FACING THE REALITY OF INDEFINITE STORAGE: WHAT DOES IT MEAN?

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Abstract

The paper encourages not only acknowledging but pro-actively addressing the issues and opportunities resulting from the uncertainty relative to how and when sufficient repository capacity becomes available. It draws on the work of a former IAEA consultancy tasked with addressing very long-term storage of spent nuclear fuel (SNF) as well as current strategic planning and associated initiatives within the U.S. Department of Energy to address the uncertainty in spent fuel management. The paper advocates addressing this uncertainty by design rather than by default. Approaches are suggested for rethinking the basis of spent nuclear fuel storage equipment, facilities, regulatory framework, and communication strategies to acknowledge and proactively address uncertainty relative to the storage duration and the end state of spent nuclear fuel.

1. LOOKING BACK

A look back over a relatively brief 75 years to the beginnings of the nuclear industry offers several valuable lessons that should guide present and future choices. Notably, hopes expressed in phrases like “too cheap to meter [1]” and “the price of nuclear fuels being so low that only hydroelectric power, which is produced without any cost for fuel could compete with it [2]” have not been realized. In context of an era when “Miss Atomic Bomb” and other nuclear-themed showgirls were Las Vegas attractions [3], atomic science kits were marketed to children, and the Ford Motor Company invested heavily in not just one but two concept cars to be powered by an on-board reactor [4], these predictions did not seem too far-fetched. **Nonetheless, these and other hopeful predictions of a bright nuclear future that seemed reasonable at the time are now generally viewed as having damaged the credibility of the industry.**

The early optimism for the future was not without apprehension. The rapid advance in the technology was focused on the race to produce nuclear weapons. The world’s introduction to the unimaginable energy density of a nuclear fuel was in the context of war, with the explosions of the first atomic bombs over Japan. Recognizing the potential dangers of the proliferation of this technology for military and other non-peaceful uses, the “Atoms for Peace” program proposed another vision: the peaceful controlled distribution of nuclear technology to all countries of the world. In exchange for this potentially life-changing knowledge, countries would agree not to pursue atomic weapons [5]. From this vision, the IAEA was established to encourage international cooperation in channelling this power towards peaceful uses. In the enthusiasm that ensued, nuclear technology was shared freely with many countries, the commercial power reactor industry began to flourish, and the United States Atomic Energy Commission predicted that, by the turn of the Twenty-First Century, one thousand reactors would be producing electricity for homes and businesses in the USA alone [6]. Unfortunately, the nuclear arms race continued, and reactor accidents such as those at Three Mile Island and Chernobyl had additional negative impacts on a public with growing concerns. Reactor construction costs rose sharply and orders dropped. In a period just over 30 years, the early dramatic rise of nuclear power went into an equally meteoric reverse [7]. **The envisioned nuclear future did not come to pass.**

Nonetheless, over 100 reactors were constructed in the U.S., all of which began construction prior to 1977. These reactors have provided nearly 20% of U.S. electrical production for the past several decades [8].

However, implementation of policy for the management of the spent nuclear fuel (SNF) resulting from reactor operations has proven to be problematic. Early efforts to establish a commercial reprocessing capability in the U.S. have been abandoned as a result of both economic and political concerns. A plant at West Valley, New York, was operated successfully from 1966 to 1972. However, escalating regulations required plant modifications that were deemed uneconomic. A plant built at Morris, Illinois was declared inoperable in 1974 after new technology that, although proven on a pilot scale, failed to work successfully in the production plant. A third plant at Barnwell, South Carolina, was aborted due to a 1977 change in government policy that ruled out all U.S. civilian reprocessing as one facet of U.S. non-proliferation policy [9].

Further, the Nuclear Waste Policy Act of 1982 directed the United States Department of Energy (DOE) to identify a deep geologic repository for disposal of SNF and high-level waste (HLW) and to take custody of SNF from commercial reactors beginning in January 1998. This did not occur, and in 2010, with over $15.4 billion invested and a license application under review by the Nuclear Regulatory Commission, the DOE decided to terminate the Yucca Mountain repository program because, according to DOE officials, it was not a workable option and there were better solutions that could achieve a broader national consensus. DOE did not cite technical or safety issues [10]. Notably, the NRC was directed to complete its review in 2013 and in 2015 reported that the application satisfied nearly all of its regulations. Also, in 2015, DOE announced plans to build two repositories, one for most of the nation's defense-related radioactive waste and another for commercial SNF and residual defense waste. In 2016, the National Defense Authorization Act denied funds for a defense-only repository. The social and political opposition to a permanent repository, not the technical issues, have proven to be the key obstacle to moving forward with a repository [11]. **Once again, the future did not unfold as predicted – and future prospects for permanent disposal remain unclear.** Amidst this uncertainty, several states have implemented restrictions on the construction of new nuclear power plants [12].

