proliferation), real or feigned interest in nuclear power, and a secret weapons program.[27]

Real or feigned interest in nuclear power provided the rationale to send hundreds of Iraqi scientists overseas for training and many of those scientists were put to work in the weapons program.[27] According to Khidhir Hamza, a nuclear scientist involved in Iraq's weapons program: "Acquiring nuclear technology within the IAEA safeguards system was the first step in establishing the infrastructure necessary to develop nuclear weapons. In 1973, we decided to acquire a 40-megawatt research reactor, a fuel manufacturing plant, and nuclear fuel reprocessing facilities, *all under cover of acquiring the expertise needed to eventually build and operate nuclear power plants and produce and recycle nuclear fuel*."[27] (emphasis added)

Miller says Japan has not actively pursued nuclear weapons – but Japan's reprocessing program suggests it has actively pursued (and achieved) a latent weapons capability. The reprocessing program provides Japan with separated, weapons-usable plutonium, and stockpiles could skyrocket if Rokkasho proceeds to operation. Rokkasho will also produce recycled uranium that could soften the blow in the event of Japan pursuing weapons and having uranium imports disrupted.

Miller says "there is strong reason to believe … that Japan's nuclear energy program has served as an additional brake on a nuclear weapons program" because the power program would likely be severely disrupted by nuclear trade sanctions in the event of Japan pursuing weapons. But he is silent about the implications of the US-India deal: based on that precedent, countries such as Japan and South Korea (i.e. US allies) might reasonably expect that sanctions resulting from the pursuit and acquisition of weapons would be manageable and short-lived.

One of the three 'policy implications' discussed in the conclusion to Miller's article is that "the United States should seek to revive its role as a nuclear supplier, because doing so would provide greater leverage over countries with nuclear energy programs that can be used to enforce nonproliferation". But the US has done nothing to curb Japan's reprocessing program and its stockpiling of separated plutonium. And the US-India deal has legitimized India's weapons program, worsened the South Asian nuclear arms race, legitimized nuclear trade with other non-NPT states (e.g. China's support for Pakistan's nuclear program), and created a precedent that could encourage other countries to pursue weapons.

Miller argues that the US should not insist that nuclear customer countries forego enrichment or reprocessing because that "gold standard" potentially reduces US leverage over other countries' nuclear programs. And why would the US want leverage? To stop countries pursuing enrichment or reprocessing, primarily. At worst, Miller's arguments are as silly and circular as those of Heard and Shellenberger.

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Hundreds of French police smash nuclear dump protest camp, raid support house and arrest opponents

Jack Cohen-Joppa reports in the *Nuclear Resister*:

Before dawn on the morning of February 22, hundreds of French police in riot gear and equipped with trucks, bulldozers, helicopters and drones, evicted dozens of nuclear waste dump opponents who had occupied disputed woods in the Meuse district for the last 18 months. A public relations offensive accompanied the action, vilifying opponents with images of previous clashes and supplying the media with dramatic body-camera footage from hooded police wielding chainsaws as they dismantled the protest camp. In anticipation of such police action, a recently-established support network among nuclear opponents across the country was pressed into action. That night, there were demonstrations in front of Prefecture offices in more than 70 cities across France.

A few years ago, the Lejuc Woods were picked as the site for ventilation shafts into the proposed underground burial vaults for France's commercial and military nuclear waste. In the summer of 2016, when the nuclear waste authority ANDRA illegally walled off a construction site in the woods, dump opponents forced them out and began their own occupation. Since then, activists have planted crops and established residency in treehouses and watchtowers to protect the communal woods. While title to the property remains in dispute, last summer a court ordered the eviction of the new community, providing police with the authority to act now.

To isolate the resisters from their supporters, police blocked roads leading into the woods while arresting activists in the lookouts and surrounding their treehouse homes. As news of the raid spread, cars approaching from several nearby villages were stopped for identity checks of the drivers and passengers. The streets in the village of Bure were blocked as police also surrounded the House of Resistance, where local opposition to the national project has been based for more than 20 years. At least 30 occupants took refuge upstairs as police broke down the door to enter. Some locked themselves together and had to be cut apart, but over the next few hours, all of the occupants were escorted out while police searched the building. Many were taken to surrounding police stations for identity checks. At the end of the day, five people remained in police custody.

