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PUBLIC PREFERENCES ON OPTIONS FOR RADIOACTIVE WASTE MANAGEMENT IN UNITED STATES

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A prerequisite to beginning a consent-based approach is to understand public awareness about current radioactive waste management practices and preferences for future management options and siting of the associated facilities. The Center for Energy, Security & Society has tracked the evolution of public preferences on nuclear energy and the management of the resulting radioactive waste through national annual surveys since 2006. The 2016 survey included questions about different storage and disposal options for radioactive management. Options range from continued reliance on on-site storage to building permanent disposal facilities deep underground. In general, the 2016 results show that support for a permanent disposal facility was higher than for continued on-site storage or building one or more interim storage facilities. As regards the nation's defense wastes generated during military and strategic research, the 2016 survey suggests a preference for co-mingling defense waste with commercial spent nuclear fuel in one repository rather than emplacing defense waste in its own separate repository. Finally, public support for an underground mine-like repository is significantly higher than for a surface storage facility. Support for deep borehole disposal ranks second, but well ahead of a surface storage option, similar to past survey results.

I. INTRODUCTION

In 2012, the President's Blue Ribbon Commission on America's Nuclear Future (BRC) concluded that effective consolidation and management of the current 2016 inventory of about 83,000 metric tons of commercial spent nuclear fuel (SNF) will require public consultation and a consent-based process for siting storage and disposal facilities.[1] As part of that consultation, a series of nationwide surveys measuring public understanding and preferences for facility design and siting have been undertaken annually by the Center for Energy, Security & Society. This paper focuses on public views concerning the types of facilities that should be used to store and dispose of SNF. Options range from continued reliance on on-site storage, to building permanent disposal facilities deep underground. This paper also focuses on public preferences regarding whether the nation's defense wastes should be "co-mingled" with commercial SNF or emplaced in a separate facility built only for defense wastes.

II. STORAGE AND DISPOSAL OF SPENT NUCLEAR FUEL

Understandably, the public knows relatively little about the technical aspects of the nuclear fuel cycle. Therefore, measuring informed opinion and preferences is challenging. The Energy and Environment survey series, initiated in 2006, annually tracks U.S. citizen views on nuclear energy and SNF management in the context of changing nations concerns (e.g., the economy and national security) and national and international events (e.g., the 2011 Fukushima nuclear accident in Japan).

Our approach in the surveys is twofold: first, provide survey respondents with quality technical information about the issues; and second, use the claims and arguments raised by policy advocates on multiple sides of the debate to provide a frame of reference for our respondents as they considered their own views and preferences.

The 2016 iteration (EE16) was completed by 2106 respondents (18 years and older) using a web-based questionnaire. The Internet sample closely approximated characteristics of the adult U.S. population. Furthermore, responses were weighted to match the 2016 demographics as estimated by the Census Bureau when analyzing data.[2]

To measure public support for alternative policy options for managing SNF in the U.S., EE16 included questions about four potential storage and disposal solutions: continued on-site storage, building one or more interim storage facilities (ISFs), building a permanent disposal facility, and implementing an integrated system that includes both ISFs and a permanent repository. This section briefly describes each option and the level of public support for each option.

II.A. On-Site Storage of Spent Nuclear Fuel

All EE16 respondents received basic information about on-site storage, and were presented arguments made for and against it by proponents and opponents of this option. Then, they were asked the following question:

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about continuing the current practice of storing spent nuclear fuel at or near nuclear power plants?