2. LESSONS LEARNED

Looking back, the key lesson seems to be that the nuclear industry has not been well served by building policies and infrastructure around what seemed, at the time, like a reasonable prediction of the future. The path taken has resulted in costly missteps and changes in direction. But, perhaps more importantly, the unrealized expectations have damaged the trust of key stakeholders who were led to believe that a final solution would be in place long before now.

National policy must be decided and implemented before SNF (and HLW) in storage can begin moving to reprocessing or disposal. Given the political challenges that have been experienced in siting a repository coupled with the relatively low near-term costs and risks associated with continued storage, it is likely that SNF will remain in storage much longer than originally envisioned, perhaps many decades or longer. Acknowledging this fact suggests a new framework for planning, design, operation, and regulation of SNF storage (SFS) and associated systems [13].

Past planning and infrastructure for management of spent fuel was based largely on a presumed future that has not occurred – at least not within the timeframes expected. Because a decision taken today could foreclose a transition to another step tomorrow, one of the main challenges is to maintain enough flexibility to accommodate the range of potential future options for the management of spent fuel given the current uncertainties regarding storage duration, future technologies, and future financial, regulatory, and political conditions [14].

Accepting and accommodating uncertainty invokes a need to explore potential future scenarios with the objective of developing robust facility and equipment designs as well as regulatory strategies that perform acceptably not just for the predicted future but under a broad range of potential futures. Indefinite storage is a future scenario that should be considered. The term indefinite is not intended to mean "forever." It simply means that storage durations cannot be defined with certainty. Although indefinite storage has generally not been considered acceptable, the fact is that, due to the dependency on unpredictable future events, storage durations are unknown. Openly discussing this reality has proven controversial, largely because it is not consistent with existing expectations.

In hindsight, the presumption that one must know the future to effectively manage spent fuel was neither reasonable nor necessary (nor even possible). Until available disposal and reprocessing capacity exceed the rate of spent fuel generation, spent fuel inventories and average storage times will continue to grow.. It is important

to recognize that neither increasing SNF inventories nor longer storage times necessarily pose an unacceptable situation. Spent fuel storage systems and equipment can be monitored, maintained, and retired and replaced when deemed appropriate. This is not unlike the way the airline industry; buildings, bridges, and roads; and other major capital equipment are presently managed. Further, once this is recognized and accepted, spent fuel storage facilities and systems can be sited and designed to facilitate this.

Managed Options for re-use of spent fuel are preserved at relatively low cost while in storage. Preservation of options for future fuel cycle choices has been undervalued in the debate about fuel cycle policy. SNF can be safely stored at reactor sites, centralized storage facilities, or geological repositories designed for retrievability (an alternative form of centralized storage) [15].

Storage of SNF, for as long as it takes until society selects and implements an end state, need not be considered unmanageable nor unsustainable. Consider that the ~80,000 tonnes of SNF generated by the U.S. more than any other country, would fill a U.S. football field (i.e., 49m × 110m) about 20 meters deep[1] [11]. Contrast this with a block of coal 1,560 kilometers high on that same field to produce the energy equivalent[2]. It should be noted that, when burned, coal is converted to solid waste in the form of ash or gaseous waste in the form of emissions.

The intense energy density of nuclear fuel can be considered an asset not only because it drastically reduces CO_2 and other greenhouse gas emissions relative to energy from fossil fuels but also because it enables its by-products to be contained in a manageable volume rather than dispersed into the environment. SNF is considered as an asset rather than a waste in some countries today and, as technologies evolve, future generations may use it to fuel advanced nuclear fuel cycles or may find other beneficial applications for this nuclear material. This, along with an enviable record of safe storage and transport, is contributing to an emerging paradigm for spent fuel management that is based on preserving flexibility while ensuring safety and security and without foreclosing options or passing an undue burden to future generations.

