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March 10, 2023

Mr. Will Tobey, Chair
Nuclear and Radiation Studies Board
National Academies of Sciences, Engineering and Medicine
500 Fifth Street, N.W.
Washington, DC 20001

Subject: National Academies of Science, Engineering, and Medicine Report "Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors" (2022)

Dear Mr. Tobey:

On behalf of the American Nuclear Society (ANS), the professional society for those working in the field of nuclear technology, I am pleased to provide ANS observations on the pre-publication version of the recent National Academies of Science, Engineering, and Medicine (NASEM) report "Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors" (2022). An ad hoc committee of ANS members bringing the varied perspectives of industry, government, and academia reviewed the report and developed these observations on the document and its findings and recommendations. I provide and discuss our most significant observations in the body of this letter; additional comments are included in the Attachment. In addition, I understand that individual ANS reviewers notified NASEM staff about specific technical inaccuracies they noted during their reviews.

ANS believes the NASEM report addresses a subject that is important to our nation's clean and secure energy future. ANS members are enthusiastic about advancing nuclear energy as a safe, clean source of energy, and part of that mission is ensuring that waste generated by the operation of nuclear power reactors is safely and securely managed, as it has been throughout the history of nuclear power. We hope that this input proves useful to the National Academies in this and future endeavors.

Key Areas of Agreement

We agree with many of the NASEM report's findings and recommendations, and highlight a few of those here. Failure to mention a finding or recommendation does not indicate disagreement; rather, that the ANS committee had no strong opinions, had differing opinions, or felt that the finding or recommendation was not a priority for further discussion.

Recommendation B: *To support the development and deployment of advanced reactor technologies, Congress and the U.S. Department of Energy (DOE) need to*

provide or assure access to materials testing and fuel qualification capabilities essential to advancing these technologies. Accomplishing this requires a coordinated plan involving DOE's Office of Nuclear Energy, Office of Science, and domestic and international user communities. The plan should consider a full range of alternatives in meeting both short- and long-term needs.

ANS endorses this recommendation, which is consistent with the February 2021 ANS report "The U.S. Nuclear R&D Imperative." We compliment the U.S. Congress and recent administrations for recognizing this need and increasing funding for nuclear energy research and development, and we believe the Department of Energy Office of Nuclear Energy has been an effective partner with industry on addressing research and development needs. We highlight the largest unfilled need – the lack of a fast neutron testing capability such as would be provided by the Versatile Test Reactor. We continue to encourage the federal government to restart and complete this important project.

Finding 7: *There is no current domestic capacity to supply high-assay low-enriched uranium (HALEU) to meet the projected needs of U.S.-based advanced reactor developers over the next decade. Therefore, if reactor projects requiring HALEU continue to advance, identifying a reliable supply of the material will be crucial. Otherwise, many developers will likely initially acquire HALEU from foreign sources, such as Russia, raising concern about ensuring reliable supply. Reliance on foreign sources of HALEU or HALEU feedstock (as many advanced reactor developers had planned to do prior to the invasion of Ukraine by Russia) without a reliable domestic supply could have serious energy and national security implications if advanced reactors using HALEU are adopted widely.*

We agree wholeheartedly that the current lack of reliable supply of HALEU is an important impediment to advanced reactor deployment. We have consistently urged the U.S. government to take the necessary steps to help establish a domestic HALEU supply, and to take compensatory supply measures while the HALEU supply chain is being established. We do take issue with part of Recommendation C, which seems to recommend delaying advanced reactor demonstration projects over addressing the shortage. The country has the technical capability to address the HALEU constraint, but a resourced program is needed to do so.

Recommendation D: *The current U.S. policy of using a once-through fuel cycle with the direct disposal of commercial spent nuclear fuel into a repository should continue for the foreseeable future. The once-through fuel cycle is the baseline, and any new fuel cycles should have advantages over that baseline for them to be deployed. However, so as not to preclude these options in the future, the U.S. Department of Energy (DOE) should continue fundamental studies to evaluate the feasibility of using recycling and transmutation for closing fuel cycles. Specifically, DOE should develop and implement a phased, long-range research and development program that focuses on advanced separations and transmutations technologies.*

We agree that the once-through fuel cycle will be the default for the United States in the near future. We also agree with the need for continued research and development on recycling, as we laid out in "The U.S. Nuclear R&D Imperative" report.

