SAND2015-9038R

Insight from Public Surveys Related to Siting of Nuclear Waste Facilities: An Overview of Findings from a 2015 Nationwide Survey of US Residents

Fuel Cycle Research & Development

Prepared for:
US Department of Energy
Nuclear Fuels Storage and Transportation Planning Project

Hank C. Jenkins-Smith,
Kuhika Gupta, Carol L. Silva
Center for Energy, Security & Society
University of Oklahoma

Evaristo J. Bonano
Rob P. Rechard
Sandia National Laboratories

September 2015
FCRD-NFST-2015-000521
NFST Working Document: External Release or Reference Requires DOE-NE Approval

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EXECUTIVE SUMMARY

The results described in this report are an analysis of nationwide surveys, administered between 2006 and 2015, which measure preferences of US residents concerning the environment and energy sources. The Energy & Environment (EE) survey series is conducted annually by the Center for Energy, Security & Society (CES&S), a joint research collaboration of the University of Oklahoma and Sandia National Laboratories. The annual EE survey series is designed to track evolving public views on nuclear materials management in the US. The 2015 wave of the Energy and Environment survey (EE15) was implemented using a web-based questionnaire, and was completed by 2,021 respondents using an Internet sample that matches the characteristics of the adult US population as estimated in the US Census. A special focus of the EE15 survey is how survey respondents understand and evaluate "consent" in the context of the storage and transportation of spent nuclear fuel (SNF). This report presents an overview of key results from analyses of questions related to consent-based siting and other elements of the nuclear energy fuel cycle.

Public Views of the Nuclear Fuel Cycle

Public views about the siting of nuclear facilities occur within a broader context of the risk and benefit perceptions associated with nuclear energy. Public attention to the events in 2011 at the Fukushima nuclear facility continues to influence the balance of risk and benefit perceptions for nuclear energy in the US, though results from EE15 suggest that the magnitude of the negative effect on support of nuclear energy has begun to diminish. Additionally, those members of the public who are most concerned about climate change are also the most likely to express broader concerns about the environment, and those who are most worried about the environment are more likely to oppose reliance on nuclear energy. However, recent surveys suggest that this relationship may be diminishing in strength. A broader implication is that perceived risks of and support for nuclear energy are subject to change over time, and therefore successful consent-based siting programs will need to be phased and adaptive to adjust to those changes.

Public Support for New Nuclear Energy Technology: The Case of Small Modular Reactors

One of the objectives of the EE series is to measure how the public perceives advances in nuclear energy technologies, and how information about these new technologies might influence their risk perceptions about nuclear energy more generally. Results from EE15 indicate that perceived risks are significantly lower for small modular reactors (SMRs) than they are for traditional nuclear reactors. Furthermore, when comparing respondents' support for adding SMRs for the purpose of expanding nuclear energy for civilian uses and for military bases, support for adding SMRs for use by military bases received substantially greater support.

Evolving Public Awareness of the Nuclear Fuel Cycle

Trends from the EE series indicate that the broader public is not well informed about the nuclear fuel cycle. The public's knowledge about US nuclear waste management policies increased in the period following the motion to withdraw the application for the licensing of the Yucca Mountain facility and following the Fukushima nuclear plant accident. However, recent surveys suggest that levels of public knowledge and awareness are declining again. These findings suggest that, when faced with making decisions about nuclear facility siting, most members of the public will rely heavily on general beliefs and risk perceptions – and less on specific knowledge about the fuel cycle. Accordingly, designing and building a robust, trustworthy basis for communication and engagement – one that is understood by the

public to be as concerned about the interests of potential host communities and the public as it is about siting a facility – will be of critical importance to the success of the consent-based siting program.

Public Understanding and Perceptions of Interim Storage

The EE15 survey results show that respondents are reluctant to continue to rely on temporary on-site storage of SNF, and that there is moderate support for developing one or more Interim Storage Facilities (ISFs). This finding is consistent with data from EE13 and EE14, suggesting that these perceptions are robust and stable over time. Support for ISFs is greater among respondents who live closest to current SNF storage sites. However, that support is also conditional on how proximate their residence would be to the proposed ISF.

Nuclear Accidents and Support for ISFs: The Case of the Waste Isolation Pilot Plant

Events such as the Waste Isolation Pilot Plant (WIPP) incident in 2014 can significantly influence public support for nuclear waste management in the US. The broader public is not well informed about WIPP (only 6% of our 2015 respondents had heard about the facility) or about current policies for the management of SNF. However, when respondents are given information about the WIPP incident, they express reduced levels of support for building new SNF management facilities in the US. The public is more sensitive to the implications of the WIPP incident for a deep geological repository than for interim storage of SNF in the US.

Public Perspectives on the Institutional Basis for SNF Management

Trends from EE surveys consistently indicate that the public's level of trust accorded to a new nuclear waste authority will be sensitive to how it is defined. A private authority would face a greater challenge in gaining public trust than would a public agency. More generally, the survey responses indicate that the government laboratories and agencies continue to be viewed by lay citizens as reasonably credible, though they are also perceived to have a modest propensity to downplay risks. Both industry groups and environmental nongovernment organizations (NGOs) are broadly perceived to be more prone to skew the representation of risks (though in opposite directions), while the National Academy of Sciences and state/local emergency responders are seen as least prone to depart from providing balanced information on nuclear risks. These perceptions of bias serve to filter the credibility of information and policy recommendations concerning nuclear waste options received by the public.

Public Views on the Design of a Consent-Based Siting Process

The EE15 survey asked respondents about their views on the design of a consent-based siting process. In particular, the survey included questions about which actors should have a veto during the siting process. Results indicate that there are important differences concerning who respondents believe should have veto authority in (a) designation of SNF transport routes and (b) siting ISFs. When asked who should be able to veto the designation of SNF transport routes, regulatory agencies – the state environmental regulatory agency, the US Nuclear Regulatory Commission (NRC), and the US Environmental Protection Agency (EPA) – topped the list. For ISF siting decisions, local and statewide residents and the state's environmental regulatory agency were most frequently chosen to have veto authority.

Prospective Public Engagement in Siting ISFs and Preferences for Influence Accorded to Decision-Making Entities

Public engagement is an important element of any consent-based siting program, yet we know relatively little about people's willingness to participate in the siting process. The EE15 survey asked respondents about their likely willingness to engage in the siting process through various modes of participation ranging from attending informational meetings, writing to their elected representative, organizing public opposition to or support for a proposed site, and serving on a citizens' committee. Results indicate that, on average, respondents are most likely to attend an informational meeting or contact their elected officials. The least likely prospective modes of engagement are speaking at a public hearing and organizing public support for a proposed site. Additionally, when asked about the preferred influence of elected officials, "technical expert panels," and local "deliberative citizen panels" in the siting process, survey respondents preferred that technical expert panels and deliberative citizen panels be given roughly equal influence in siting an ISF. By contrast, for transportation routes, respondents preferred expert panels to have greater influence than citizen panels. In both cases, survey respondents preferred to give elected officials less influence than either expert panels or local deliberative citizen panels.

ACKNOWLEDGEMENTS

The authors would like to thank the following individuals at the University of Oklahoma for their contributions to the creation of this report Dr. Joseph Ripberger, Matthew Henderson, Nina Carlson, and Wesley Wehde.

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ACRONYMS

BRC	Blue Ribbon Commission on America's Nuclear Future
CES&S	Center for Energy, Security and Society
DOE	US Department of Energy
EE	Energy and Environment survey series
EE15	the 2015 iteration of the EE survey series
EPA	US Environmental Protection Agency
FCRD	Fuel Cycle Research and Development
GHGs	greenhouse gases
ISF	interim storage facility
NEI	Nuclear Energy Institute
NFST	Nuclear Fuels Storage and Transportation Planning Project
NGO	nongovernmental organization
NRC	Nuclear Regulatory Commission
SNF	spent nuclear fuel
SNL	Sandia National Laboratories
SMR	Small Modular Reactor
SSI	Survey Sampling International, Inc.
WIPP	Waste Isolation Pilot Plant

NUCLEAR FUELS STORAGE AND TRANSPORTATION PLANNING PROJECT

CONSENT-BASED SITING OF NUCLEAR WASTE MANAGEMENT FACILITIES: AN OVERVIEW OF FINDINGS FROM A 2015 NATIONWIDE SURVEY OF US RESIDENTS

1. INTRODUCTION

In a report titled *Strategy for the Management and Disposal of Used Nuclear Fuel and High Level Radioactive Waste* (DOE 2013), the US Department of Energy (DOE) has outlined a national strategy for how spent nuclear fuel (SNF) should be managed. In line with the recommendations provided by the Blue Ribbon Commission on America's Nuclear Future (BRC 2012), the DOE report highlights the importance of consent-based storage and disposal facility siting. Critical elements of this consent-based strategy include open and transparent communication of the benefits and risks of various SNF management options and the incremental implementation of a "flexible" SNF storage system (DOE 2013, p. 4). More recently, the importance of finding a consensual process for siting nuclear waste facilities has been raised at the Congressional level in a Senate bill (Nuclear Waste Administration Act of 2015). The bill outlines the establishment of a new organization to manage nuclear waste and the need for a consensual siting process. The study described in this report was undertaken to inform the Nuclear Fuels Storage and Transportation (NFST) Planning Project on how consent as well as risks and benefits, in the context of nuclear facility siting, are understood and evaluated by a cross-section of the American public.

1.1 Energy and Environment Survey Project

The *2015 Energy and Environment Survey* (EE15) was fielded by the Center for Energy, Security and Society (CES&S), a joint research center of the University of Oklahoma and the Sandia National Laboratories (SNL). The survey was designed to measure US residents' perceptions, beliefs, and preferences for SNF management policies. The EE survey series, initiated in 2006, has annually measured and tracked Americans' views on nuclear energy and SNF management.[a] The series has focused on a range of nuclear energy issues over time, but more recently the surveys were designed to facilitate understanding of public beliefs and perceptions regarding SNF management and consent-based siting. Fielding these surveys annually has made it possible to track public views on important issues related to nuclear energy and waste management and analyze American residents' policy preferences in the context of changing national concerns (e.g., the relative concern about the economy or national security) and evolving international and domestic events (e.g., the Fukushima nuclear event and the Waste Isolation Pilot Plant—WIPP—incident).