3. LOOKING FORWARD

The nuclear community is now faced with an opportunity stemming from the recognition that SNF disposal solutions are likely decades or more away – coupled with a concurrent recognition that nuclear power can play a substantive role in addressing pressing environmental and societal needs. Figure 1 below, based on information from the 2018 edition of the IAEA's energy estimates through 2050 [16], projects that nuclear power generation could range from a decline of ~10% to an increase of ~90% over the next 30 years.

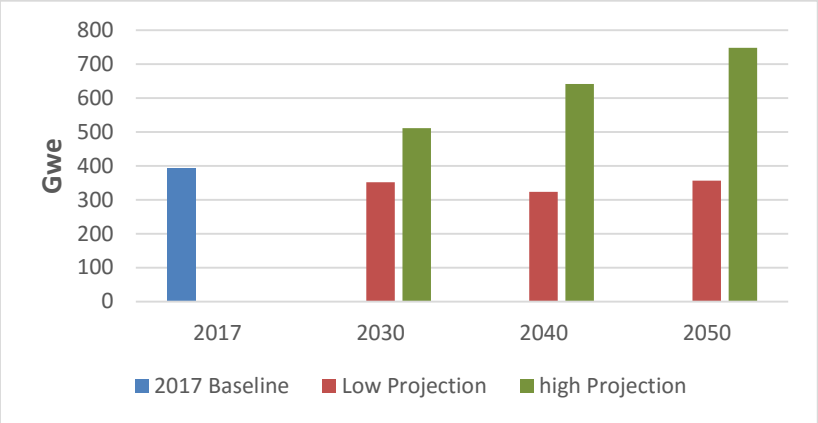

FIG. 1. World Nuclear Electricity Projections.

[1]Comparing this estimate of 20 meters deep with a former GAO estimate of a football field 15 feet deep based on 65,000 tonnes leads one to believe that 80,0000 tonnes would fill the football field only 20 feet (~6 meters) rather than 20 meters deep. This has been independently confirmed by the author.

[2] Based on 45GWD energy per metric tonne SNF and 1E6 BTU energy per cubic foot of coal. Note that when burned, coal is converted to solid waste in the form of ash and gaseous waste in the form of emissions.

With a significant amount of SNF currently in storage, no SNF disposal facilities presently available, and world-wide reprocessing capacity well below current the rate at which SNF is being generated, even the low projection can be expected to result in increasing SNF inventories along with the attending increase in storage durations. Figure 2, based on information from Table A-14 of [17] summarizes the current projections for the status of SNF inventories from 13 countries.

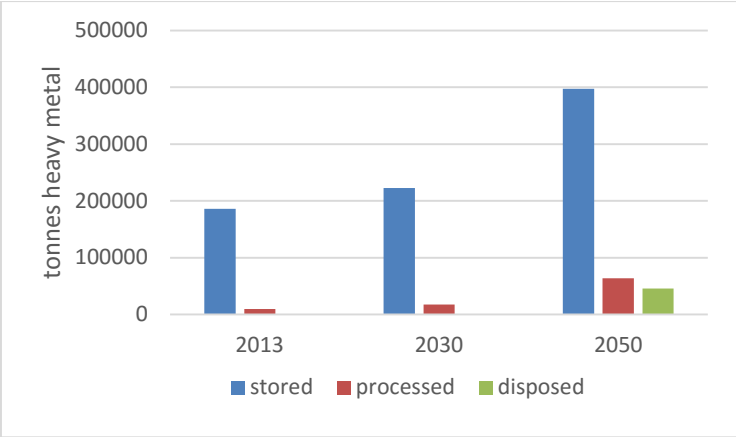

FIG. 2. Spent fuel inventory projections.

The high projections for the nuclear energy contribution would be expected to further increase inventories and storage durations. Interestingly, the high projection presumes that nuclear energy maintains only a constant ~5.7% share of a total energy market that grows by ~90%. This is significant because growth in the nuclear market share should also not be ruled out. History confirms that public attitudes toward nuclear can swing substantially in relatively short periods. Additionally, past projections of energy needs and the energy mix have not been particularly good at matching future reality. Much could change in the energy landscape as the third world develops, the transportation sector is electrified, and environmental and climate impacts are better understood.

