NUCLEAR PROLIFERATION PREVENTION PROJECT

February 24, 2021

Mr. James Lovejoy
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via email: VTR.EIS@nuclear.energy.gov

Re: Public Comment on Draft Versatile Test Reactor Environmental Impact Statement

Dear Mr. Lovejoy,

This submission responds to your announcement of February 12, 2021, extending the public comment period until March 2, 2021, for the Draft Versatile Test Reactor Environmental Impact Statement (Draft VTR EIS). I am submitting via email. **Please confirm receipt of this submission via return email to akuperman@mail.utexas.edu.**

I am Associate Professor at the LBJ School of Public Affairs, University of Texas at Austin, where I also am coordinator of the Nuclear Proliferation Prevention Project (www.NPPP.org). My comment focuses on the inadequacy of the Draft VTR EIS's analysis of environmental and related risks arising from the proposed fabrication and use of fuel incorporating tens of metric tons of plutonium. The Draft VTR EIS discusses these risks in only a cursory manner, as if large-scale fabrication of nuclear fuel that includes substantial amounts of plutonium were a routine activity having a successful historical track record, which is opposite of the truth.

The Draft VTR EIS states that, "during the reactor fuel production process, up to 34 metric tons of plutonium could be needed for startup and 60 years of VTR operation" (S-12). "Preparation of the source material may be required to convert the plutonium into a metal and to remove impurities" (B-59). To fabricate driver fuel, "Steps in the process include fuel alloying and homogenization, fuel slug casting and decasting, fuel pin assembly, and fuel assembly fabrication" (B-64). "The equipment layout that would be used has not been determined and would be finalized during the detailed design of the fuel production facility" (B-78).

Such proposed large-scale fabrication and use of fuel containing a mixture of plutonium and uranium (henceforth, "plutonium fuel") raises a number of major concerns. Despite the proposed activities encompassing multiple processing steps including possible conversion of plutonium between oxide and metal forms, and despite the absence at this time of even basic information such as the actual equipment layout, the Draft VTR EIS optimistically assumes that any radiological risk would be minimal (B-76). Other related risks that I detail below – including economic, security, and public acceptance – are barely mentioned let alone analyzed in the Draft VTR EIS. I contend that before DOE engages in further consideration of the VTR, the

National Environmental Policy Act (NEPA) requires an analysis of the historical global track-record of such activities, which the Draft VTR EIS fails to provide.

More than a year ago, I published a refereed journal article: Alan J. Kuperman, "Challenges of Plutonium Fuel Fabrication: Explaining the Decline of Spent Fuel Recycling," *International Journal of Nuclear Governance, Economy and Ecology* 4, 4 (2019): 302-316. The article presents key findings of the first comprehensive global study of the commercial fabrication and use of plutonium fuel – analyzing environmental impact, health and safety, economics, security, performance, and public acceptance. Your draft EIS cites neither this article nor the book containing the underlying data: Alan J. Kuperman, ed., *Plutonium for Energy? Explaining the Global Decline of MOX* (Austin: NPPP, 2018), https://repositories.lib.utexas.edu/handle/2152/69255. The Draft VTR EIS thus neither conducts its own comprehensive global study of the historical track record of plutonium fuel fabrication and use, nor does it reference the only such study in existence. Clearly, the Draft VTR EIS does not rigorously evaluate the environmental and related risks arising from the proposed activity, as required by law.

Below I summarize these risks, as analyzed in my article and book (Kuperman, 2018a, 2019), based in part on field research in all seven countries that have engaged in the commercial production or use of plutonium fuel: Belgium, France, Germany, Japan, the Netherlands, Switzerland, and the United Kingdom. Five of these seven countries already have decided to phase out commercial plutonium fuel activities. The price of plutonium fuel has proved to be three to nine times higher than traditional uranium fuel. Plutonium fuel also has sparked political controversy, due to safety and proliferation concerns, in four of the six countries where it has been used commercially.

These problems have been due mainly to the fact that plutonium has three big downsides compared to the uranium traditionally used to make nuclear fuel: it is much more likely to cause cancer if inhaled, may be used to make nuclear weapons, and (largely due to the first two characteristics) is very expensive to purify and fabricate into fuel. Despite these challenges, the aforementioned seven countries attempted to engage in the commercial fabrication and/or use of plutonium fuel. Three of these countries both fabricated and used plutonium fuel commercially: Belgium, France, and Germany. Three used but did not fabricate it commercially: Japan, the Netherlands, and Switzerland. One country fabricated but did not use it commercially: the United Kingdom.