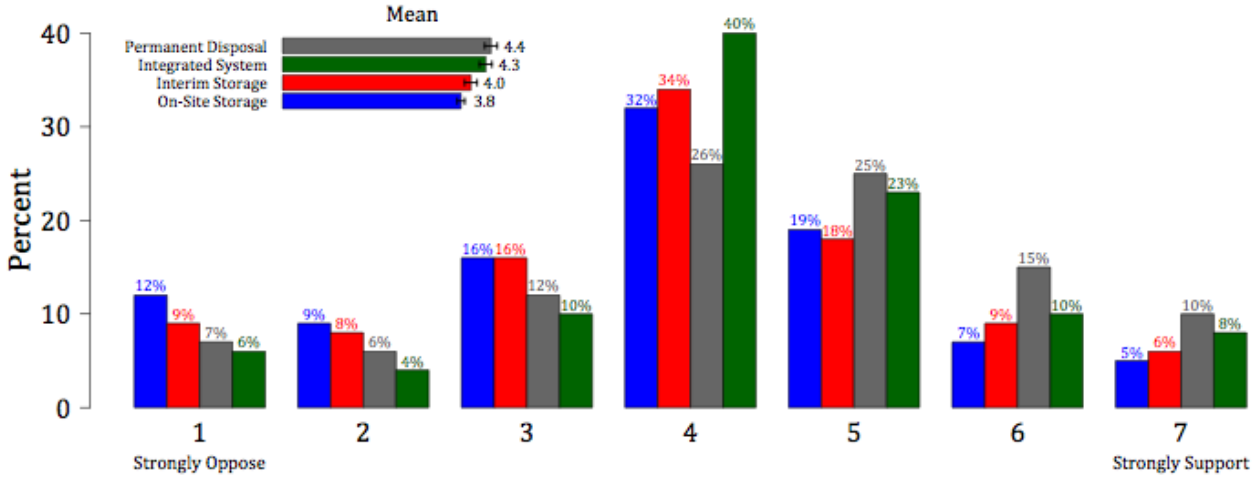

Fig. 1. Public support in 2016 for various storage and disposal options to manage spent nuclear fuel.

As shown in Fig. 1 (on-site storage responses shown in blue), 31% of EE16 respondents support continued on-site storage, with only 5% being strongly supportive. 37% of the respondents oppose the option, with 12% being strongly opposed to continued on-site storage. Mean support for on-site storage on the scale from 1 (strongly support) to 7 (strongly oppose) was 3.8, indicating that on average, this policy option garners more opposition than support. Given that public consent will be a key component in any policy design, this finding provides an important baseline for comparison as decision makers weigh alternative options for managing SNF.[1,3]

After indicating their level of support or opposition for continued on-site storage, EE16 respondents were assigned to one of three survey tracks: one considered ISFs, a second considered permanent disposal facilities, and a third considered an integrated system approach.

II.B. Interim Storage of Spent Nuclear Fuel

One SNF management option is to construct one or more regional ISFs. Like the questions about on-site storage, EE16 respondents received background information about the policy, as well as pros and cons as presented by proponents and opponents of ISFs. The full survey is described elsewhere, but an example of the pros and cons presented are as follows (where the group of arguments FOR and AGAINST were presented in random order but not the bulleted list): [2]

> Key arguments that are made FOR siting interim storage facilities include the following:
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> • Supporters argue that interim facilities can be constructed relatively soon (within 10-15 years) to safely store spent nuclear fuel, allowing more time for the government to decide on a permanent disposal strategy.
> • Interim facilities would allow removal of "stranded" spent nuclear fuel from a number of sites and eventually other sites where nuclear reactors have been dismantled or shut down, and for which expensive security measures must be continued to protect the stored nuclear materials. Supporters argue that these savings could partially pay for constructing the interim storage facilities.
> • Interim storage facilities would consolidate much of the growing amount of spent nuclear fuel currently being stored at or near nuclear power plants, many of which are near large population centers, rivers, and oceans. Also, interim facilities could repackage the spent nuclear fuel into more durable containers for eventual shipment to permanent storage and disposal sites.
>
> Key arguments that are made AGAINST building interim storage facilities include the following:
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> • Opponents argue that expanding current "on-site" storage practices at or near operating and shut down nuclear power plants is cheaper and politically more acceptable than siting and building consolidated interim storage facilities.
> • Opponents argue that transporting spent nuclear fuel to interim sites will pose greater risks than continuing temporary storage at the sites of operating or dismantled nuclear power plants. They argue that the spent fuel should be moved only after the government has succeeded in siting and building a permanent disposal facility, so the spent fuel would only need to be shipped one time rather than twice.
> • Opponents argue that building interim facilities will delay the more politically difficult solution of siting and building permanent storage and disposal facilities. If the government is unable to site a permanent disposal facility, the spent fuel would be stranded at the interim facilities even though they are not intended to be permanent storage sites.