Nuclear energy could play a significant role in addressing one of the key challenges facing the twenty-first century – dramatically reducing emissions of greenhouse gases while simultaneously expanding energy access and economic opportunity to billions of people. Without a substantial contribution from nuclear energy, the costs of achieving the necessary deep decarbonization of electricity increase significantly [18]. In other words, it is plausible that the nuclear future may not unfold as currently predicted and that nuclear energy could grow significantly, with a corresponding increase in spent fuel generation rates. Like past projections that proved overly optimistic, resulting in unrealized expectations and costly missteps, the future may also disprove our current pessimistic projections relative to the future the role of nuclear energy. The nuclear industry will be well-served to acknowledge and plan for uncertainty.

4. EMBRACING UNCERTAINTY

Accommodating storage periods of unknown duration can be incorporated into design, planning, and regulatory requirements. Accepting uncertainty as a reality that must be accommodated is an empowering and overdue concept that opens new possibilities. Several initiatives have been undertaken in recent years that acknowledge and aim to address this uncertainty. A brief summary of some of these initiatives is provided below.

4.1. International Atomic Energy Agency

An IAEA consultancy tasked with considering very long-term storage (e.g., greater than 100 years) considered how spent fuel storage infrastructure could be adapted to address the uncertain storage periods that will be necessary until an acceptable end point is achieved. Key concepts from their recently issued report are summarized below [13, 19]:

4.1.1. Design of future SNF storage systems

Much of the past and current effort related to extending SNF storage has focused on developing the technical basis for ensuring that existing SNF, packaging components, and related safety-significant structures, systems, and components (SSCs) will continue to perform their credited safety functions during extended storage. This is a necessary activity for extending the storage periods of existing facilities. However, because the vast majority of storage systems and facilities for the SNF that will require storage have not yet been designed or built, there are opportunities to include up-front design and functional requirements to accommodate the uncertainties of future spent fuel storage.

Future spent fuel storage (SFS) facilities and packages should consider designs that facilitate extending storage and that could adapt to different safety strategies. Adaptability will be necessary to address changing conditions, regulations, and societal values, which may occur over extended storage periods. Although these design considerations may result in increased up-front investment, the lifecycle costs may be lower than more traditional approaches that presume static conditions over the SFS facility lifetime.

SFS systems designed to accommodate extended storage must contemplate a broader range of scenarios that could occur over the longer time period. These include the potential for increased magnitude and likelihood of challenges due to natural phenomena, the accrued effects of aging, and the impacts of changing societal values and policies. Designs for extended SFS should consider increased safety margins to accommodate the potentially broader range of conditions that may be encountered during extended storage.

To ensure that safety is maintained as storage periods are extended, evaluation of the cumulative effects of both physical aging and equipment obsolescence must be an ongoing activity. Monitoring and inspection systems should consider advanced surveillance and non-destructive examination techniques to monitor storage conditions and support aging management through both preventive and predictive maintenance. Designs for SNF storage facilities, equipment, and packaging should consider the possibility that SNF, and/or its packaging, may require remediation to ensure safe post-storage transportability and/or to ensure compatibility with future SNF management steps. Hence, SFS facilities should be able to maintain, confirm, and, if needed, restore transportability.

4.1.2. SFS packaging considerations

Until an end state is identified and implemented, uncertainty will remain with respect to the optimum design for the packaging and disposal container, as well as for the acceptance criteria for the contained waste form. In the meantime, packaging alternatives should be evaluated to select a storage strategy that can be sustained over extended storage periods while maintaining flexibility and adaptability to accommodate a broad range of plausible future scenarios.

For fuel that is packaged prior to storage, a robust strategy may be to assume that repackaging will eventually be necessary and to design packaging and operational strategies accordingly. An approach that plans for periodic repackaging can (1) provide a basis for cost planning; (2) enable periodic inspection to confirm compliance with performance requirements; and (3) allow for renewal and updating of SNF packaging components and monitoring equipment. This approach also allows one to capitalize on new technologies and to address new or changed requirements. However, repackaging can add risk, cost, and personnel exposure and also generates additional radiological waste.

The alternative to packaging prior to storage is to store SNF as bare assemblies. Bare SNF can be stored in pools or in dry vaults that provide shielding and other necessary safety features. Pool or vault storage systems will require a larger initial investment and likely larger operational and maintenance costs associated with increased reliance on active systems for safety and security. However, advantages include the relative ease of access for monitoring and inspection throughout the storage period, the benefit of additional cooling time prior to packaging, the ability to capitalize on future packaging technologies and materials, and a “fresh” package for post-storage transport and handling that can be optimized for future storage concepts, criteria, and requirements. Additionally, storing bare SNF for future packaging as is done in the CLAB facility in Sweden allows repository design and selection to proceed without being constrained or influenced by decisions related to SNF packaging.