1.2 EE15 Survey Sample Characteristics

The sample frame for the EE15 survey was purchased from Survey Sampling International, Inc. (SSI), a leading provider with direct access to more than six million research respondents plus millions of others through preferred partner relationships across 54 countries. The respondents for EE15 were recruited by SSI, which provides direct access to millions of potential survey respondents. Decisions to participate

[a] Beginning in 2012, the University of Oklahoma, Office of the Vice President for Research, has funded the EE survey design and data collection. The series began in 2006 and has been fielded annually.

were entirely voluntary and recruitment was carefully monitored to ensure that the sample was Census balanced and therefore representative of the US population.

The EE15 survey was conducted on June 24 and 25, 2015. In total, 2,021 adults (age 18 and older) completed an Internet-based questionnaire. On average, respondents took about 31 minutes to complete the survey. The characteristics of the respondents – including mean age, percentages of men and women, race and region – approximated those of the national Census, as shown in Table 1.1. When analyzing the data, the respondents were weighted to match national demographic characteristics. The technical characteristics of the survey design, recruitment, data collection and weighting are described in a supplemental report entitled *Public Preferences Related to Radioactive Waste Management, Nuclear Energy, and Environment: Methodology and Response Reference Report for the 2015 Environment and Energy Survey* (hereafter referred to as the *Reference Report*).

Table 1.1 Demographic Attributes of EE15 Survey Respondents Compared to 2014 US Census Estimation

Demographic	% US Population 18 Yrs. of Age and Above*	% EE15 Respondents
Gender		
Female	51.3	51.4
Male	48.7	48.6
Age		
18–29	21.8	20.0
30–49	33.8	27.9
50+	44.4	52.1
Ethnicity		
Hispanic	15.0	15.0
non-Hispanic	85.0	85.0
Race		
White	79.0	77.7
Black or African American	12.6	13.0
Census Region		
Northeast	18.3	18.6
Midwest	21.5	21.0
South	37.4	37.6
West	22.8	22.7

*Note: Population estimates exclude AK, HI, and DC.

The content of the survey questionnaire ranged from queries concerning general beliefs about energy and environmental issues to very specific measures of knowledge, attitudes, and preferences for the

management of SNF. The following sections use these survey responses, supplemented where appropriate with data from the CES&S's studies of social media, to report on eight topics: [b]

1. Trends in public perceptions of nuclear energy, with particular attention to the continuing implications of the March 2011 Fukushima nuclear event and beliefs about climate change;
2. Evolving public awareness of the nuclear fuel cycle;
3. Public views about and support for new nuclear technologies like the Small Modular Reactor (SMR) technology;
4. Public understanding and perceptions of interim SNF storage facilities, with an emphasis on the effects of proximity to proposed interim storage facilities (ISFs) and to current temporary SNF storage facilities;
5. The effects of nuclear accidents such as the WIPP incident on support for ISFs and deep geological repositories in the US;
6. Views of the expected "risk biases" of key institutions that have a role in the storage and transportation of SNF and the mean trust in the information provided by these institutions, including alternative institutional bases for a new single-purpose entity to manage SNF storage and disposal;
7. Public views of the appropriate bases for the design and implementation of a consent-based process for siting transportation corridors and interim SNF facilities; and
8. Public expectations concerning their levels of involvement and engagement in the process of siting ISFs, including public preferences for the extent to which different decision-making entities should be involved in the siting process.

The *Reference Report* includes a full listing of the question wording and the response frequencies.

1.3 A Guide to Reading this Report

The topics covered in this report will be of varying importance and interest to different readers. An overview of the primary findings is provided in the Executive Summary.

For those who want to efficiently get to the material of immediate relevance to *consent-based siting program design*, we suggest beginning with Section 4 (understanding support for ISFs), Section 8 (public views on the design of a consent-based siting process), and Section 9 (prospective public engagement in the siting process).

For readers with an interest in the *broader context that has shaped US residents' perspectives on nuclear energy and SNF management* we recommend a close reading of Section 2 (the energy and policy context) and Section 4 (evolving public awareness of SNF issues).

For those who are chiefly concerned with the *variations in public confidence in agencies (and other stakeholders) for management of SNF and implications for the institutional design of a new nuclear waste*

[b] The EE survey series differs from popular opinion polling. Polls tend to be snapshots in time of public opinions on subjects that more often can be categorized with yes—no, for—against responses, typically based on information that the person can recall from memory. By comparison, academic surveys like the EE series are designed to investigate more complex issues that (a) require much more attention and thought from respondents (as noted by the time respondents took to complete the survey), (b) involve more complex question wording, (c) may provide balanced background information, and (d) allow more subtle response variations (as shown in the sections that follow). The EE surveys yield data that can help explain which complex policy options are preferred, why these policy preferences are formed and how they evolve over time related to the topic areas analyzed in the report.

authority, we recommend reading Section 7 (public perspectives on the institutional basis for SNF management).

For a presentation of the full survey question wording, and a detailed discussion of sampling and weighting methodologies used in collection of the data, see *EE15 Reference Report*, to be published in December 2015.

2. PUBLIC VIEWS OF THE NUCLEAR FUEL CYCLE

In order to gauge how members of the American public might respond to efforts to site nuclear facilities, we first address the broader context that informs these responses. This context includes the public's preferences regarding the future mix of energy sources, general beliefs about nuclear technologies, and the perceived risks and benefits associated with nuclear energy. This section outlines the evolution of some of the key public perceptions and preferences that shape the debate over SNF facility siting.

2.1 Trends in Public Support for Nuclear Energy

The EE series has monitored US residents' perceptions about the risks and benefits associated with nuclear energy since 2006. In the EE15 survey, respondents to the survey were asked the following questions:

> First we want to know about your beliefs concerning some of the possible risks associated with nuclear energy use in the U.S. Please consider both the likelihood of a nuclear event occurring and its potential consequences when evaluating the risk posed by each of the following on a scale from zero to ten where zero means *no risk* and ten means *extreme risk.* [The order of the risk questions was randomized; the labels in **bold** were not included]
>
> **[Operational accident]** An event at a U.S. nuclear power plant within the next 20 years that results in the release of large amounts of radioactivity.
>
> **[Storage or Transportation accident]** An event during the transportation or storage of spent nuclear fuel from nuclear power plants in the U.S. within the next 20 years that results in the release of large amounts of radioactivity.
>
> **[Terrorist attack]** A terrorist attack at a U.S. nuclear power plant within the next 20 years that results in the release of large amounts of radioactivity.
>
> **[Diversion to nuclear weapons]** The diversion of nuclear fuel from a nuclear power plant in the U.S. within the next 20 years for the purpose of building a nuclear weapon.
>
> Now we want to know about your beliefs concerning some of the possible benefits associated with nuclear energy use in the U.S. Please evaluate the benefits associated with each of the following on a scale from zero to ten, where zero means *not at all beneficial* and ten means *extremely beneficial.* [Presented in random order]
>
> **[Reduced greenhouse gas emissions]** Fewer overall greenhouse gas emissions because nuclear energy production does not create greenhouse gases.
>
> **[Reliable electrical power]** Reliable power because nuclear energy generates large amounts of electricity and is not affected by weather conditions, such as low rainfall or no wind.
>
> **[Energy independence]** Greater U.S. energy independence because nuclear energy production does not require oil or gas from foreign sources.
>
> **[Less mining / extraction]** Reduced environmental damage because of less need for mining coal or extracting oil and gas.

The responses to each question in 2015 and the comparison with the mean responses in 2014 are shown in Table 2.1.

Table 2.1. Mean Nuclear Risks and Benefits: 2014 vs. 2015

	2014	2015	*p*-Value
Nuclear Risks: 0 = No Risk—10 = Extreme Risk			
Terrorist attack	7.06	6.83	.0574
Operational accident	6.81	6.55	.0299
Transportation and storage accident	6.67	6.55	.4586
Diversion to nuclear weapons	6.14	5.99	.2711
Nuclear Benefits: 0 = Not At All Beneficial—10 = Extremely Beneficial			
Energy independence	7.22	7.09	.2748
Less mining / extraction	6.95	7.10	.1723
Reliable electrical power	7.07	7.01	.5744
No greenhouse gas emissions	6.82	6.79	.7537

As shown in Table 2.1, the mean score for each of the perceived risk categories was above midscale on a scale ranging from 0 (no risk) to 10 (extreme risk). A comparison between average perceived risks from 2014 and 2015 surveys highlights some important differences. In the EE15 survey, perceived risks from an operational accident at a nuclear facility declined after having increased in the prior two years. This shift is statistically significant (at the 0.05 level). Risk perceptions associated with terrorist attacks, transportation and storage accidents, and from the possible use of nuclear fuel to construct nuclear weapons declined nominally, but these changes were not statistically significant. None of the changes in perceived benefits were statistically significant; public perceptions of the benefits of nuclear energy have remained largely unchanged since 2011.