As of 2018, five of the seven countries had already ended, or decided to phase out, their commercial plutonium fuel activities. Belgium halted both plutonium fuel fabrication and use in 2006. Switzerland ended its plutonium fuel use in 2007. The UK terminated commercial plutonium fuel fabrication in 2011. Germany halted plutonium fuel fabrication in 1991, and inserted its final plutonium fuel assembly in 2017. The Netherlands plans to load its last plutonium fuel assembly in 2026 and remove it four years later, when its sole nuclear power reactor will close. Except in the last case, commercial plutonium fuel activities were curtailed prior to a decision to phase out nuclear power. This track-record leaves only two countries planning to continue commercial plutonium fuel activities – France and Japan – and their programs too face financial and political challenges (Kuperman, 2018b).

Fabricating Plutonium Fuel

As detailed below, five of the six fabrication facilities for plutonium fuel that ever operated commercially have closed prematurely, and most of them underperformed while they were open.

A seventh facility in Germany was canceled after construction, an eighth in Japan is stalled at the early stages of construction, and a ninth in the United States was canceled in 2018 after partial construction costing billions of dollars (Gardner, 2018). The main underlying cause of this poor track-record is that plutonium is far more hazardous than uranium, leading to high costs and public opposition. Plutonium mostly comprises isotopes that are relatively long-lived but emit significant levels of alpha radiation. One isotope of plutonium, Pu-241, is not an alpha emitter but decays relatively quickly into americium-241, which is an especially strong alpha emitter. Such alpha radiation is not a major problem outside the body because it can be blocked by many materials including skin. However, if inhaled and lodged in the lungs, plutonium and americium isotopes persistently bombard the surrounding tissue with alpha particles that induce mutations, so that at a sufficient dose they are almost guaranteed to cause cancer, as demonstrated in laboratory studies (Oghiso, et al., 1998).

This danger arises especially during plutonium fuel fabrication, including when plutonium is in the form of an oxide that may be inhaled. To reduce the health risk to employees and surrounding communities, plutonium fuel plants employ costly hardware – including air purifiers, glove boxes, and automated equipment – and costly procedures such as lengthy shutdowns to clean up spills. As detailed below, these substantially raise the production costs for plutonium fuel compared to uranium fuel, even excluding the expense of obtaining plutonium in the first place. Attempting to reduce such fabrication costs has backfired by increasing accidents, outages, scandals, and public protest – thereby reducing the output and raising the per-unit cost.

The biggest failure was the UK's British Nuclear Fuel Ltd (BNFL) plant at Sellafield (SMP), which had a planned output of 120 metric tons of heavy metal per year (MTHM/yr, including both plutonium and uranium). In practice, during its operation from 2001 to 2011, the facility produced a total of only 14 MTHM, an average of barely one MTHM/year, or about one percent of its intended output. The two principal causes of this profound failure arose from the safety risk of plutonium: unproven automated techniques to reduce worker exposure, and an unreasonably small facility footprint to reduce the costs of worker-protection measures. The consequences were failed equipment, expensive repairs, and prolonged suspensions of production. Although SMP's troubles could be attributed to experimental technologies and poor design, both of those choices arose from concerns over plutonium's health threat and the costs of mitigating it (Mann, 2018).

BNFL's preceding and much smaller commercial demonstration facility also ended in failure, although to a lesser extent. The plant's capacity was eight MTHM/yr. During operation from 1993 to 1999, it produced a total of 20 MTHM, for an average of about three MTHM/yr, or 40 percent of capacity. However, the plant closed prematurely after revelations that workers had repeatedly falsified quality-control data, which led to an international scandal culminating in $100 million in penalties and the return of unirradiated plutonium fuel assemblies from Japan (Mann, 2018). It is uncertain why BNFL failed persistently to monitor quality control at this plant, which had paid high costs to address plutonium's health risks.

Germany's Alkem Hanau plant underperformed persistently and then closed prematurely in 1991 due to a radiation accident. The facility's potential output was 25 MTHM/yr, but from 1972 to 1991, its average annual production was eight MTHM, or about 30 percent of capacity. This shortfall stemmed partly from complications of plutonium's radiotoxicity, including "repair work under difficult glove-box conditions" and "plutonium contamination in the fabrication areas that required time-consuming cleanup," according to a senior facility official at the time.