After the information and arguments were presented, respondents were asked the following question:

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about siting and constructing one or more interim storage facilities for consolidating spent nuclear fuel in the U.S.?

The distribution of support and opposition for ISFs is shown in Fig. 1 (in red). In comparison to public preferences about on-site storage (mean score of 3.8 on a 1-7 scale), the average level of support for ISFs is modestly (but statistically significantly) higher (4.0). There is a nominal dip in the percentage of respondents that are strongly opposed to ISFs (9%) in comparison with on-site storage (12%). Overall, about 33% of respondents support this option, 34% neither support or oppose it, and 33% oppose it. Members of the public are (on average) slightly less likely to oppose ISFs than continued on-site storage, though overall our respondents hold very mixed preferences for this option.

II.C. Permanent Storage of Spent Nuclear Fuel

Building a deep geologic repository (DGR) to permanently dispose of these materials has long been considered by experts to be the safest way to permanently isolate SNF from people and the environment.[4] While there may be broad agreement among experts, public support—both nationally and at a potential host site—will be a crucial component of a consent-based siting process.[1] Therefore, understanding what members of the public think about permanent disposal (and all of the feasible options) is critical. In the EE16 survey, respondents were given information about a DGR for permanent disposal, and about the pros and cons of this option, similar to those presented for interim storage. They were then asked this question:

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about siting and constructing a permanent storage and disposal facility for consolidating spent nuclear fuel in the U.S.?

As shown in Fig. 1 (in grey), half of the respondents (50%) support this option, and only 25% oppose it. On average, public support for a permanent disposal facility leans positive (with a mean value of 4.4 on the 1-7 scale). More importantly, when compared to on-site and ISF storage, support for a permanent disposal facility is significantly higher, and opposition is notably lower.

II.D. Integrated Storage of Spent Nuclear Fuel

Since 2013, the U.S. Department of Energy (DOE) has advocated a new approach to managing the nation's SNF and high-level waste (HLW), called an "integrated waste management system." The integrated system calls for a phased and complementary strategy where both ISFs and permanent repositories will be constructed to consolidate and eventually dispose of the nuclear waste. While independent components of this strategy (ISFs and permanent geologic facilities) have been a part of the SNF management debate for a long time, public understanding of and preferences for this new integrated approach need to be understood. To gauge the extent of public support or opposition for an integrated system approach to managing SNF, EE16 introduced respondents to background information and arguments offered by proponents and opponents. Then, they answered this question:

- Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about pursuing an integrated spent nuclear fuel management system in the U.S., including the coordinated siting and construction of interim and permanent storage and disposal facilities?

Results suggest that on average (Fig. 1, in green), support for an integrated systems approach (mean score of 4.3 on a 1-7 scale) is similar to that for building a DGR facility (mean score of 4.4). Support for this approach is significantly higher than that for on-site and ISFs, with slightly more than 40% of respondents indicating they support this strategy, and only 20% saying they oppose it.

It is notable that a significant fraction of our respondents chose the midscale response (Fig. 1), indicating mixed or uncertain preferences for an integrated system. 40% of respondents chose the midscale response, as compared to 26% who chose the same response option for a DGR. This difference suggests that a relatively complex characterization of the option, as required for this study, leads to uncertainties among our respondents; some simply did not know whether to support or oppose an integrated system. Providing clear, comprehensible characterizations of such a system will be necessary in order to obtain clear guidance in a consent-based process.

III. DEFENSE-ONLY AND COMBINED WASTE DISPOSAL FACILITY OPTIONS

Another important factor for SNF and HLW disposal options concerns the origin of waste (i.e., whether the waste was produced by defense programs or civilian energy production). Two options under consideration include (1) a combined facility that would include (or co-mingle) both commercial and defense-related SNF/HLW, and (2) separate facilities for defense-related SNF/HLW and commercial SNF/HLW. Recent technical analyses by DOE have recommend that the department seriously consider the latter option.[3,5] Among the points made in favor of separate facilities is that the repository could be of smaller size, and would handle older (and therefore cooler) waste, and that the waste origin (defense activities) might make garnering public acceptance for the site less difficult.[6]