Figure 2.1 displays the trends in perceived risks and benefits from 2006-2015:

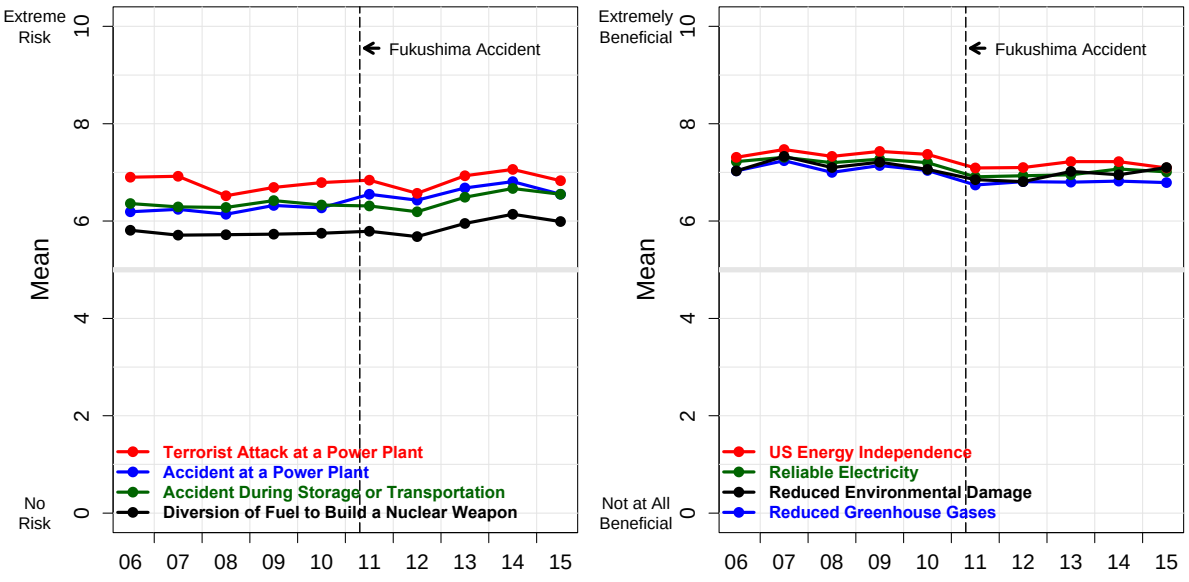

Figure 2.1: Public Perceptions about the Risks and Benefits Associated with Nuclear Energy

Following the set of nuclear risk and benefit questions, respondents were asked to provide their assessments of the aggregate balance of risks and benefits of nuclear energy. The question wording was as follows:

> Now please consider the overall balance of these possible risks and benefits of nuclear energy in the U.S. Using a scale from one to seven, where one means the risks of nuclear energy far outweigh its benefits, four means the risks and benefits are equally balanced, and seven means the benefits of nuclear energy far outweigh its risks, how do you rate the overall balance of the risks and benefits of nuclear energy in the U.S.? Remember, you can choose any number from one to seven.

Figure 2.2 shows the trend in the mean balance of perceived risks and benefits from 2006 through 2015:

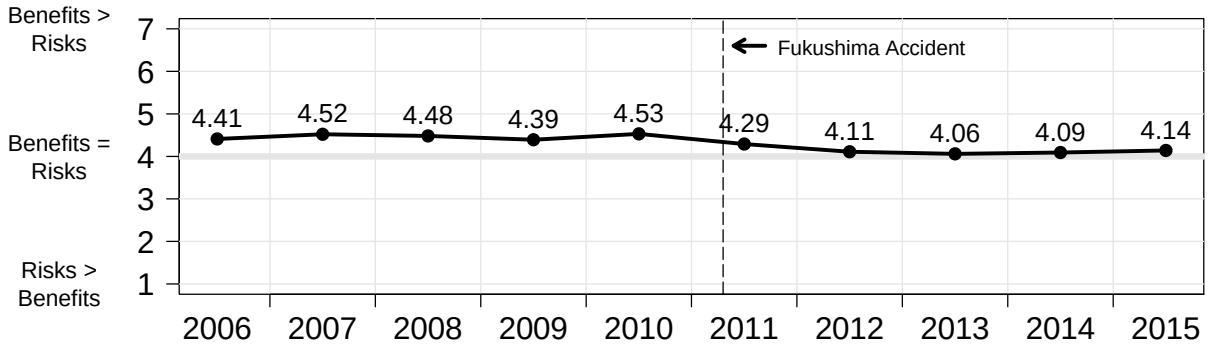

Figure 2.2 Trends in Balance of Nuclear Energy Risks and Benefits

As is evident in Figure 2.2, the balance between the perceived risks and benefits of nuclear energy has changed gradually over time. From 2006-2010, survey respondents perceived the benefits of nuclear energy to be higher than the perceived risks. However, this trend began to shift after 2010. From that point on, respondents have viewed the risks and benefits of nuclear energy to be roughly equal. This pattern indicates the probable effects of the Fukushima accident in March of 2011. EE15 results show a nominal shift toward perceptions of greater benefits, though the magnitude of this shift is not statistically significant.

In addition to measuring the risks and benefits that respondents associate with nuclear energy, the EE series has tracked public support for the construction of new nuclear reactors. Since 2006, the following questions have been asked in each of the EE surveys:

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about constructing additional nuclear reactors at the sites of existing nuclear power plants in the U.S.?

> Using the same scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about constructing additional nuclear power plants at new locations in the U.S.

Figure 2.3 shows the trends in mean responses to these two questions over the 2006-2015 period. The blue trend line shows mean support for new reactors at the site of existing nuclear power plants; the red line show support for new reactors at new locations.

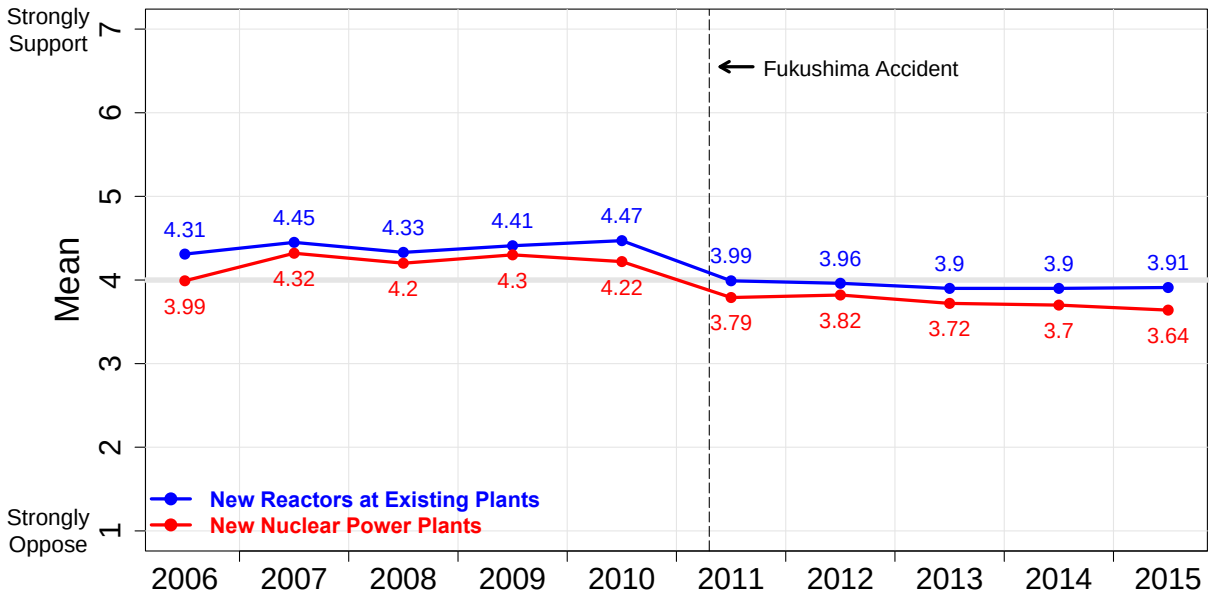

Figure 2.3: Trends in Support for New Reactors at Existing and New Sites

As shown in Figure 2.3, mean support for new reactors at existing locations has consistently remained higher than support for new nuclear power plant construction in the US It is also evident that mean levels of support have shifted over time. For instance, support for both reactor locations was above midscale from 2007 through 2010, after which it declined and has remained below midscale. Note that the timing of the March 2011 earthquake in Japan, followed by the ongoing Fukushima nuclear event, preceded the decline in public support for new nuclear reactors in the US

The public's risk and benefit perceptions about nuclear energy, and their support for nuclear generation are related to their preferences for the future mix of energy sources. Since 2006, the EE series has asked respondents the following question about their preferred sources of future energy supply:

> Now think about the overall mix of all sources of energy for the U.S. We currently get about 82 percent of our energy from fossil fuels, 9 percent from nuclear energy, and 9 percent from renewable sources (hydroelectric dams, wood, biofuels, wind, waste products, geothermal, and solar). We want to know approximately what percentage of the total U.S. energy supply over the next 20 years you would like to see come from each of these three primary sources.

Figure 2.4 shows the results for each of the three energy sources and the preferred energy mix over the next 20 years. As seen, respondents want half of the US energy supply to come from renewable sources, with 35% from fossil fuels, and 16% from nuclear energy.[3] The percentage of preferred energy from each source has remained relatively stable in the last few years, indicating an enduring public preference for a significant contribution by nuclear energy to the nation's energy needs.

[3] Note that the decline in the preferred share of nuclear energy (between 2009 and 2011) followed the withdrawal of the license application for the Yucca Mountain repository and the Fukushima accident in 2011. The change in public preferences may reflect these events (or the media reporting on them), though establishing a causal effect is not possible with these survey data.

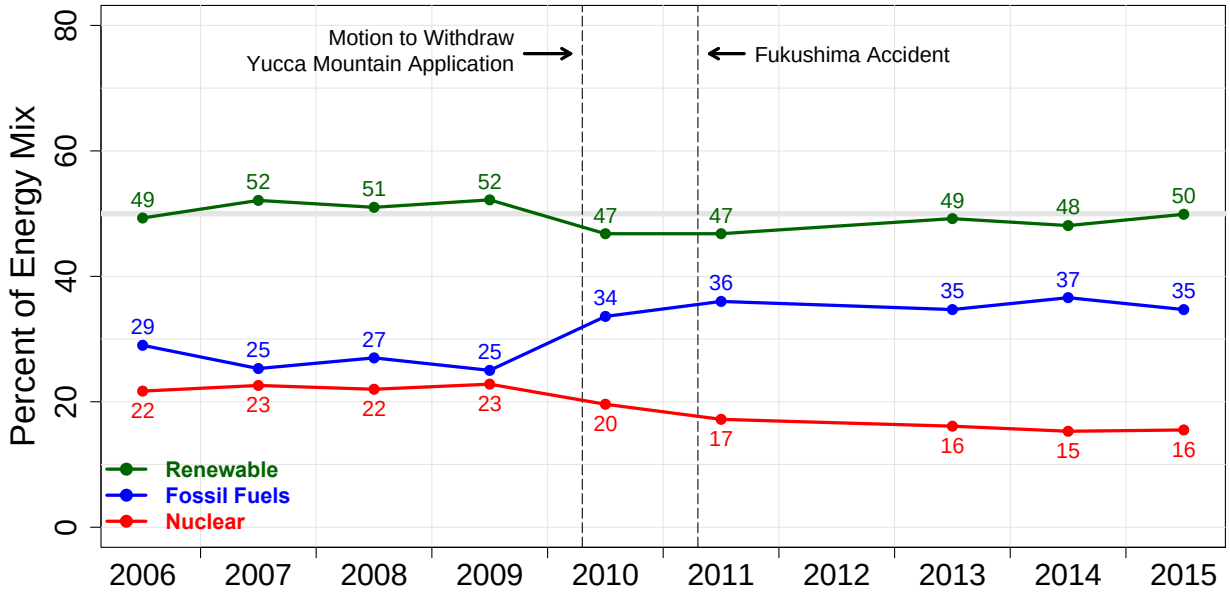

Figure 2.4: Preferences for Sources of Future Energy Supply (% Preferred from Each Source)