4.1.3. Regulatory considerations

Aging management and storage systems should be considered holistically by regulators, industry, and research institutions. The need for periodic license extensions should be considered and built into regulations and associated guidance to ensure that the aging management process both manages degradation and produces the information needed to demonstrate the safety of continued storage for successive licensing periods. Effective implementation of this approach can ensure compliance with requirements for as long as may be necessary.

Risk analyses provide a better understanding of the probability and consequence of specific age-related failures, which may offer insights and alternative approaches for ensuring safety. For example, some SFS safety functions are often allocated to SNF cladding, which helps to confine radiological materials and maintain the geometry of the SNF. Cladding integrity is difficult to inspect and not practical to repair or replace. For extended storage periods, safety strategies should consider shifting safety functions to packaging or facility components that can be more readily monitored and inspected and, if needed, repaired or replaced.

Performance-based approaches establish requirements based on satisfying specified performance criteria without explicitly prescribing the methods for meeting the criteria. By focusing on assuring safe conditions while leaving flexibility to the licensee as to the means of meeting established safety criteria, performance-based regulation can provide the flexibility to accommodate uncertainties such as undefined storage durations and evolving technologies and policies.

Effective use of both risk-informed and performance-based approaches will encourage development of new technologies and/or more effective approaches for addressing uncertainties associated with the need for SFS license extensions and for ensuring long-term SFS safety.

4.1.4. Policy and public confidence

Delaying a final solution will result in escalating SNF inventories and management costs – making it progressively more difficult to commit resources toward reaching an end state. Delays in reaching an end state, as well as growing SNF inventories, will also negatively impact public confidence that is necessary for moving forward with lasting solutions. Therefore, a strong caution is given that policies relying on extending SNF storage, though presently necessary, be managed to ensure that commitment to achieving a sustainable solution is maintained.

4.2. U.S. Nuclear Regulatory Commission

In recognition of the uncertainty of the timing of repository availability, the U.S. NRC has prepared a generic environmental impact statement that evaluates potential environmental impacts of continued storage of commercial spent fuel over three possible timeframes: a short-term timeframe, which includes 60 years of continued storage after the end of a reactor's licensed life for operation (~100 years storage); an additional 100-year timeframe to address the potential for delay in repository availability; and a third, indefinite timeframe to address the possibility that a repository never becomes available. The results of this assessment confirm that the environmental impacts are relatively insensitive to the storage duration and that “small” impacts are possible under all three scenarios [20].

The NRC has also revised its interim staff guidance (ISG) on fuel retrievability during spent fuel storage. The former guidance, developed when a repository was expected to be operating in the near future, required that individual fuel assemblies remain retrievable during storage. Because the duration of spent fuel storage remains uncertain, the staff re-assessed the regulatory necessity of maintaining the ability to handle an individual fuel assembly. Based on the re-assessment, a new revision to ISG-2 [21] was issued which allows retrieval of SNF from storage by one or more of the following methods:

— Individual or canned spent fuel assemblies from wet or dry storage;
— A canister loaded with spent fuel assemblies from a storage cask or overpack;
— A cask loaded with spent fuel assemblies from the storage location.

NRC staff recommended that this definition of retrieval, which accommodates degradation of the SNF if safety functions are maintained, be incorporated into several other NUREGs related to spent fuel storage.

In 2016, the NRC also revised NUREG-1927 [22]. A key objective of this revisions was to expand guidance for aging management programs (AMPs) and to ensure the response to operating experience remains adequate throughout the period of extended operation (i.e., learning AMPs). The NRC has also prepared a draft NUREG-2214, "Managing Aging Processes in Storage (MAPS) Report." The MAPS Report evaluates aging mechanisms that have the potential to challenge the ability of dry storage system components to fulfil their important-to-safety functions and provides acceptable methods to identify and manage their effects. The MAPS Report also describes acceptable generic AMPs that an applicant may use to maintain the approved design basis of its storage system [23].