He reports that production also was hindered by intrusive EURATOM safeguards inspections and domestic controversy over transport security, both arising from plutonium's proliferation concerns. In 1991, a plant worker was contaminated by a glove-box accident, and public outrage led to permanent closure of the facility. Related controversy also blocked the opening of a nearly completed follow-on facility, Hanau 1, which was canceled in 1995 (Kennedy, 2018).

Belgium's P0 plant, operated by Belgonucléaire in Dessel, closed prematurely due to inefficiency, competition, and vanishing global demand for plutonium fuel. The plant had a capacity to fabricate 32 MTHM/yr of plutonium fuel rods, which were then combined into fuel assemblies at a neighboring facility owned by FBFC. From 1973 to 2006, the P0 plant produced approximately 600 metric tons of plutonium fuel rods, an average of nearly 18 MTHM/yr, or 55 percent of capacity. However, costs were extremely high, due mainly to efforts to address plutonium's health threat (Bonello, 2018). Eventually, P0 could not compete with France's more-efficient MELOX facility, especially as demand declined, so the Belgian plant closed for economic reasons rooted in the safety hazards of plutonium and the reduced global use of plutonium fuel. Meanwhile, a broken plutonium fuel rod at the adjacent FBFC facility in the mid-1990s compelled the shutdown of that facility's plutonium and uranium fuel operations, followed by a costly decontamination, and then the expensive construction of a new annex exclusively for plutonium fuel assemblies (Bonello, 2018).

France has been more successful at fabrication of plutonium fuel, at two successive facilities, but they too have faced economic and safety challenges. France's commercial fabrication of plutonium fuel started in 1989, in Cadarache, at the ATPu plant, whose capacity increased gradually from 20 to 40 MTHM/yr of plutonium fuel rods that later were combined into assemblies at plants in Belgium or France. In 1995, due to earthquake risk, French safety authorities ordered that the plant cease operations "shortly after 2000," and it did so in 2003 (Burns, 2018). Concerns included that an earthquake could trigger a plutonium fire, criticality accident, or other release of radioactivity.

The most successful plutonium fuel fabrication plant to date, and the only commercial facility still operating, is France's MELOX. The plant has a nominal capacity up to 250 MTHM/yr, but it has never been authorized above 195 MTHM/yr, and in practice it has produced much less. From 2014 to 2017, MELOX produced on average under 125 MTHM/yr, or less than half its nominal capacity. Such depressed output stems mainly from sharply decreased foreign demand (none from Germany since 2015, and only about 10 MTHM/yr combined from the Netherlands and Japan in recent years), while France's domestic utility has not significantly increased its use of plutonium fuel, possibly due to high cost. In 2017, MELOX also reported some "technical production difficulties" that may explain a further reduction in annual output to 110 MTHM (Burns, 2018).

Using Plutonium Fuel

All six countries that have commercially used plutonium fuel in reactors discovered that its price was many times that of traditional uranium fuel. The main cause was the increased cost of fuel manufacturing due especially to plutonium's health threat but also other factors, including small batch size, the challenge of uniformly blending uranium and plutonium, and enhanced security for transport (Kuperman, 2018b). Plutonium's greatest cost impact was on activities to fabricate fuel rods. According to an article by Belgian industry officials who led their country's efforts, "For plutonium fuel, the cost of this group of activities is typically 15 to 25 times higher" than for uranium fuel (Vielvoye and Bairiot, 1991).

Everywhere it has been used, plutonium fuel has proved much more expensive than uranium fuel, both in terms of fabrication cost and purchase price. Japanese utilities in recent years have paid at least nine times as much for imported plutonium fuel as equivalent uranium fuel, according to press reports (Energy Monitor Worldwide, 2015). If Japan proceeds with its planned domestic plutonium fuel facilities, plutonium fuel would cost even more, 12 times as much as uranium fuel, according to the Japan Atomic Energy Commission (Atomic Energy Commission Bureau, 2011). In Belgium, a 1998 industry study found that plutonium fuel cost at least five times as much to produce as uranium fuel, even ignoring the expense of material inputs for plutonium fuel while including them for uranium (Belgonucléaire, 1998). In Germany, the cost to produce plutonium fuel was three to five times that of uranium fuel, according to experts from government, industry, and civil society (Kennedy, 2018). In the Netherlands, a 2010 utility licensing submission to initiate commercial use of plutonium fuel portrayed its fabrication cost as five times that of uranium fuel (EPZ, 2010). In the UK, the Department of Energy estimated in 1979 that fabrication costs were four times higher for plutonium fuel than for uranium fuel (Jones, 1984). In Switzerland, utilities historically paid about six times as much (inflation-adjusted) for plutonium fuel as the current price of uranium fuel (Kim and Kuperman, 2018).