2.2 Implications of Fukushima for Nuclear Attitudes

Focusing events like the Fukushima accident that capture global attention and place the issue on the public and government agenda can have a lingering effect on the future of nuclear energy, especially in the minds of the public. Beginning in May 2011, the EE surveys have tracked this effect by posing direct questions to respondents about the extent to which the Fukushima event has influenced their support for nuclear power production in the US Prior to asking them the question, the survey provides respondents a brief description of what happened on the day of the accident. Priming respondents with factual information about the event ensures that all of them have basic knowledge about the accident before they answer questions about it. The question was worded as follows:

> As you may recall, a severe earthquake occurred on March 11, 2011 in the Pacific Ocean near Japan, creating large tidal waves that destroyed some Japanese coastal cities. Also damaged was the Fukushima nuclear power plant, which released radioactivity into the atmosphere and nearby portions of the sea. The earthquake and tidal wave killed thousands of people; the release of radiation at Fukushima is not known to have produced any deaths, but could contribute to future illnesses. We would like to know how the Japanese experience has influenced your confidence in U.S. nuclear power.
>
> On a scale from minus ten to plus ten, where minus ten means the Japanese experience has *strongly reduced* your support for U.S. nuclear power production, zero means the Japanese experience has had *no effect* on your support, and plus ten means the Japanese experience has *strongly increased* your support, how have recent events in Japan influenced your support for nuclear power production in the United States?

The average self-assessed effect of the Fukushima event on support for reliance on nuclear energy in the US, in each year since the event, is shown in Figure 2.5.

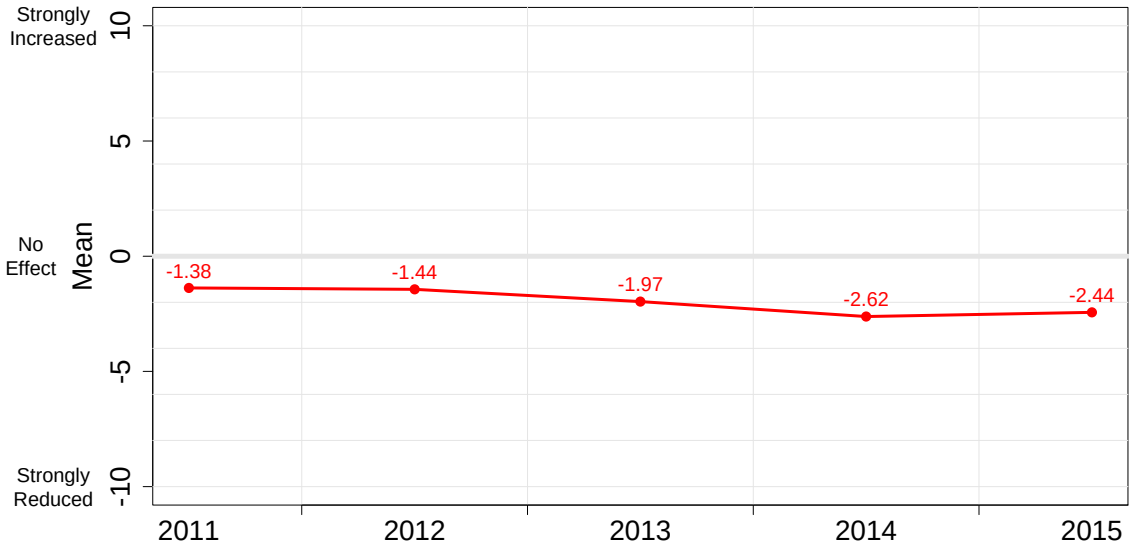

Figure 2.5 Mean Effects of Fukushima on US Public Support for Nuclear Energy: 2011 through 2015

As shown in Figure 2.5, the self-reported effect of the Fukushima nuclear event on support for US nuclear energy appeared to grow over time from 2011 through 2014. In part this appears to reflect the ongoing nature of the event, coupled with the continuing press and social media attention to it. Following the 2014 iteration of the survey the negative trend appears to have reached a nadir, with a nominal (but not statistically significant) decrease in the self-reported effect of the event on support for nuclear energy in the US

2.3 Implications of Climate Change for Nuclear Attitudes

Events like those at the Fukushima nuclear reactors have an influence on public support for nuclear power, but they are just one of the factors that shape overall opinions about nuclear energy. Another potentially long-term influence is that of the debate over the causes and implications of climate change. As shown in section 2.1, public support for nuclear energy declined in the last few years. Is it possible that the climate-friendly nature of nuclear energy – inasmuch as it produces substantially less carbon dioxide than does energy generation using fossil fuels (Coleman et al. 2012) – can shift these opinions and lead to increased support? The EE15 survey included questions about respondents' perceptions of climate change. First, respondents were asked the following question:

> As you may know, the issue of global climate change has been the subject of public discussion over the last few years.
>
> In your view, are greenhouse gases, such as those resulting from the combustion of coal, oil, natural gas, and other materials causing average global temperatures to rise?

Consistent with other surveys of the US public, a large majority of the respondents to the EE15 survey believe that human-generated greenhouse gases (GHGs) are causing the climate to change. Figure 2.6 shows the trends in the proportions of the EE15 respondents who do, and do not, believe that human activity is causing climate change since 2006.

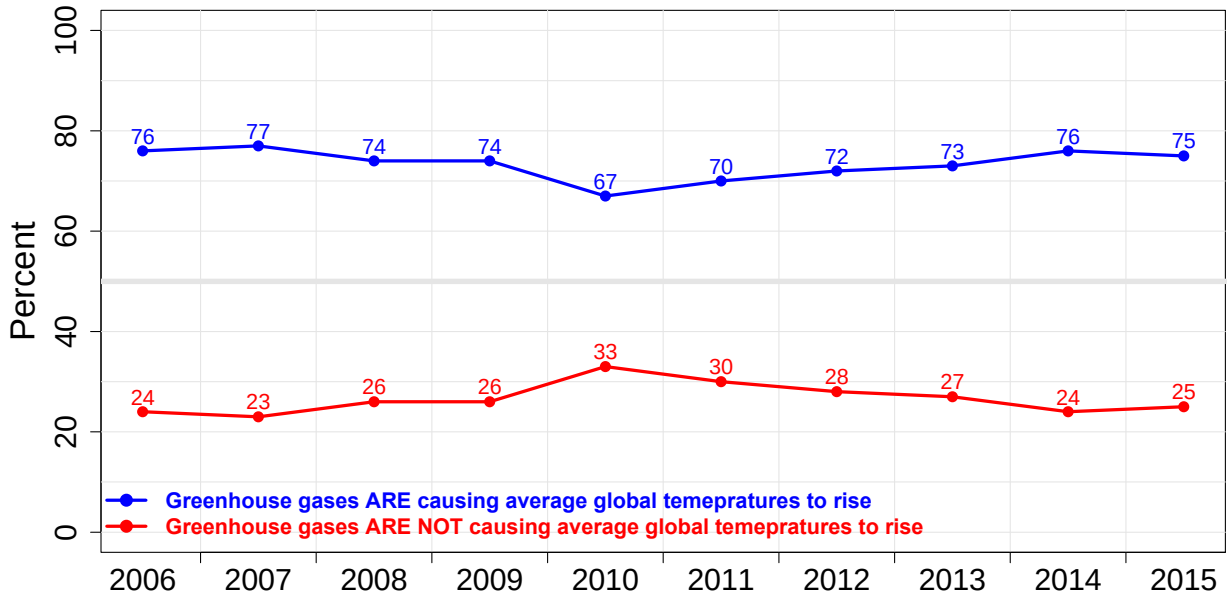

Figure 2.6: Trends in Public Perceptions about Greenhouse Gases and Global Temperatures

As shown in Figure 2.6, the percentage of respondents who believe that GHGs are causing climate change has been increasing since 2010. Responses to EE15 indicate that 75% of respondents believe that GHGs are causing climate change as opposed to 25% who think they are not. In sum, a substantial majority of respondents have consistently expressed the belief that the climate is changing in response to human generated GHGs. Does this belief translate into support for nuclear energy?

Figure 2.7 provides one possible answer to this question. For each year of the EE survey results, the figure shows the mean level of support for new nuclear reactors among those who do, and do not, believe that climate change is resulting from human-generated GHGs. Results indicate that those who believe that climate change is occurring as a result of anthropogenic greenhouse gases are also consistently *less* supportive of new nuclear reactors than are those who do not. In other words, the belief that anthropogenic climate change is occurring does *not* seem to indicate greater support for nuclear energy. Indeed, the belief that humans are causing the climate to change is associated with *less* support for nuclear energy, in spite of the current and potential future role of nuclear energy in reducing greenhouse gas emissions.