With that being said, ANS Position Statement 45, Nuclear Fuel Recycling, states "… continued research and development of nuclear fuel recycling without a policy and plan for deployment will not make the technology a practical reality." Thus, ANS favors (i) an energy policy and legal framework that addresses a comprehensive and sustainable program for the U.S. nuclear fuel cycle, which includes used fuel recycling and geologic disposal, and (ii) directed development of fuel recycle options in parallel with advanced nuclear reactor systems.

Recommendation G: Congress should establish a single-mission entity with responsibility for the management and disposal of nuclear wastes.

We agree with this recommendation, which is of course a long-standing recommendation of many organizations, including ANS (see ANS Position Statement 22, Creation of an Independent Entity to Manage U.S. Used Nuclear Fuel). We agree that the entity must have continuity of leadership and reliable access to funding. We note that the NASEM committee believes the entity should begin site selection immediately. We believe that key legal, regulatory, and social groundwork needs to be accomplished before a new repository site selection process should begin.

Recommendation I: *The principal agencies (U.S. Department of Energy, U.S. Nuclear Regulatory Commission, and U.S. Environmental Protection Agency) should initiate a coordinated effort to develop regulations and standards for a generic repository (i.e., not specific to Yucca Mountain) and new types of spent fuel and waste forms in order to support geologic disposal of new fuel types from advanced reactors. Developers of advanced nuclear reactors also need to anticipate the impact of new fuel types on their performance as a waste form in a geologic repository.*

ANS emphatically agrees with the recommendation to update the existing generic disposal standards. The recommendation dates back at least to the 2012 Report of the Blue Ribbon Commission on America's Nuclear Future. ANS echoed the recommendation in its 2020 Issue Brief "A Proposal for Progress on Nuclear Waste Management." On February 17, 2023 the ANS Special Committee on Generic Standards for Disposal of High-Level Radioactive Waste issued a draft report for comment with recommendations on generic disposal standards. It is hoped that the ANS report will spur the federal government to take action in this area. Note that the NASEM statement "… the regulatory framework in the United States is site specific" (p. 163) is not strictly correct, because both the Environmental Protection Agency and Nuclear Regulatory Commission have generic disposal regulations in place (40 CFR Part 191 and 10 CFR Part 60, respectively). However, the generic regulations are outdated,

unnecessarily challenging to apply, and in some aspects inconsistent with the current international state-of-the-practice.

Key Areas of Disagreement

Similar to the areas of agreement, lack of mention in this section does not indicate agreement on the part of the ad hoc committee with the NASEM finding or recommendation, rather that the ANS committee had no strong opinions or held differing opinions on the matter, or felt that the finding or recommendation was not a priority for further discussion.

General 1 – The report did not fully address its congressional mandate.

As stated in the Executive Summary, Public Law 166-94 and Public Law 116-260 "… mandated that the National Academies of Sciences, Engineering, and Medicine examine the merits and viability of different nuclear fuel cycle options, waste aspects of advanced reactors and their fuel cycles, and nonproliferation and security risks of these technologies." The report did little to address the first part of the charge: examine the merits and viability of different nuclear fuel cycle options.

It is increasingly evident that realizing a clean and secure energy future for the United States requires that nuclear energy play a significant role. Moreover, advanced reactors offer the potential for missions that go beyond standard electricity production that is accomplished ably by the country's fleet of 92 nuclear power reactors. Details are provided in ANS Position Statement 35, Advanced Reactors. However, the NASEM report makes scant mention of the merits and viability of different fuel cycle options. The potential benefits from nuclear power reactors in general as well as specific reactor types (e.g., baseline electricity production, capability to generate high-temperature process steam, security of fuel supply) go unmentioned. Instead, the report is primarily a catalog of problems to be surmounted.