In France, despite economies of scale, plutonium fuel costs four to five times as much to fabricate as uranium fuel, according to industry and other interviewees (Burns, 2018). A French government report, in 2000, indicated that the total cost of producing plutonium fuel, including obtaining plutonium via reprocessing, was 4.8 times that of uranium fuel (International Panel on Fissile Materials, 2015; Charpin, et al., 2000).

Public Acceptance

The decline of plutonium fuel is not merely an economic phenomenon, nor ancillary to a broader global retreat from nuclear power. Plutonium fuel has repeatedly proved less popular than traditional uranium fuel due mainly to plutonium's safety and security concerns. In Germany, anti-nuclear protests escalated in the 1990s, when they started focusing on the environmental and proliferation risks of international shipments associated with plutonium fuel. Popular outrage spurred a 2002 German law that prohibited the export of spent fuel for reprocessing after 2005; this occurred well before Japan's 2011 Fukushima accident prompted Germany to expedite a phase-out of nuclear energy (Winter, 2013). Ironically, the advent of plutonium fuel, originally conceived as necessary to sustain nuclear power, instead roused anti-nuclear sentiment in Germany.

In Japan, too, plutonium fuel has proved more controversial than uranium fuel for both domestic and international audiences due to health and security concerns. In 1999, Japanese anti-nuclear NGOs successfully persuaded the government, based on safety issues, to reject and return plutonium fuel that had been imported for the Takahama-4 reactor, yet they could not stop the plant from continuing to use uranium fuel. In 2001, again mainly on safety grounds, Japanese voters blocked the use of plutonium fuel in the Kashiwazaki-Kariwa-3 reactor, despite allowing the plant to continue operating with uranium fuel. Also in 2001, due to safety concerns, a governor withdrew consent for plutonium fuel use at the Fukushima power plant, which nevertheless continued using uranium fuel. These three popular revolts against plutonium fuel had the effect of delaying by a decade the commercial introduction of plutonium fuel in Japan, thereby exacerbating the Japanese-owned plutonium stockpile that recently totaled 47 metric tons (Acharya, 2018). Neighboring countries, including China, South Korea, and North Korea, have expressed strong security concerns about this plutonium accumulation, which is sufficient for more than 5,000 nuclear weapons (Tajima, 2018; Min-Hyung, 2018). Thus, Japan's plutonium fuel program has sparked both domestic and international protest.

In other countries as well, plutonium fuel has proved more controversial than nuclear power *per se*. In Switzerland, a 2003 referendum imposed a moratorium on exports of spent fuel for reprocessing to produce plutonium fuel, effective in 2006, yet Swiss voters continued to support operation of nuclear reactors until Japan's Fukushima disaster spurred a 2017 vote to phase out nuclear energy by around 2050 (Kim and Kuperman, 2018). In Belgium, in the 1990s, NGOs focused their anti-nuclear energy campaigns on plutonium fuel's proliferation, terrorism, and environmental risks. These efforts compelled the Belgian government in 1993 to initiate a moratorium on new reprocessing contracts and to start a reassessment of plutonium fuel, culminating in 1998 with termination of the last existing reprocessing contract. Belgium's Vice-Prime Minister explained, in 1998, that based on the "information we have concerning economic and ecological aspects, there is no justification to use another time the reprocessing technology," and he also cited proliferation concerns (WISE-Paris, 1999; Bonello, 2018). This was five years before the government, in 2003, decided to phase out nuclear power entirely with a target date of 2025. Only in two countries, France and the Netherlands, has commercial plutonium fuel proceeded without provoking decisive public opposition yet.

Conclusion

The Draft VTR EIS does not adequately assess the environmental and related risks arising from the proposed large-scale fabrication and use of fuel incorporating tens of metric tons of plutonium. Adequate assessment would include a comprehensive global study of the historical track record of such large-scale fabrication and use of plutonium fuel, which is absent from the Draft VTR EIS. Accordingly, NEPA requires that DOE revise the Draft VTR EIS to include such an assessment, which if conducted properly would reveal the environmental, health, economic, security, and public acceptance risks that have bedeviled past attempts at large-scale fabrication and use of plutonium fuel. These risks are so large that they would tilt the balance in favor of the "No Action Alternative."

I stand ready to provide further information upon request. Thank you for your consideration of these comments.

Sincerely,

Alan J. Kuperman

Alan J. Kuperman, Ph.D.

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