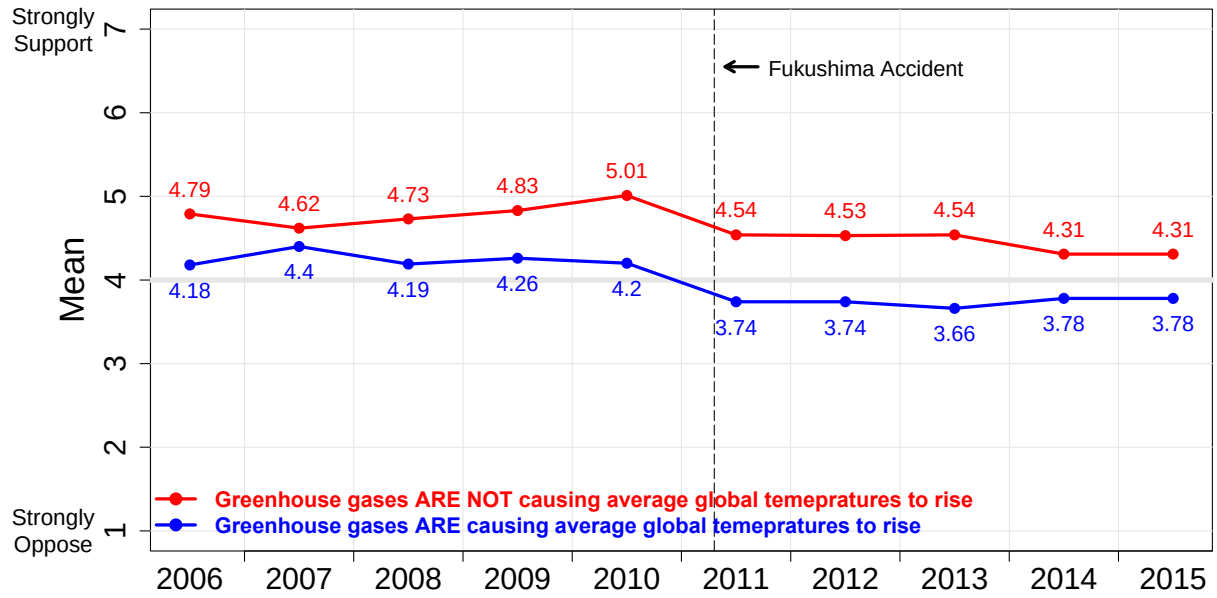

Figure 2.7: Trends in Public Support for New Nuclear Construction by Beliefs about Global Climate Change

Why is there an inverse relationship between beliefs about climate change and support for nuclear energy? Most broadly, belief in climate change is strongly associated with underlying attitudes about the environment that also affect perceptions about the risk and benefits of nuclear energy. People who believe that nature and the environment is fragile and easily harmed by modern day human activities also tend to believe that anthropogenic GHGs are causing the Earth's climate to change. This general view of nature coincides with views about nuclear energy being environmentally risky, leading to the inverse relationship discussed above. Sometimes described as the "legacy effect," this pattern reflects the association between nuclear energy and images of nuclear meltdowns, accidents at Chernobyl, Three Mile Island, and Fukushima, and the unresolved issues of nuclear waste disposal (for example, see Brumfiel and Fuyuno 2012; Medvedev 2009). Beliefs about climate change and support for nuclear energy are also mediated by political ideology; conservatives tend to be less likely to believe in climate change and are also more likely to be supportive of nuclear energy.

In aggregate, as discussed in this section, the continuing attention to Fukushima, coupled with its negative implications for public support for nuclear energy, has changed the context in which nuclear facility siting efforts will occur. Concerns about climate change, in turn, are rooted in general attitudes about the environment that have traditionally been negatively correlated with support for nuclear energy. These trends color the broader context in which discussions of siting nuclear facilities will take place. Keep in mind however that perceived risks and support for nuclear energy are subject to change over time. Consent-based siting programs will need to be sufficiently flexible to adapt to those changes.

3. PUBLIC PERSPECTIVES ON NEW NUCLEAR TECHNOLOGIES

One of the objectives of the EE series is to measure how the public perceives advances in nuclear energy technologies, and how information about these new technologies might influence their general risk perceptions about nuclear energy. With that in mind, the EE15 survey investigated respondents' perspectives about SMRs. Respondents were provided with background information about SMRs along with some advantages and disadvantages associated with this new technology. Providing respondents with information about technologically complex concepts such as SMRs is crucial; it helps familiarize respondents with the technology and gives them a brief overview of the kinds of pros and cons surrounding SMRs that are likely to be voiced in the public discussion. These pros and cons are carefully selected and worded to match actual policy debates that members of the public will likely encounter in the news or social media. The background information about SMRs included in EE15 is reproduced below.

Now we would like to ask you some questions about new nuclear energy technologies. Before you answer these questions, please review the following information carefully.

The U.S. government is providing incentives to accelerate the development and licensing of a new nuclear energy technology called the small modular reactor (SMR), which would be pre-fabricated in a factory and then transported to the site of electricity generating plants. Current SMR designs are based on established reactor technology, and are called small because each reactor produces a small fraction of the electricity produced in a typical full-sized reactor. They are called modular because they can be operated in groups, and can be added to or replaced as needed. Manufacturers say they are safer because they rely on simpler cooling and safety systems (called "passive" safety systems) that require no outside source of power to operate or shut down. These reactors are still in the development phase, and have not yet been built, licensed, or constructed.

[Random order for grouped sets of bulleted arguments]

Key arguments that are made FOR small modular reactor technologies include the following:

- Once they are licensed, new SMR plants will be able to start producing electricity in a shorter period of time than new traditional nuclear reactor plants.
- Because SMRs will eventually be mass-produced, they will be less expensive build and install than traditional nuclear reactors.
- Once an SMR design has been certified, it will be easier to demonstrate that SMRs can meet regulatory requirements than traditional nuclear reactors because all SMRs of a particular design will be identical, rather than different designs for each reactor.
- SMRs can provide clean, affordable power for locations that do not require large power plants. They may be especially useful for smaller electricity markets, isolated areas, smaller grids, and places with limited water and land.

Key arguments that are made AGAINST small modular reactor technologies include the following:

- The design and safety features of SMRs are not yet publically available because they are still being developed, which makes it difficult to evaluate the safety and utility of SMR technologies. Until these features are well understood, it will be impossible to obtain a license to operate an SMR.
- Constructing, transporting, and siting SMRs at many locations may expose a larger portion of the U.S. public to the risks associated with radioactive material.
- The costs associated with SMRs will be lower in part because the regulatory requirements for the containment vessels and the extent of security requirements will be reduced. Some people are concerned that this will make the SMRs less safe.
- To make SMRs cost effective, hundreds of units will have to be ordered and produced, and it is not yet clear that the demand for SMRs in the U.S. will support this supply.

The survey included three questions about SMRs, and the first question (worded as shown below) asked respondents to compare the perceived safety of this new technology to that of traditional nuclear reactors.

> Using a scale from one to seven, where one means that SMRs are a lot less safe than conventional nuclear energy reactors, four means that SMRs are about as safe as traditional nuclear energy reactors, and seven means that SMRs are a lot safer than traditional nuclear energy reactors, how do you feel about the safety of SMRs as compared to the safety of traditional nuclear energy reactors?

The results from this question are illustrated below in Figure 3.1. As shown, the mean of 4.34 is above midscale, indicating that SMRs are generally viewed as safer than traditional reactors. Approximately 42% of the respondents said that SMRs are safer than traditional nuclear reactors, whereas only 19% said they are less safe.

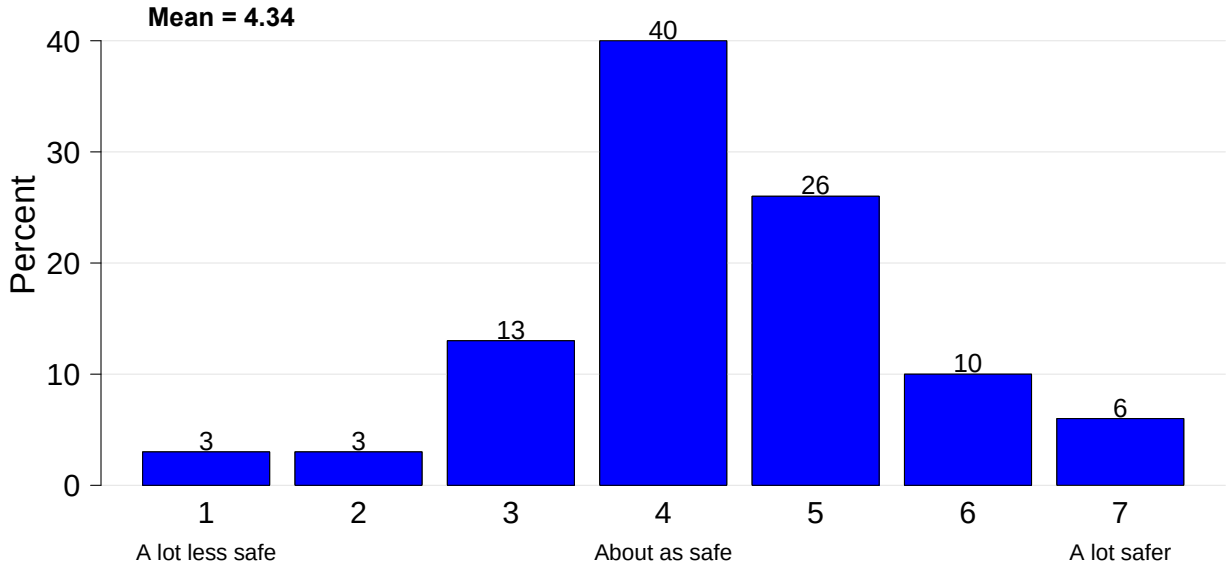

Figure 3.1: Public Perceptions About the Safety of SMRs and Traditional Nuclear Energy Reactors

The respondents were then asked to indicate their level of support for SMRs in civilian and military settings. The question wording was as follows:

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about the construction and use of small modular reactors to generate electricity in the U.S.?

> Using a scale from one to seven, where one means *strongly oppose* and seven means *strongly support*, how do you feel about the construction and operation of SMRs at U.S. military bases within the U.S.?

Figure 3.2 illustrates variations in levels of support for the construction and operation of SMRs and traditional nuclear reactors in the US Findings from the EE15 survey suggest that members of the public not only think that SMRs are safer than traditional reactors, but that support for the use of this new nuclear energy technology is higher than that for traditional nuclear reactors. As shown in the figure, mean support for building traditional reactors at existing or new locations is below midscale whereas support for SMRs at civilian or military locations is above midscale. The level of support is highest for building SMRs at military bases in the US; a majority of the EE15 survey respondents (51%) registered some level of support for this option.