General 2 – The report painted a far too negative picture of nuclear energy and its important role in meeting our country's current and future energy needs.

This observation goes hand-in-hand with the aforementioned concern that the report did not address its full mandate. ANS does not expect NASEM to engage in cheerleading for nuclear energy, but the tone of the report was quite negative and the report ignored positive aspects and accomplishments. Examples are provided below.

- Finding 4 leads with "Most of the advanced reactors, especially the non–light water reactors, will confront significant challenges in meeting commercial deployment by 2050." The implication of this repeated reference to 2050 deployment is that advanced reactors can make no near-term contribution to the near-term United States energy supply. That implication has no foundation in fact. The year 2050 is more than a quarter century in the future, and two demonstration advanced reactors are already proceeding toward deployment. Due to fuel supply issues and other constraints, they

may not meet their original 2027 target dates, but that is a far cry from 2050. In addition, NuScale, General Electric Hitachi, and Holtec small modular light water reactor projects are working apace toward deployment around the end of this decade. As with all disruptive technologies, none of these programs are assured of success, but there are others in the pipeline as well. The glass is not half-empty, it is far more than half-full, and we believe NASEM should acknowledge the promising, creative, and entrepreneurial developments underway in nuclear energy.

- The nuclear industry has a stellar record with the safe storage and transportation of radioactive materials, including spent nuclear fuel, that dates back for more than a half century. That important fact went unmentioned in Section 5.6.1 which addressed current status of storage and transportation. The report pointed out work that needs to be done in the area of storage and transportation for advanced reactors, but nowhere was it stated that the successful experience with storing and transporting both light water reactor fuels and research reactor fuels provides high confidence that existing and proven designs and capabilities will be modified as needed and successfully applied to new fuel types as well.
- Chapter 6 on nonproliferation implications and security risks was overwhelmingly and unjustifiably negative about the challenges raised by different fuel types. Once again, the committee failed to mention the excellent record of the light water reactor industry in these areas. The discussion of proliferation challenges posed by HALEU was particularly disappointing, as the report failed to recognize that any group seeking to steal or divert HALEU in order to make a nuclear weapon faces the same barriers that are currently presented by low enriched uranium. The fact that HALEU requires somewhat less additional enrichment to achieve assays typical of nuclear weapons pales in comparison to the overall steps required to successfully construct a nuclear weapon from raw HALEU (or raw LEU). This point is further discussed in ANS Position Paper 84, "Safeguards and Security for Advanced Reactors Using HALEU."
- The NASEM report addressed reprocessing and geologic disposal of TRISO fuel in Appendix G. The appendix glossed over the extensive data base for performance of TRISO fuel worldwide while citing a need to develop "… a broader understanding of the behavior of radionuclides in TRISO fuels during reactor operation … ." The report made no mention of the Advanced Gas Reactor Fuel Development and Qualification (AGR) Program conducted by U.S. national laboratories and industrial partners. The program began in 2002 and is now winding down. It also failed to mention the Electric Power Research Institute topical report "Uranium Oxycarbide (UCO) Tristructural Isotropic (TRISO) Coated Particle Fuel Performance: Topical Report EPRI-AR-1(NP)" or the associated Nuclear Regulatory Commission Safety Evaluation [see letter dated August

11, 2020, Segala (NRC) to Stover (EPRI)]. Instead, the appendix recited a litany of supposed "research needs" and altogether painted a distorted picture of the knowledge and experience base associated with TRISO fuel. It is unfortunate that the appendix only considered TRISO as a waste form and left the impression that, on balance, TRISO is a relatively unproven fuel and waste form. In reality, from many perspectives TRISO may be superior to ceramic uranium dioxide pellets clad in zirconium as a fuel and a waste form. Moreover, compared to other alternative fuels/waste forms, there is a relatively high state of knowledge about TRISO. Overall, the NASEM committee's discussion of the state of research and development on alternative fuels/waste forms is unbalanced.