4.3. U.S. Department of Energy

The U.S. DOE currently manages over 200,000 SNF pieces or assemblies from various experimental, research, and production reactors that have been designed and operated over the past ~80 years. To acknowledge and address the uncertainty relative to storage durations for its SNF, the U.S. DOE is preparing a strategy that specifically considers aspects related to SNF management that may have changed since former decisions were made [24]. One of the six identified strategic goals is focused on accounting for uncertainty in the timing and availability of a path forward. A key guiding principle for developing the strategy is to maintain flexibility needed to accommodate and/or to capitalize as circumstances evolve. Specific examples include:

- Recognize the challenges and opportunities associated with the need to plan for indefinite storage;
- Acknowledge the potential impacts of evolving circumstances (e.g., new technologies, societal values, etc.) relative to SNF management strategies;
- Allow for variations in disposition pathways to account for multiple outcomes (e.g., different repository concepts, processing, continued storage, etc.);
- Avoid needlessly surrendering options.

There is a high degree of uncertainty associated with the availability dates for any large, complex industrial facility. This is particularly true with respect to nuclear facilities, given the technical challenges and institutional concerns that must be accommodated before such facilities can be constructed and operated. Identifying a disposition path is only a first step. Considerable uncertainty will remain until the end state facility, e.g., repository, and all intermediate supporting facilities and infrastructure are operating with sufficient capacity. The plan recognizes the uncertainty relative to the timing and availability of facilities and supporting infrastructure for achieving an SNF end state and incorporates that uncertainty into planning. Two specific strategies for addressing uncertainty include (1) development and use of a standard canister and (2) a plan for transitioning all SNF, except that planned for processing, to a road-ready dry storage configuration.

By relying on safety features that can be designed, engineered, and tested to current requirements rather than on SNF properties that may have large margins of uncertainty, the standard canister increases the safety and surety of operations while enabling risks to be better quantified and managed. This approach also minimizes radiological wastes and personnel exposure associated with characterization of DOE SNF. Because the sealed canister provides the credited safety features and essentially becomes the waste form, there is significant tolerance for the condition and properties of the contained SNF. This applies to both the SNF as initially placed and to its degradation behavior over indefinite storage periods. In other words, the safety case is insensitive to the condition of the SNF within the canister or its degradation mechanisms as long as they do not jeopardize the integrity of the canister itself.

Many DOE SNFs are currently stored in aging facilities in a variety of wet and dry storage configurations. In many cases, facility throughput and equipment constraints will pose challenges for transitioning to newer packaging in a timely manner. Hence, the DOE is evaluating the paths and associated needs for moving all DOE SNF to a road-ready dry storage configuration. The objective is to be able to ensure safe storage for as long as may be necessary while substantially reducing maintenance and operations costs and being prepared to capitalize on any opportunities to move the fuel to a consolidated interim storage or a disposal facility at the first opportunity.

5. INDEFINITE STORAGE – WHAT DOES IT MEAN?

Increasing storage durations and inventories for spent nuclear fuel are a reality. As illustrated above, governments are recognizing and adapting their guidance and strategies to address this reality. Industry is also responding with additional research and testing; new storage concepts, equipment, and facilities [25, 26, 27], as well as guidance and support for safely extending storage within existing equipment and facilities [28]. However, the necessary technical and regulatory solutions are unlikely to be enough to clear the path for nuclear to play a vital role as a large-scale, low-carbon energy source[3]. Discrimination against nuclear as a low-carbon energy source is not rooted in technical issues. Rather, it is primarily rooted in public attitudes, which translate into discriminatory public policies [17]. As with past efforts to effectively manage and dispose of spent fuel, social and political opposition, not technical issues, will likely continue to be the key obstacle.

Failure to achieve sufficient public acceptance has been a persistent source of difficulties, delays, and challenges to maintaining the political will needed for successful siting and licensing not only a repository for final disposal of SNF and HLW but also for other facilities needed for effective spent fuel storage and management. This is a key factor in missed commitments and continued difficulty making substantive progress, which reinforces risk perceptions and further erodes public confidence that the nuclear waste problem can be solved. This, in turn, increases both the quantity of SNF and the duration of SFS, while further increasing the challenges associated with siting and licensing SFS facilities.