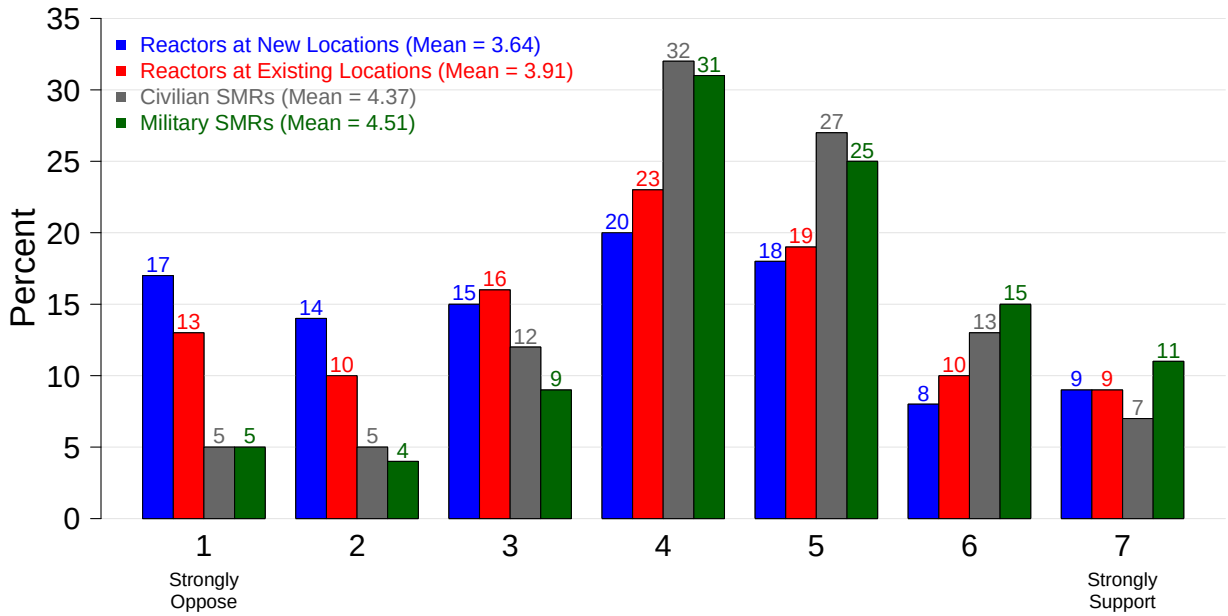

Figure 3.2: Support for Construction of SMRs vs. Traditional Nuclear Reactors

4. EVOLVING PUBLIC AWARENESS OF THE SNF CYCLE

Consent-based siting programs are intended to engage a broad range of important stakeholders, increase awareness among the public, foster open communication, and disseminate relevant information about the siting process in an open and transparent manner. In the longer term, accomplishing these goals is intended to increase community trust in the siting process and, ultimately, the level of community acceptance and ownership of the outcome produced by the process.

In order to successfully design and initiate such a program, it is important to evaluate the background knowledge and understanding of the relevant aspects of the nuclear fuel cycle that can be expected of the public. For instance, how much do members of the public know about current SNF policies in the US? Figure 4.1 shows public responses to questions about existing nuclear waste management practices. Respondents are given four options and asked, what, to the best of their knowledge, is currently being done with most of the SNF produced in the US

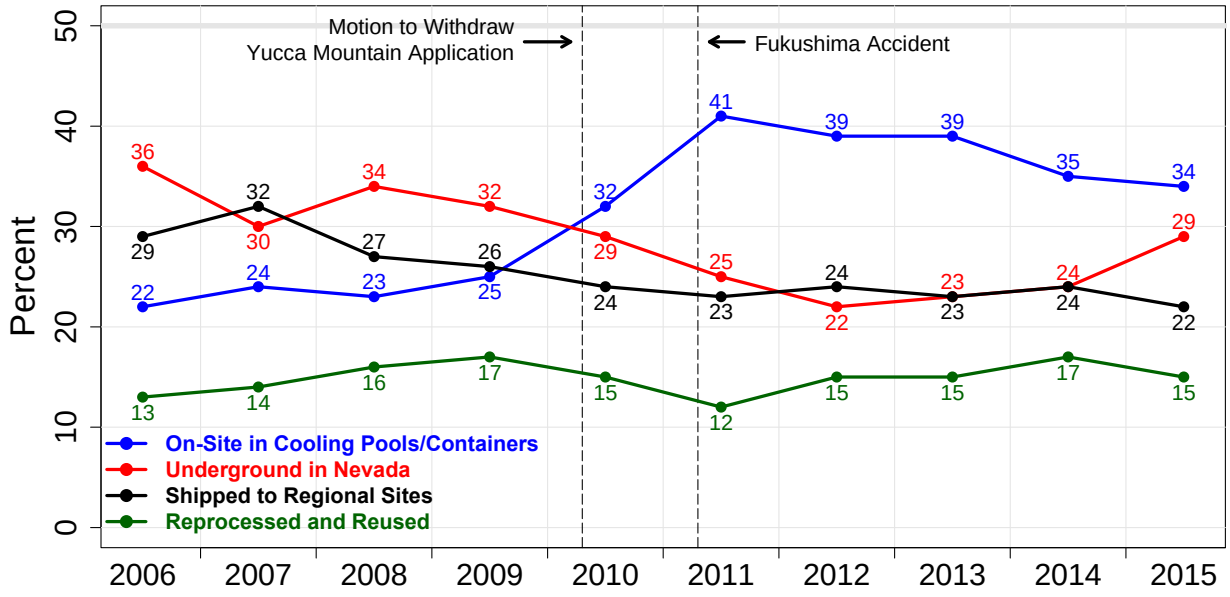

Figure 4.1: Trends in Public Knowledge of Current SNF Policy in the US

Trends from the EE series indicate that the broader public is not well informed about the nuclear fuel cycle. In the 2015 survey, only a third (34%) of the respondents chose the correct option of on-site cooling pools. Nearly one respondent in three believed that SNF was being stored underground in Nevada, and close to 25% responded that SNF is being shipped to regional facilities. Note that the public's knowledge about US nuclear waste management policies increased in the period following the motion to withdraw the application for the licensing of the Yucca Mountain facility and following the Fukushima nuclear plant accident. Media reports after these events tended to focus on SNF and how it was stored. However, recent surveys suggest that levels of public knowledge and awareness are declining again.

In addition to questions about current nuclear waste management, the EE15 survey also contained a number of questions intended to gauge public background knowledge and awareness of aspects of nuclear

energy, spent nuclear fuel, and current nuclear waste policy. The questions in this set included those shown in Table 4.1.

Table 4.1: Public Knowledge and Awareness about Nuclear Energy and SNF Policy

Knowledge Measure	% Correct Responses (2014)	% Correct Responses (2015)
Is your primary residence located within approximately 100 miles of an operating nuclear power plant?	45	45
What currently is being done with most of the used nuclear fuel produced in the U.S.? (Correct answer: temporary on-site storage)	35	34
Is your primary residence located within approximately 100 miles of a site where used nuclear fuel is being stored?	25	23
Have you heard or read about the Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico?	8	6

One of the knowledge questions included in the EE series is whether respondents are aware of their proximity to an operating nuclear power plant. When asked whether they lived within 100 miles of an operating plant, less than half responded correctly (29% said they did not know; 55% gave an incorrect answer).[4] Respondents were also asked whether their residence was within 100 miles of a site where spent nuclear fuel is stored; only 23% correctly responded to this question. As noted above (and shown in Figure 4.1), 34% were able to correctly identify on-site storage as the most common practice for storing SNF. On a related note, when asked about WIPP, the nation's only licensed deep-geologic repository, only 6% of respondents reported to have ever heard of it.

The results in Table 4.1 and Figure 4.1 make clear that public knowledge relevant to SNF management policies is often sparse, though events widely reported in the media can lead to temporary increases in awareness. Consent-based siting programs for SNF facilities will therefore need to consider engagement with members of the public who are not well informed about nuclear energy and nuclear waste issues. Furthermore, it is quite likely that during the siting process there will be an array of stakeholders seeking to inform and influence the public, and some are likely to be providing conflicting kinds of information (Jenkins-Smith and Silva 1998). And, despite the policy specific knowledge deficits described here, members of the public are very discerning about the potential biases of the different actors who are purveyors of policy information (see Section 7.1, below). Designing and building a robust, trustworthy basis for communication and engagement – one that is understood by the public to be as concerned about the interests of potential host communities as they are about siting a facility – will therefore be of critical importance to the success of the consent-based siting program.

[4] The location of respondents' residences was recorded either using geo-location of their device or (where location identification permission was not given by the respondent) by utilizing the respondents' residential ZIP codes. Using this location data, the distance to the nearest operating nuclear power plant was calculated. This method was also used to calculate the respondents' proximity to the nearest temporary spent nuclear fuel storage site.