The negative picture is particularly evident in the details of the report presented in Chapter Six as discussed below. Additional examples are noted in the attachment.

Chapter 6 – Nonproliferation and Security Risks

Overall, Chapter 6 projects a very pessimistic outlook on the proliferation risk associated with advanced reactors and their fuel cycles. The discussion is dominated by evaluations of material attractiveness drawn almost exclusively from one work by a single expert. That work's reduction of material attractiveness to a numerical figure-of-merit (FOM) is regarded as a gross over-simplification by many physical and social science scholars and practicing professionals working on international nuclear nonproliferation. It addresses only what is theoretically possible once enriched uranium or separated plutonium is acquired, while trivializing the technical challenges to weaponization of HALEU or plutonium containing a substantial quantity of even-numbered plutonium isotopes.

The discussion of both proliferation and security risk associated with advanced reactors focuses too heavily on HALEU. Several portions of the report make the proliferation risk associated with HALEU sound more profound than it is by deemphasizing or omitting relevant facts and even contesting established ones. The report neglects to explicitly acknowledge that HALEU is LEU according to IAEA's definition of significant quantity and its goals for timely detection of diversion, even though that definition is synopsized in the report itself. The report neglects to disclose that separative work to produce 90 percent enriched uranium is already reduced by more than a factor of 3 when natural uranium is enriched to 4.5 percent in uranium-235. It also attempts to argue, contrary to IAEA's definition, that HALEU is direct-use material because it has a finite critical mass, despite that mass being nearly 800 kg.

Recommendation O: The U.S. Nuclear Regulatory Commission should initiate a rulemaking to address the security and material accounting measures for high-assay low-enriched uranium (HALEU) and other attractive nuclear materials that may be present in advanced reactor fuel cycles.

ANS disagrees with this recommendation, which may be founded on an incomplete understanding of NRC regulations and the process for modifying them. The NRC regulation 10 CFR Part 73 already contains security requirements for the physical protection of HALEU; similarly, NRC regulation 10 CFR Part 74 already contains material control and accounting requirements for HALEU and the facilities that store or use it. The NRC is already undertaking a limited scope rulemaking for Part 73 and a comprehensive rulemaking for licensing new reactors (Part 53) which will in part cover advanced reactors that may use HALEU. NRC rulemaking is a laborious process and additional rulemaking should not be undertaken lightly. The NASEM committee did not identify specific shortcomings associated with the current regulations. Before launching into additional rulemaking, the scope and purpose of the effort must be well understood; open-ended rulemaking such as the NASEM committee is recommending is simply not a good idea. To the extent there are any gaps or shortcomings in the current regulatory framework, it will most likely be feasible to address them through regulatory guidance, which is generally quicker and less resource-intensive.

Findings and Recommendations Not Made

The ANS committee believes that the NASEM report should have included at least two additional recommendations, as discussed below.

Spent Fuel Disposal Contract for Advanced Reactors

The Standard Contract between DOE and nuclear power plant operators for waste disposal (and its amended version for new reactors) are based on light water reactor fuel and is not suitable, in its current form, for advanced non-LWRs. The need for an advanced reactor waste disposal contract was discussed at the NASEM committee's public meeting No. 9 on September 15, 2021 and its public meeting No. 12 on December 16, 2021. Given the desire to have at least two advanced reactors operational by the end of this decade, it is important that the contractual provisions for waste acceptance and disposal be established soon. The ANS ad hoc committee believes this issue should have been identified in the report and called out as a recommendation for timely action by DOE.