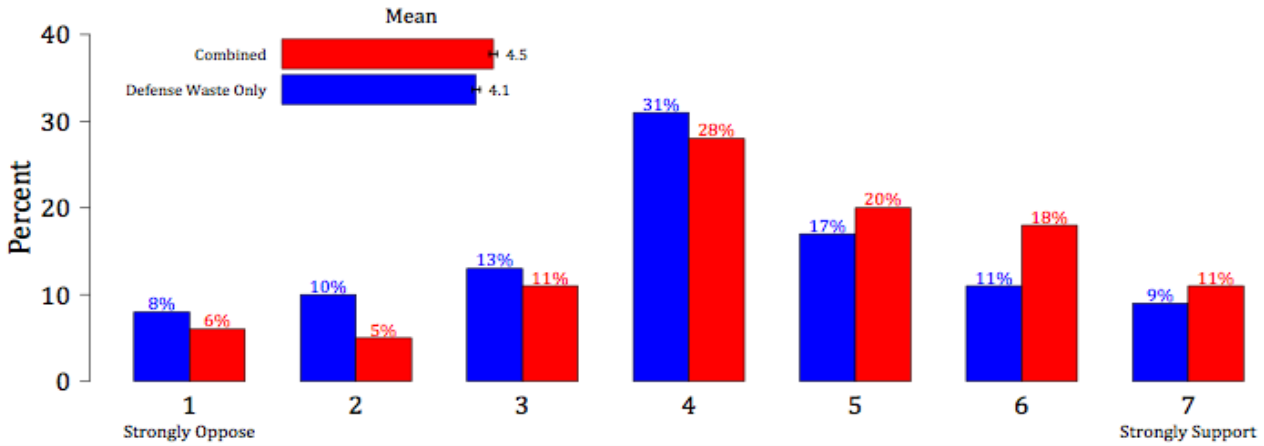

Fig. 2. Public support in 2016 for a repository for only defense waste versus a repository that combines defense and commerical wastes.

Here we focus on relative public preferences for a defense waste only repository compared to a combined commercial and defense waste repository. EE16 respondents received basic information about the options, and arguments for and against a "defense waste only" facility. Then they were asked to indicate their levels of support for pursuing a defense waste only repository versus a co-mingled waste repository (the options were presented to respondents in random order):

- Site and construct a "defense waste only" disposal facility in the U.S., only for the disposal of radioactive wastes generated by defense programs.
- Site and construct a "mixed waste" disposal facility in the U.S. for both defense wastes and commercial spent nuclear fuel.

As shown in Fig. 2, support for a combined facility (mean score of 4.5 on a 1-7 scale) is significantly higher than a defense waste only facility (4.1), although both receive modest support. About 49% of respondents support a combined facility, as opposed to 37% who support a "defense waste only" facility. Similarly, opposition for a combined facility (22%) is lower than that for a "defense waste only" facility (31%).

The results in Fig. 2 make clear that we should not assume that a defense waste only repository will receive greater public support than a combined waste repository. Among a broad cross-section of the U.S. public, the potential benefits of a defense waste only repository, even after reading the pro (and con) arguments, do not directly translate into greater support for the disposal facility (see the EE16 Reference Report for full question wording).[2]

IV. DESIGN OF PERMANENT STORAGE AND DISPOSAL FACILITIES

Scientists and engineers have considered the feasibility and robustness of several different disposal facility designs, including underground mine-like repositories, deep borehole disposal, and surface storage facilities. As with other components of siting nuclear facilities, public preferences about the characteristics of storage and disposal facilities are likely to be an important part of the consent-based siting process. The EE16 survey included questions about three different options for designing permanent storage and disposal facilities in the U.S. (presented to respondents in randomized order):

- Store spent nuclear fuel at or near the surface of the earth in concrete and steel structures. This allows monitoring and future retrieval of the spent fuel. It is considered to provide a safe means to manage the material for about a hundred years.
- Build mine-like storage facilities that are up to several thousand feet deep underground. These can be constructed to allow materials to be retrieved, or they can be designed to permanently block access in the future. They are suitable for storage over many thousands of years, and are expected to contain the material until it is no longer radioactive.
- Drill multiple boreholes of about 1.5 feet in diameter and up to three miles deep. Spent nuclear fuel would be stored in the deepest parts of the boreholes that are in bedrock. There is almost no chance that the materials could migrate into the surface environment over many thousands of years, and are expected to contain the material until it is no longer radioactive. The

spent nuclear fuel would be extremely difficult to retrieve after the boreholes are sealed.