5. PUBLIC UNDERSTANDING AND PERCEPTIONS OF INTERIM STORAGE

Given that most members of the public know relatively little about nuclear fuel cycle issues, measuring informed opinion and preferences is challenging. Our approach is to provide the respondents with background information on the issues, using as our guide the kinds of claims and arguments raised by policy advocates on multiple sides of the policy debate. In this way, the EE15 survey respondents received a condensed and somewhat simplified version of the kinds of arguments that they will hear in an actual policy debate.[5] To illustrate how this was accomplished, one portion of the survey is designed to elicit preferences about how the US should store SNF—continue on-site storage or build interim storage facilities. To elicit meaningful preferences, we provide respondents with the following background information and then ask them to answer a set of related questions:

> **Now we need to provide essential information for you to consider before answering additional questions. We ask that you read the following three paragraphs carefully so that everyone taking the survey has the same minimum level of factual information.**
>
> Used nuclear fuel is highly radioactive and must be safeguarded for thousands of years or chemically reprocessed, which is not economically feasible in the U.S. today. In 2010 the government halted construction of a deep underground facility inside Yucca Mountain in Nevada that had been intended for permanent storage and disposal of used nuclear fuel.
>
> Currently, used nuclear fuel in the U.S. is stored at more than 100 temporary storage sites in 39 states. This used fuel is stored in cooling pools "on-site" at nuclear power plants and decommissioned facilities. As part of the nation's used nuclear fuel storage policy, the government is trying to decide whether this used fuel should continue to be stored on-site, or whether it should be transported to interim storage facilities until a permanent repository can be constructed.
>
> [Random order for grouped sets of bulleted arguments]
>
> Key arguments that are made FOR current "on-site" storage practices include the following:
>
> - Keeping the used nuclear fuel at current facilities until a permanent repository is constructed would ensure that the radioactive materials have to be moved only once instead of twice.
> - Packaging and transportation of used nuclear fuel from nuclear facilities to interim storage facilities is risky.
> - Storing fuel "on-site" at nuclear facilities is less expensive than building interim storage facilities and buys time for finding permanent future solutions.
> - Current storage at nuclear power plants has not caused any accidents that have exposed the U.S. public to radiation, and with significant investment, current storage sites can be made safer from terrorists and other threats such as flooding.
>
> Key arguments that are made AGAINST current "on-site" storage practices include the following:
>
> - Storing used nuclear fuel at nuclear facilities does not provide adequate protection from terrorists, and increasing security would require substantial effort, time, and money.
> - Some nuclear power plants where used nuclear fuel is stored are near rivers and oceans where flooding is possible, and many are near large population centers, making huge numbers of U.S. residents

[5] We also evaluate these arguments for technical validity by having the survey questionnaires reviewed by technical experts in fuel cycle issues at Sandia National Laboratories (SNL). University of Oklahoma faculty and staff make all final decisions about question wording, and the University of Oklahoma's Institutional Review Board approves all questions for human subjects application.

vulnerable to risks from flooding and other accidents. On rare occasions, used nuclear fuel has leaked radiation into the cooling pools.

- Large volumes of these materials are accumulating that require expensive security; yet current practices do not provide a permanent solution.
- Some of these sites have been dismantled or shutdown, resulting in "stranded" used nuclear fuel. Expensive security measures must be maintained to protect these stored nuclear materials. Interim storage facilities could help consolidate this used fuel.

As shown below in Figure 5.1, public preferences for continued on-site storage have been remarkably stable from 2006 through 2015, with average support falling below midscale. In May of 2010, 40% of the survey respondents opposed continued on-site storage, 33% were unsure, and 27% were in support. Beginning in the 2011 survey, which was administered two months after the Fukushima nuclear event, public support for continued on-site storage declined modestly. By 2013, nearly half (49%) opposed continued on-site storage, and only 22% supported continuation of the practice. This downward trend has ebbed slightly by 2015, when about 42% opposed continued on-site storage, 32% were unsure, and 25% supported the current practice.

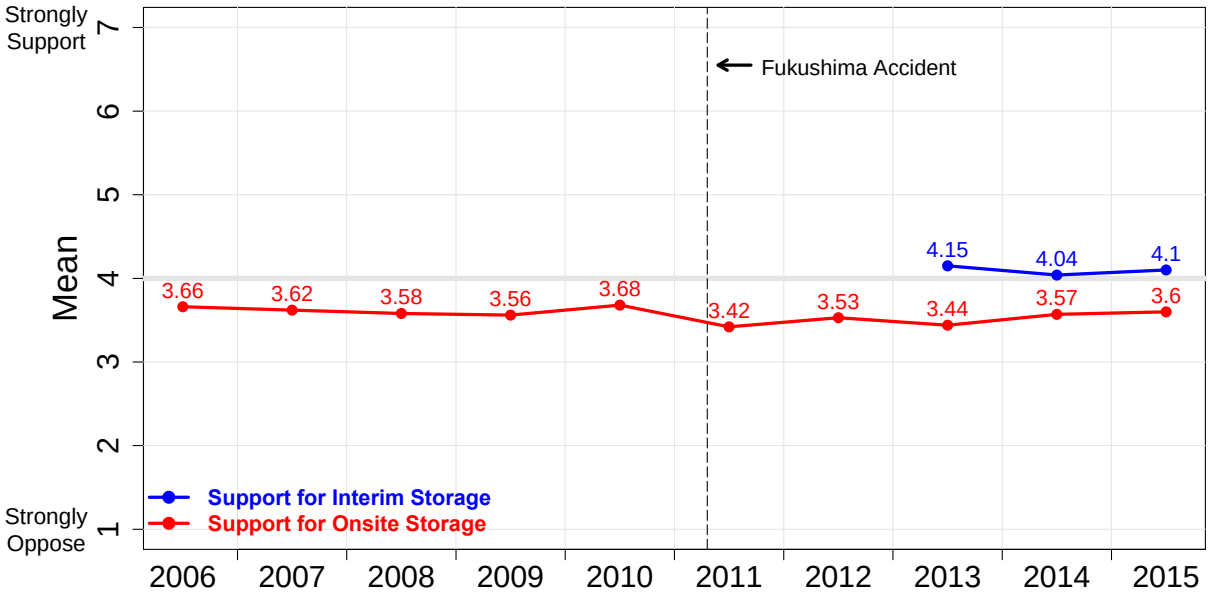

Figure 5.1: Trends in Public Support for Interim vs. On-Site Storage in the US

To elicit public preferences for greater reliance on interim storage, respondents received the following background information and key arguments made by competing stakeholders before answering the question at the end:

> Though nuclear power plants will continue to store some used nuclear fuel in their cooling pools, much of the radioactive materials currently at more than 100 temporary storage sites in 39 states could be consolidated at a smaller number of facilities. The President's Blue Ribbon Commission on America's Nuclear Future recognized that constructing underground repositories for permanent storage and disposal of used nuclear fuel will take decades, and the Commission recommended building interim storage sites in the next 10-15 years where used nuclear fuel could be consolidated, stored, and better secured while one or more permanent nuclear repositories are being developed. These interim storage sites would meet all technical and safety

requirements set by the U.S. Nuclear Regulatory Commission, the U.S. Environmental Protection Agency, and state regulatory agencies.

[Random order for grouped sets of bulleted arguments]

Key arguments that are made FOR interim storage sites include the following:

•Interim sites can be constructed sooner (within 10-15 years) to safely store used nuclear fuel for up to a hundred years, which is longer than feasible for temporary storage at nuclear power plants, and allow more time to develop permanent repositories.

•Interim sites would consolidate used nuclear fuel while providing better protection from terrorists and allowing the radioactive materials to cool and be packaged for eventual shipment to a permanent repository.

•Interim sites would reduce the growing amount of radioactive materials currently being stored at nuclear power plants, many of which are near large population centers, rivers, and oceans where flooding is possible.

•Interim sites would allow removal of "stranded" used nuclear fuel from ten sites and eventually other sites where nuclear reactors have been dismantled or shutdown, but expensive security measures must be continued to protect the stored nuclear materials. Those savings could partially pay for constructing interim storage sites.

Key arguments that are made AGAINST interim storage sites include the following:

•Building interim sites might lead to delaying the more politically difficult solution of building permanent repositories, which may take 30 or 40 years to construct.

•Transporting used nuclear fuel by barge, train, or truck to interim sites is more risky than continuing temporary storage at the sites of operating or dismantled nuclear power plants.

•Expanding current "on-site" storage practices at or near *existing* operational nuclear power plants is cheaper and politically more acceptable than building consolidated interim storage facilities.

•No members of the public have yet been harmed by current practices for temporarily storing used nuclear fuel, and even though many of today's sites are near large population centers, security can be improved to reduce the risks of terrorist attacks and flooding.

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

The answers to this question provided by the 2015 survey respondents are shown in Figure 5.2. As evidenced by the figure, 39% supported the construction of one or more ISFs, 29% opposed, and 32% were unsure, suggesting that EE15 respondents were slightly more supportive of interim storage (mean = 4.10) than on-site storage (mean = 3.60). A comparison of levels of support for on-site and interim storage options is shown above, in Figure 5.1.

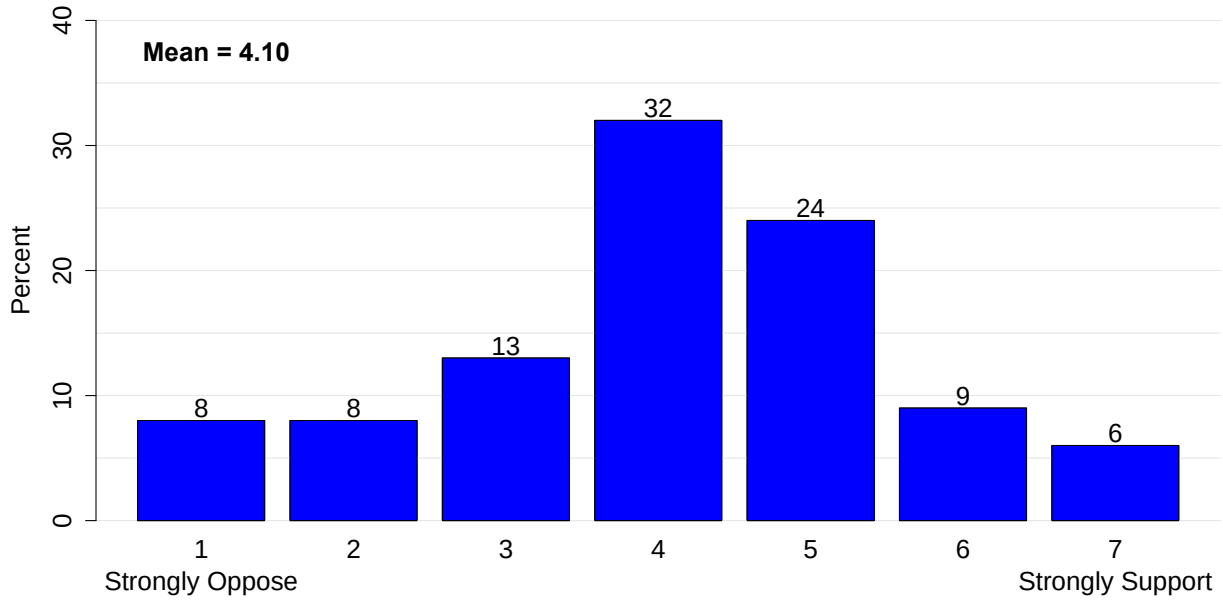

Figure 5.2: Public Support for Siting Interim Storage Facilities in the US

5.1 Proximity to Temporary SNF Storage and Prospective ISF Storage

In addition to broad beliefs about nuclear energy, risk and benefit perceptions, as well as beliefs about climate change, one key factor that defines the context within which individuals make decisions about facility siting is likely to be *proximity*. How far away is the proposed ISF going to be? How close is the nearest temporary storage facility that currently holds SNF? The EE15 survey was designed to consider both aspects of proximity.