Rulemaking on Recycling

The current NRC regulatory framework for reprocessing facilities is 10 CFR Part 50, which is deterministic in nature and focused on light water reactor licensing; it would be extremely challenging to apply the regulation to a modern recycling facility should one be proposed. This large regulatory uncertainty is a significant barrier to advanced reactor fuel cycles that would include recycling. Beginning in the late 2000s the NRC did work evaluating

the issue, identifying 23 gaps in its regulations in SECY-09-0082.[1] In SECY-11-0163,[2] the NRC developed a draft regulatory basis that provided resolution paths for 17 of the 19 high- and moderate-priority gaps identified in SECY-09-0082 to support a future rulemaking. SECY-11-0163 stated

> The staff recognized that because 10 CFR Part 50 had evolved into a regulation specific to light-water reactors (LWRs), it would be difficult to modify this part into an effective and efficient regulation for a production facility that reprocessed SNF. Additionally, the materials utilization requirements in 10 CFR Part 70 do not address potential fission product hazards associated with SNF reprocessing. Thus, the staff envisioned that integrating applicable requirements from 10 CFR Part 50 and 10 CFR Part 70 into a new regulation (i.e., 10 CFR Part 7x) might best address the unique safety and design issues for commercial SNF reprocessing facilities.

Ultimately, however, the NRC declined to pursue rulemaking to establish a modern, technology-neutral, risk-informed, performance-based regulatory framework for reprocessing facilities. The ANS ad hoc committee recognizes that NRC rulemaking is a heavy lift but believes that in this instance the goal is well-defined and the investment in resources justified. If NRC waits until a workable, updated regulation is imminently needed, then it will be too late. ANS supports rulemaking to establish a modern, workable regulatory framework for reprocessing (see ANS letter dated May 28, 2020). While the NASEM report mentions the proposed NRC rulemaking (see Sections 2.5.1 and 3.3.4), it makes no recommendations on the point. ANS believes the NASEM recommendations should have addressed this point.

In conclusion, ANS appreciates the challenging task that was before the NASEM committee. We agree with many findings and recommendations in the report, but we have some significant areas of disagreement as well. Further, we suggest the report should have included additional recommendations on an advanced reactor spent fuel disposal contract and on a recycling rulemaking. We hope that these comments will be useful to NASEM in its ongoing and future work. We would be glad to discuss these matters further if desired by NASEM committee members or staff.

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[1] SECY-09-0082, Update on Reprocessing Regulatory Framework – Summary of Gap Analysis, Michael F. Weber, Director, Office of Nuclear Material Safety and Safeguards, May 28, 2009.
[2] SECY-11-0163, Reprocessing Rulemaking: Draft Regulatory Basis and Path Forward, Catherine Haney, Director, Office of Nuclear Material Safety and Safeguards, November 18, 2011.

Sincerely,

Dr. Steven Arndt
President
American Nuclear Society

Craig H. Piercy
Executive Director / CEO
American Nuclear Society

Attachment: Additional comments

cc: Ms. Janice Dunn Lee, Chair, Committee on Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors

Dr. Charles Ferguson, Staff Director, NASEM Nuclear and Radiation Studies Board

Attachment

Additional American Nuclear Society Ad Hoc Committee Comments on the National Academies of Science, Engineering, and Medicine Report "Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors" (2022)

No.	Location	Comments
1.	Summary p. 7	Recommendation A of the report encourages DOE to downselect to "a few promising technologies" for public support. There is certainly an appropriate role for public investment in advanced reactors (see 2021 ANS report "The U.S. Nuclear R&D Imperative"). However, a major strength of the U.S. is that it encourages innovation and competition and does not rely on government to decide outcomes. It is neither necessary nor desirable for DOE to pick winners and losers among advanced reactor designs. Also, there has been substantial private investment in advanced reactors and provisions in the 2022 Inflation Reduction Act should encourage further private investment. It is also noted that the selection criteria proposed by NASEM are narrow and, if applied to a downselect, should be revisited. For example, economic viability is not mentioned.
2.	Summary p. 9	Finding 9 argues for a holistic treatment of the fuel cycle rather than addressing reactor considerations only. The finding is largely correct, but it should not be inferred that fuel cycle safety is a concern. The U.S. has a robust and conservative regulatory structure for fuel cycle facilities. The implication that advanced reactor developers are deficient for focusing primarily on reactor operation at this time is naïve. It is not possible to do everything at once – something has to come first, and that is the logical progression. The reactor needs to be designed to understand what the form, quantity, and periodicity of the "waste" or used fuel that will be produced. Moreover, it is incorrect to imply that advanced reactor developers are ignoring addressing issues related to storage and transportation for their used nuclear fuel. As a side comment, ANS would like to see other technologies, including renewable energy, also held to the standard of considering the range of impacts (e.g., mining waste, disposal costs, and opportunity costs of extensive land usage).