This circular effect is illustrated in the lower loop of the figure below, which shows that a lack of public confidence and political will to address the problem can complete a feedback loop that aggravates the original problem – further impeding a lasting solution. However, it should be noted that public confidence is influenced not only by perceived risk but also by perceived benefits – suggesting that both areas present opportunities for bolstering public confidence.

A key observation from the figure below is that public confidence is actually influenced by the perception of both risks and benefits. Hence, although adequate safety performance is necessary, reducing risks and risk perceptions alone is unlikely to be sufficient to reverse the cycle. Benefits must also be recognized and valued. Building the public confidence requires that the public recognize the opportunity for real benefit from nuclear, and/or to avoid real cost, relative to their values. Absent this incentive, there is no motive for constituents to reconsider their risk perceptions [18].

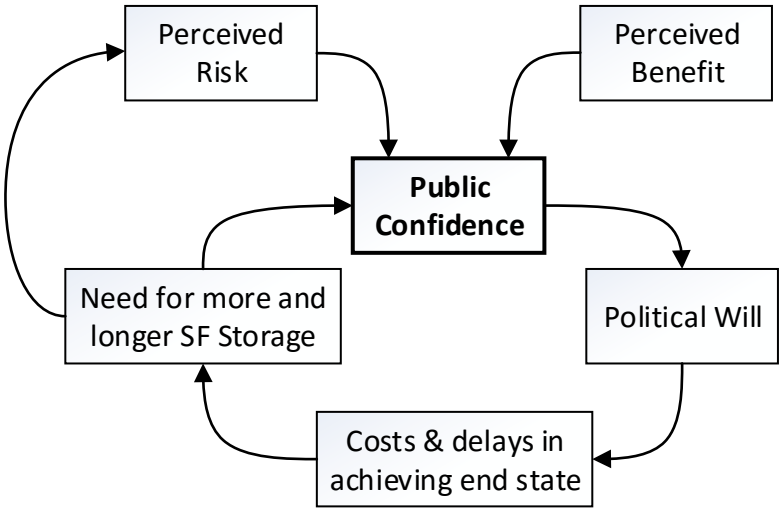

FIG. 3. The public confidence dilemma – or opportunity [19].

[3] Though many consider nuclear to be a carbon-free energy source, fuel production, plant construction and operation, and decommissioning and disposal of the plant and its spent fuel are not carbon-free. Similarly, solar, wind, hydroelectric, or any other power source is not carbon-free. Use of the term low-carbon here is intended to encourage consideration of accurate life-cycle carbon footprints when comparing energy sources.

So, although we cannot credibly argue that we know how long SNF must remain in storage, we can make a credible case that SNF can be stored safely for as long as may be necessary, that nuclear energy can provide significant environmental and economic benefit in a carbon-constrained world, and that it can be managed safely and sustainably without passing an unacceptable burden to future generations. The spent fuel management community must do its part. In addition to driving towards an acceptable solution for completion of the nuclear fuel cycle, we must face the current reality of indefinite storage -- meaning 1) that spent fuel storage durations and inventories will continue to increase for the foreseeable future, 2) that the future is not foreseeable, 3) that this uncertainty need not and should not pose a problem, and 4) that our industry infrastructure, communications, and policies can and must look ahead, confront, and openly address the unknown durations and increasing inventories.

6. EPILOGUE

This paper is not intended, in any way, to discourage commitment to achieving a sustainable end state[4]. It does advocate for accepting the reality that SNF storage periods cannot be credibly defined and for designing and planning our infrastructure accordingly.

Reviewers have expressed discomfort with the idea of storing SNF over undefined periods. An IAEA Consultancy encountered similar concerns from reviewers of the IAEA Technical Report entitled 'Storage of Spent Nuclear Fuel until Transport for Processing or Disposal' [19]. The source of this discomfort seems to result primarily from two issues.

— A perceived conflict with the desire to maintain pressure on the policy makers to follow through with implementing geologic disposal;
— Concerns relative to the need to maintain institutional controls over extended periods along with the potential of passing obligations to successive generations.

Both of these policy considerations are valid and should be addressed openly and directly. SNF can be stored until another pathway becomes available without stoking concerns that safety may be unacceptably compromised in the interim. We simply cannot predict when a better solution will become available. But we can, and must, ensure safe storage until then. By openly acknowledging and accepting this, our design, operational, and regulatory frameworks can incorporate the features needed to ensure safe and effective storage in the interim -- as well as a smooth transition to a subsequent phase or the final end state.

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