A joint press communique from nine of the groups opposing the dump condemned the raid and the hypocrisy of the government. While Environment Minister Nicolas Hulot had declared that dialogue, not "force and brutality," would mark the way forward on the dump question, he sent the groups a disingenuous invitation just the day before to meet with his deputy Sebastien Lecornu, due to arrive in the region on the evening of the raids for consultations in the Prefecture of Bar le Duc the next morning, February 23.

The groups rejected the invitation, asking: "Is this the way democracy is practiced? Diplomatic visits, promises of employment and nuclear development on one side, and, simultaneously, brutality and indiscriminate repression of an opposition. … Who is illegal at Lejuc Wood? The occupants of the forest who built a barricade against a project insane and questioned from all sides, or the authorities who by this incomprehensible evacuation supports this project? The government claims to enforce the law, while the ANDRA has been sentenced three times and is still the subject of four complaints and legal action before the courts for illegal work on the contested property of Lejuc Wood."

These raids are the latest escalation in ANDRA's effort to get a hole in the ground. They come after recent convictions of dump opponents arrested during earlier clashes with police, who face a possible jail sentence next month.

A recently announced information tour to begin discussion with supporters around the country during the last week of February now takes on more urgency, as does the recent call for people to come to Bure during the first weekend of March to help prepare the camp in the woods for actions this summer.

For more information, visit http://en.vmc.camp/2018/02/22/expulsion-forest-info-thread/

A chronicle in English of the last two years of nuclear dump resistance can be found in the pages of the *Nuclear Resister* newsletter from issues #182 (September 6, 2016), #184, #185 and #186 (download at www.nukeresister.org/back-issues/).

Jack Cohen-Joppa, 23 Feb 2018, 'Hundreds of French police smash nuclear dump protest camp, raid support house and arrest opponents', www.nukeresister.org/2018/02/22/hundreds-of-french-police-smash-nuclear-dump-protest-camp-raid-support-house-and-arrest-opponents/

India's 'No First Use' policy

Kumar Sundaram and M. V. Ramana (both contributors to Nuclear Monitor) have written an article for the Journal of Peace and Nuclear Disarmament on India's 'No First Use' nuclear weapons policy. A short excerpt is copied below and the full article is online.

"Indian officials have long claimed that the country's nuclear weapons are governed by a No First Use (NFU) policy, and they have often used this policy as proof that India is a responsible nuclear weapon state. However, there are many influential strategists and policy makers who have argued that India should abandon that policy. There is also some evidence that despite the public talk of a NFU policy, the leadership might not be actually contemplating acting in full accordance with such a policy. Finally, ongoing military acquisitions, such as a canisterised missile mated to a nuclear warhead, could provide the necessary material capability for India to launch a first strike. If indeed Indian policy makers are seriously interested in using the NFU as a tool for risk reduction and building stability, they would have to stop such acquisitions and not deploy nuclear weapons, either mated to missiles (land based or sea based) or to aircraft, both as a matter of stated formal policy and practice.

"India's constant emphasis on the NFU is also out of touch with the what is happening with the effort to achieve nuclear disarmament, wherein the focus has been on a total ban on the use and threat of use of nuclear weapons; in contrast, the NFU does not in any way make the possession of nuclear weapons illegal. The effort to ban nuclear weapons has achieved some recent success through the Treaty to Prohibit Nuclear Weapons (or Ban Treaty) being adopted at the United Nations in July 2017 and opened for signature to member states in September 2017. India did not sign the treaty nor did it participate in the negotiations of the treaty."

Kumar Sundaram and M. V. Ramana, Feb 2018, 'India and the policy of no first use of nuclear weapons', Journal of Peace and Nuclear Disarmament, www.tandfonline.com/doi/full/10.1080/25751654.2018.1438737

Our friends at Green Action in Japan need our help!

Our friends at Green Action in Japan need our help! The governor of Japan's Fukui Province approved the restart of two reactors at the Ohi nuclear plant near Kyoto. This took place in the face of much public opposition, and we are supporting the activists of Kyoto as they fight to keep the reactors off line. On February 16, Kyoto citizens and others from the surrounding region went to Kyoto City to urge legislators to oppose Ohi nuclear power plant restart. Please sign Green Action's petition to keep Ohi closed.