No.	Location	Comments
3.	Summary p. 9	Recommendation E states “Congress and the U.S. Department of Energy should incentivize safety improvements across the supporting fuel cycle.” This is a badly worded recommendation and it presupposes that safety is not currently adequate. In fact, the U.S. nuclear power industry has a stellar safety record, including fuel cycle facilities. There is no basis for the implication that current nuclear fuel cycle facility safety is currently deficient, and there is no baseline for advanced reactor fuel cycle facilities from which to require “safety improvements.”
4.	Summary p. 10	Finding 11 cites six reasons for the failure of the U.S. program to dispose of used nuclear fuel and high-level radioactive waste. However, the NASEM committee does not include the primary cause for failure: the U.S. government (executive and legislative branches) chose not to implement the policy that it enacted in the Nuclear Waste Policy Act, as amended. One may argue that the policy was flawed, but the reason it failed is that it ultimately was not pursued. When the government refuses to carry out its own laws, there is no possibility of success. In fact, the program did achieve notable successes and was on the way to receiving regulatory approval for construction of a repository when the federal government discontinued work on it. Reason (2), a “slowly developing and changing regulatory framework,” was indeed a challenge for the program, but it did not contribute significantly to program failure. Reason (6), “insufficient public engagement in decisions concerning the basic strategy for the storage and disposal of the waste,” is at best arguable. Note that the public in the vicinity of the proposed Yucca Mountain repository supported the project, and the public in the state of Nevada did not rise up en masse to oppose the project.
5.	Summary p. 11	Recommendation H advocates for the implementer of the nuclear waste management and disposal program to support research and development on advanced reactor waste disposal and related matters. Such research is needed, but the implementing entity should focus on “here and now” used fuel that requires disposition. Responsibility for implementation of the waste program should be moved out of DOE, but DOE should retain responsibility for disposal research and development, particularly for fuel that does not yet exist.

No.	Location	Comments
6.	pp. 11, 75-76, 129-132	ANS agrees that radiotoxicity is "a poor metric for repository performance and risk to the public from waste disposal" [see Finding 13, p. 11]. However, there are several instances throughout the report in which radiotoxicity is used by the NAS Committee to either make or support Committee conclusions. For example, in Sections 3.2.5.3 (pp. 75-76) and 3.2.5.4 (p. 76), the Committee makes nearly exclusive use of radiotoxicity arguments in four publications (especially Piet (2013)) to conclude that the radiological hazard of the thorium/uranium cycle is no lower than that of the uranium/plutonium cycle.
7.	Summary p. 13	Recommendation L seems to imply that DOE should perform criticality, thermal, and shielding assessments of storage and transportation systems. That work is typically the responsibility of the storage and/or transportation system designer, not DOE. The recommendation should be clarified.
8.	Summary p. 13	Recommendation K states "The U.S. Department of Energy (DOE) should require advanced reactor developers that receive DOE funding to work with designers of storage and transportation concepts to mitigate potential fuel cycle disconnects caused by suboptimized designs that satisfy only one operational aspect of the back end of the fuel cycle (e.g., storage, transportation, or disposal)." This recommendation is ill-defined, open-ended and therefore impossible to carry out. "Potential fuel cycle disconnects" are subjective, as is acceptable mitigation, particularly early in the design process. DOE should not be levying ill-defined requirements as a precondition for funding that is necessary for advanced reactor research and development. Moreover, advanced reactor developers are not blithely ignoring back end issues. Established storage and transportation companies are currently supporting a number of advanced reactor developers.