Respondents were asked to indicate their level of support for each of the three options, on a scale from one to seven, where one means strongly oppose and seven means strongly support. As displayed in Fig. 3, on average, an underground mine-like repository received the most support (mean score of 4.8 on a 1-7 scale), followed by deep boreholes (4.5). Surface facilities received the least support, with the average falling below the scale mid-point (3.8).

These findings in Fig. 3 indicate that, all else held equal, an underground disposal facility design will encounter less opposition from members of the public than would a proposed surface facility. Though the deep borehole option received modestly less support than did the deep geologic repository, our results indicate that members of the public may be receptive to this disposal approach.[a]

V. SUMMARY AND IMPLICATIONS

Results from the EE16 survey indicate that engineering design considerations for SNF storage and disposal will matter to the U.S. public, affecting levels of public support for proposed program options. First, members of the public prefer a deep geologic repository for disposal of SNF to continued reliance on storage on-site at nuclear power plants. An integrated storage and disposal system including interim storage and permanent disposal facilities also received support, though the greater frequency of mixed and uncertain responses indicates that more extended public discussion of this approach will be required. Second, when prompted to think about the origins of wastes to be stored in these facilities, respondents prefer a combined disposal option that would include both commercial and defense wastes. It is important to note that EE16 respondents represent a broad cross-section of U.S. residents; a local population with different characteristics (e.g., near existing defense nuclear facilities) may have a different pattern of preferences. Finally, on average, members of the public prefer a mine-like repository to surface facilities; a deep borehole option also received modest support. In sum, these findings indicate that the engineering features of a program for SNF and HLW disposal will play a part in public support for that program.

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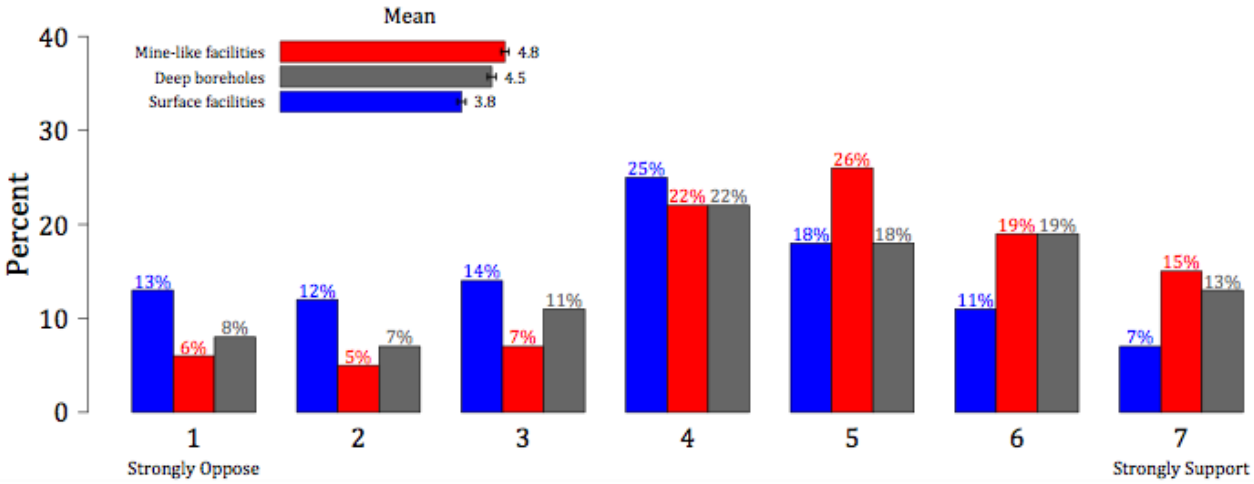

Fig. 3. Public support in 2016 for facility design options emphasizing various storage and disposal depths.

[a] Responses to proposed experimental deep borehole projects in North and South Dakota ran into significant opposition by participants at public hearings.[7] It is unclear whether the positions expressed at the public meetings were representative of the broader public in the affected counties and states.

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