Petition: www.change.org/p/12948839/u/22390039

Green Action Japan: http://greenaction-japan.org/en/

– Tim Judson, Nuclear Information & Resource Service

US: National Grassroots Activist Summit on Radioactive Waste – Chicago, March 16–18

A National Grassroots Activist Summit on Radioactive Waste (March 16–18 in Chicago) will hear voices on environmental justice from front-line communities – people living near nuclear reactors as well as near nuclear dump-targeted sites. In addition, the summit will hear from people living in urban centers that would be nuclear transport hubs if consolidated storage of highly radioactive waste or Yucca Mountain are approved to go forward.

The event is being organized by the Nuclear Information and Resource Service and the Nuclear Energy Information Service with the support of many grassroots partner organizations.

For more information and to register: www.nirs.org/radioactive-waste/hlw/waste-summit/

Europe: Cross-border cooperation on nuclear safety inadequate

Cross-border cooperation on nuclear safety between the Netherlands, Belgium and Germany leaves a lot to be desired, the Dutch Safety Board has concluded in a new report. Although the report says that the chances of a serious incident are "small", it warns that cross-border nuclear accident cooperation would "not run smoothly" and urges the authorities to improve contingency planning.

Belgium's nuclear reactors have long courted controversy due to their age, well-documented safety concerns and their close proximity to the country's borders with Germany and the Netherlands. The Dutch Safety Board report looked into how well the three countries are working together on aspects like evacuation strategies, plant maintenance and contingency planning. Its report highlighted that radiation treatment measures vary between the three countries. For example, Germany has issued iodine tablets to some border communities while towns on the other side of the borders go without. Evacuation plans also differ.

Euractiv, 6 Feb 2018, www.euractiv.com/section/energy/news/cross-border-nuclear-cooperation-must-improve-dutch-watchdog-warns/

Nuclear energy challenged by Austria, questioned in France

Energy Post Weekly reports:

Austria has officially launched a lawsuit against the European Commission for its approval of Hungarian state subsidies for the construction of two new reactors at the Paks nuclear power plant. The Austrian government had announced on 22 January that it intended to file the suit. Austrian Sustainability Minister Elisabeth Köstinger has confirmed that the government has now filed the suit with the European Court of Justice.

The Paks plant, which is 100 km south of Budapest, currently comprises four Russian-supplied VVER-440 pressurised water reactors, which started up between 1982 and 1987, reports World Nuclear News. An inter-governmental agreement signed in early 2014 would see Russian enterprises and their international sub-contractors supply two new units at Paks – VVER-1200 reactors – as well as a Russian state loan of up to €10.0 billion (US$11.2 billion) to finance 80% of the project.

"Hungary received the go-ahead to start construction of new nuclear power units at Paks this year as planned, following the Commission's approval last March of commitments the country had made to limit distortions in competition. The Commission concluded that Hungary's financial support for the Paks II project involves state aid, but it could approve this support under EU state aid rules on the basis of these commitments." Köstinger said that Austria is convinced that nuclear power must not have a place in Europe.

In France, the European home of nuclear power, the sector is increasingly under pressure. Environment Minister Nicolas Hulot has said that "France has no need to build new nuclear reactors in addition to the one currently being assembled in Flamanville", reports Reuters. President Emmanuel Macron had earlier said "he would not rule out France building new nuclear reactors to replace state-controlled utility EDF's ageing reactors."

But Hulot said, "For the moment, frankly, there is no need to consider building other nuclear reactors in addition to Flamanville." Hulot said in November last year that reducing the share of nuclear energy in France's power mix to 50 percent from 75 percent would probably take until 2030-35, dropping an initial 2025 target date.

Journalist Craig Morris, writing for the website Energy Transition of the Heinrich Böll Foundation, recently speculated that France may be about to close five nuclear reactors "without any official announcement". He bases this mainly on announcements on the website of French nuclear operator EDF, which say that four plants currently closed "will be reassessed and … will be restarted if economically justified".

According to Morris, such as a sentence is "highly unusual". EDF, he adds, would not comment.

Abridged from Energy Post Weekly, 27 Feb 2018, https://energypostweekly.eu/february-27-2018-express/#section_3