No.	Location	Comments
9.	Box 2.1 p. 41	Box 2.1 begins with the sentence "To illustrate the impact of monorecycling on the buildup of Pu isotopes and two important minor actinides, ^{241}Am and ^{244}Cm, assume that seven spent pressurized water reactor (PWR) uranium oxide (UOX) fuel assemblies are reprocessed to recover enough Pu to fabricate one new PWR-MOX (mixed oxide) assembly with an initial Pu content of ~8.65 percent." However, the table in this box clearly shows a net reduction in the overall Pu content in the MOX fuel (27.6% decrease per the table), for four out of five Pu isotopes (with the non-fissile isotope ^{242}Pu increasing). Both fissile isotopes, ^{239}Pu and ^{241}Pu, have a 41.4% decrease per the table. The only "buildup" is of the minor actinides and the ^{242}Pu. Thus, the lead-in sentence for Box 2.1 incorrectly states a buildup of Pu where there is actually a reduction – and a quite significant one for fissile Pu. At a bare minimum, the word "buildup" in this first sentence should have been "reduction/buildup" to reflect the actual benefits of monorecycling in reducing the Pu inventory.
10.	Section 2.3.2.2 p. 41 1st ¶ under box	Identifying "reprocessed uranium" as a waste stream is disingenuous and instead should at the very least be neutrally addressed or better yet, identified as a resource, especially for future generations when uranium ore may not be so plentiful or cheap to mine as today. This is the approach generally taken in France, though some enriched reprocessed uranium has already been used in PWRs.
11.	Section 2.3.2.2 p. 41 2nd ¶ under box	The first sentence states "… spent MOX fuel management must take into account decay heat, potential criticality safety, and radiation source terms. These additional considerations are required because the decay heat generation of spent LWR-MOX decreases more slowly than that of spent uranium oxide (see Figure 2.2)." First of all, spent UOX must take those very same considerations (decay heat, potential criticality safety, and radiation source terms) into consideration, so they are not "additional considerations." Second, the rate of decrease of decay heat has nothing to do with criticality safety. Third, the paragraph compares one spent MOX fuel assembly to one spent UOX fuel assembly, when in fact it should consider the bigger picture. For example, the higher decay heat from one spent MOX assembly will still be less than the decay heat produced from 7 spent UOX assemblies recycled to produce the MOX assembly. Furthermore, the decreased fissile Pu inventory in the spent MOX assembly over the 7 UOX assemblies improves criticality margins. Overall, this paragraph paints an overly negative picture of spent MOX fuel.

No.	Location	Comments
12.	Section 2.3.2.2 pp. 41-42 3rd ¶ under box	The first sentence of the third paragraph states: "As discussed above, monorecycling of the plutonium recovered from spent LWR fuel by reprocessing has been implemented to avoid the economic penalties associated with storage of the extracted plutonium." This conclusion about the motivation for monorecyling is not justified by the information in the report, it is not attributed to any responsible authority, and it is wrong. Monorecycling has generally been implemented to reuse a valuable resource, especially in countries with little to no natural uranium resource (or oil and/or coal resources). There are many economic considerations associated with fuel cycle choices, such as the cost of storing used UOX fuel assemblies at dozens of different sites around the country and the ultimate cost of a repository on a "per assembly" basis. The economics are not as simple as is implied in the NASEM report.
13.	Section 5.2 pp. 149-150	The discussion of the waste management situation in the U.S. is incomplete. No mention is made of naval reactor fuel, research reactor and university reactor fuel, or commercial reprocessing waste at West Valley, NY.
14.	Section 5.2.2 p. 152	The report states "… the de facto U.S. strategy for dealing with commercially generated spent nuclear fuel is the possibility of consolidated, interim to indefinite storage." That statement is not correct. The de facto U.S. strategy is obviously indefinite onsite storage, which has been ongoing for many decades. The ability to begin a program of consolidated interim storage, in the absence of a repository program and in light of state opposition to both proposed consolidated storage facilities in the U.S., is questionable.
15.	Section 6.3.2 pp. 207-209	The report is very pessimistic about pebble bed reactors because monitoring their fuel depletion online will present new technical challenges – implying those challenges are insurmountable. They are not. The report could have recommended investments in research and development for online monitoring technologies but for some reason chose not to make that recommendation. Given the level of concern expressed in the NASEM report, this lack of any recommendation for additional work seems puzzling. It should be noted that while the ANS ad hoc committee acknowledges the material accountancy challenges associated with some advanced reactor fuel cycles, we believe they can be surmounted. The nuclear industry has many years of successful experience in the area, including successful application of material accountancy at industrial-scale reprocessing facilities.

No.	Location	Comments
16.	Section 6.3.2.1 p. 209	The first paragraph states that "… all isotopic mixtures of plutonium, except those with 80 percent or more plutonium 238, may be attractive to some degree for nuclear weapons." The reality, of course, is the adverse isotopics is a real disincentive to theft or diversion of plutonium. There is a reason why countries went to a lot of trouble and expense to produce weapons grade plutonium for use in weapons. It is already very difficult to fashion a nuclear weapon; starting with isotopically degraded plutonium makes it even less likely that the weapon would actually function. The idea that an entity, particularly a subnational group or non-weapon state, would successfully fashion a nuclear weapon out of plutonium that is 79 percent Pu-238 is rather low on the list of proliferation threats.
17.	Section 6.3.2.1 p. 209	The second paragraph is dismissive of the point that TRISO fuel would be difficult to reprocess and therefore has increased proliferation resistance relative to other fuel forms. It is a valid point, and it is not clear why the Committee is reluctant to credit the point (or for that matter, the point that high burnup leads to undesirable isotopics that makes nuclear material less attractive for theft or diversion).
18.	Section 6.3.3 pp. 210-213	Similar to an earlier comment on pebble bed reactors, the report is very pessimistic about molten salt reactors because monitoring their fuel depletion online will present new technical challenges – implying those challenges are insurmountable. They are not. The report could have recommended investments in research and development for online monitoring technologies but for some reason chose not to make that recommendation. Given the level of concern expressed in the NASEM report, this lack of any recommendation seems puzzling. It should be noted that while the ANS ad hoc committee acknowledges the material accountancy challenges associated with some advanced reactor fuel cycles, we believe they can be surmounted. The nuclear industry has many years of successful experience in the area, including successful application of material accountancy at industrial-scale reprocessing facilities.
19.	Section 6.3.3 pp. 210-211	The section notes that molten salt-fueled reactors can be considered bulk-handling facilities similar to reprocessing plants. However, nowhere does the report acknowledge that there are decades of successful experience with material accounting at industrial-scale reprocessing plants. This is another example of the inappropriately pessimistic tone of Chapter 6 of the report.

No.	Location	Comments
20.	Section 6.3.4.1 pp. 214-215	The section is inappropriately pessimistic about the threat posed by the direct use of HALEU in a nuclear weapon. The very large size of a theoretical HALEU weapon, coupled with the fact that one has never been tried, much less successfully used, makes it clear that the IAEA is correct to classify HALEU as an indirect-use material. Belaboring HALEU concerns exacerbates the unnecessarily negative tone of the body of the report on proliferation issues.
21.	Section 6.3.4.3 pp. 216-217	The discussion about further enrichment of HALEU to high enriched uranium (HEU) is entirely inapplicable to use of HALEU in the United States (a weapons state). It would only be an issue for a non-weapons state. However, Section 6.3.4.3 does not make that point. It is another example of how the text of the report paints an unduly negative picture of advanced reactor proliferation issues.
22.	Section 6.3.5 pp. 219-220	The report places undue emphasis on the proliferation risks associated with reprocessing and recycling. It does not give appropriate weight to the fact that reprocessing and recycling has been carried out (and continues to be carried out) on an industrial scale in multiple countries - and has never resulted in proliferation of weapons-usable material. This important fact should, at a minimum, be acknowledged.