When survey respondents were invited to participate in the EE15 survey, they were asked for permission to use their location information.[6] Figure 5.3 shows the approximate location of each survey respondent (each point on the map), and for comparison, the location of current temporary SNF storage sites (triangle). About 78% of 2015 respondents reside within 100 miles of a SNF storage site, while 46% of 2015 respondents reside within 50 miles.

[6] If permission was provided, location information was obtained either directly by their Internet browsers, or their IP address, or by user-entered ZIP codes.

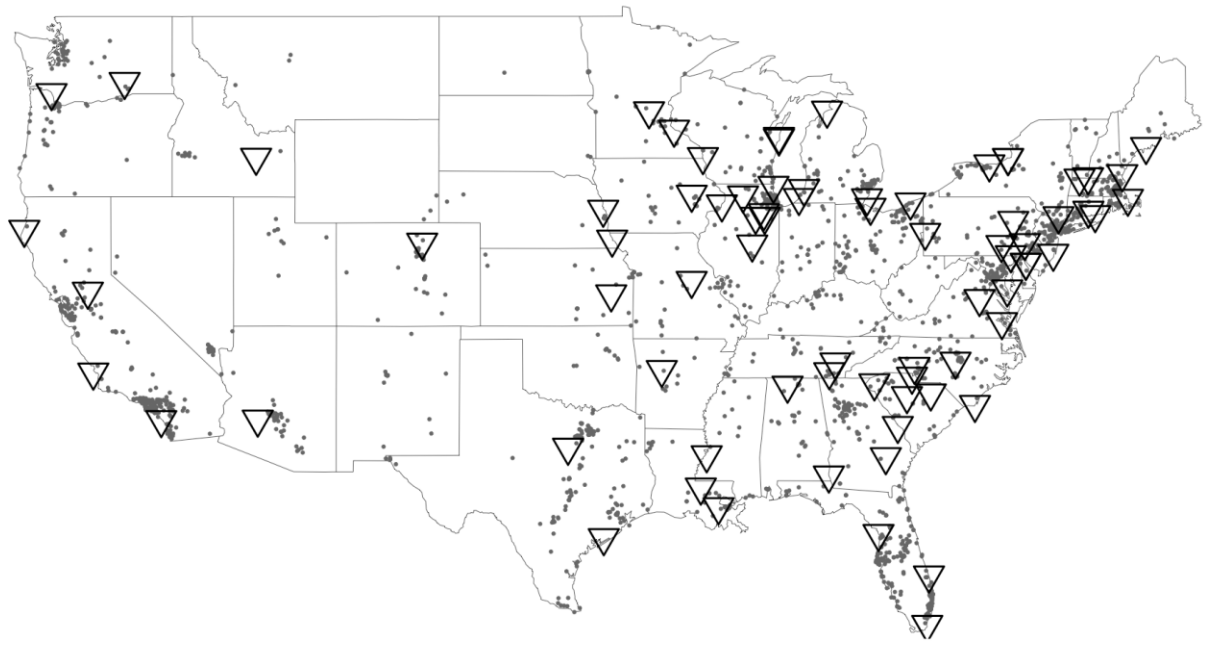

Figure 5.3: Location of EE15 Respondents and Temporary SNF Storage. About 78% of population and 2015 respondents reside within 100 miles of a storage site and 46% of 2015 respondents reside within 50 miles.

The respondents' location data were used in the survey to provide respondents with an estimate of the distance of their residence to the nearest SNF storage site, using the following language:

> Based on the location information you provided: your primary residence is approximately [insert estimate] miles (straight line) from the nearest nuclear energy facility where spent nuclear fuel currently is in temporary storage.

In addition to providing distance to the nearest SNF storage site, we experimented with hypothetical distances to a proposed new ISF. After asking respondents about their general level of support for constructing one or more ISFs (see the results in Figure 5.2), we posed the following question:

> Now assume that this interim storage facility is to be located (randomly assign a distance ranging from 50-300 miles, in whole numbers) miles from your primary residence.
>
> How do you feel about constructing this type of interim storage facility? [*Responses were recorded on a scale ranging from 1 ("strongly oppose") to 7 ("strongly support")*].

Figure 5.4 below presents a comparison between public preferences for siting an ISF and hypothetical proximity to the facility (shown on the left), and public preferences for siting an ISF when considering their current proximity to spent nuclear fuel (shown on the right).

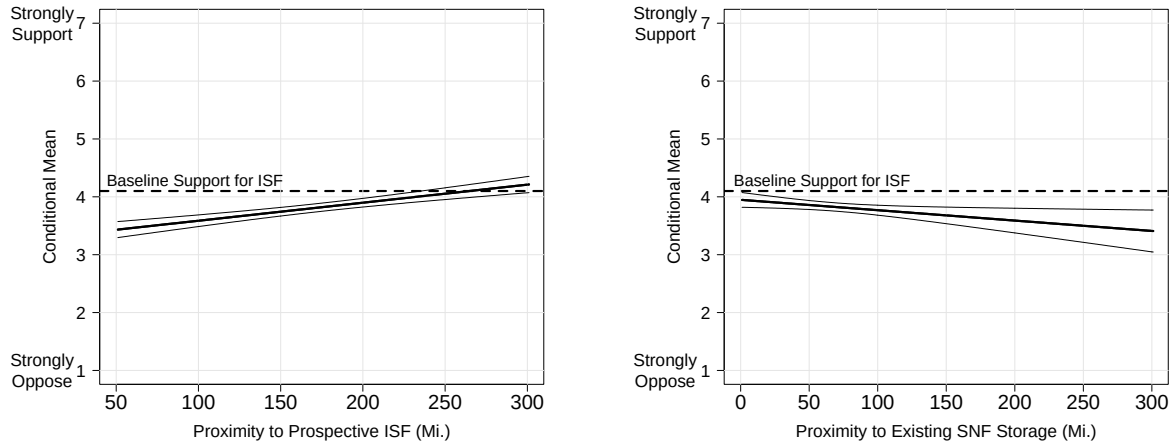

Figure 5.4: Public Preferences for Siting an ISF and the Effects of Proximity

Based on the EE15 survey data, there is a statistically significant negative relationship between support for an ISF and the hypothetical proximity to that facility. In other words, when told to assume that the interim storage facility would be within 50-100 miles of their primary residence, the average level of support is 3.40 (on a seven-point scale). However, support increases as the distance to the ISF goes up. When told that the ISF would be 250-300 miles away, average public support goes up to 4.19 (on a seven-point scale). This relationship is shown in the left-side panel in Figure 5.4.

On the other hand, the relationship between current proximity to SNF and support for siting an interim storage facility is inverse. As distance from current storage of spent nuclear waste increases, the average level of support for siting an ISF decreases. This relationship is also statistically significant, and is shown in the right-hand panel in Figure 5.4.

It is important to note that this exercise in estimating the effects of proximity and distance on support for an ISF is useful for evaluating *general* effects among a population that has not yet engaged with siting officials and other stakeholders on the issue of siting an ISF. Specific effects of distance and proximity are likely to vary by region and by other population characteristics. Also, as with the effects of the Fukushima accident and climate change on nuclear attitudes, proximity is but one variable that may explain individual support for nuclear facility siting. More importantly, as engagement over the siting issue proceeds over time, it is likely that levels of public support will change. In the case of the WIPP, analysis of surveys taken over time in the 1990s showed that average public support for the facility grew considerably over time, and that support was greatest near the proposed facility (Jenkins-Smith et al., 2011). But as the next section will illustrate, the recent WIPP incident may influence the level of support that facility, or similar ones, would receive in the future. A similar (though less widespread) effect of proximity was seen in the case of the proposed Yucca Mountain repository, though a majority of the Nevada public persistently opposed opening the repository (Dunlap et al., 1993; Flynn and Slovic, 1995).

In summary, the EE surveys indicate that members of the public are somewhat reluctant to support continued temporary storage of SNF on-site at nuclear power plants. They are slightly more supportive of constructing one or more interim facilities for the storage of nuclear waste while the US considers a more permanent solution. When respondents are informed of their proximity to existing SNF storage, those who live closest to current temporary sites tend to be more supportive of siting ISFs. On the other hand, when asked about support for a prospective ISF without considering their current proximity, distance has a negative effect on public support. These factors are likely to influence the initial public responses to ISF

siting issues, and should be anticipated by program officials in the early stages of consent-based siting efforts.

6. NUCLEAR ACCIDENTS AND SUPPORT FOR ISF: THE CASE OF WIPP

In tandem with studying the effects of the Fukushima accident on nuclear attitudes, the EE15 survey asked respondents how the incident at the WIPP facility in New Mexico, US on February 14, 2014 affected their support for a prospective ISF. As was illustrated with the data on the Fukushima event, focusing events involving nuclear accidents have the potential to influence the context within which the public views the risks and benefits associated with nuclear energy. At the same time, incidents like the one at WIPP that involve nuclear storage might have a unique influence on public preferences for siting nuclear storage facilities. WIPP is the only operating deep geologic waste repository in the US, and well-publicized incidents that undermine public beliefs that the operators the facility can manage it safely might influence future support for WIPP and other storage facilities.

Before asking respondents how the incident at WIPP influenced their support for building ISFs, we asked if they had ever heard about the facility. Only 6% of our respondents said they had previously heard about WIPP. In order to provide a baseline level of knowledge about WIPP to all respondents, we described the facility, and the incident in February 2014, as follows:

> The Waste Isolation Pilot Plant (WIPP) in New Mexico is the only deep geological repository in the US. For permanent disposal of certain classes of nuclear waste termed "transuranic materials." These radioactive materials were created during the production of U.S. nuclear weapons and are being buried in salt deposits at depths of about 2,000 feet under the New Mexico desert. The materials stored at WIPP DO NOT include spent nuclear fuel from nuclear power plants. The site has been operational since 1999.
>
> On the evening of February 14, 2014, trace amounts of airborne radioactive materials were discovered above ground near the facility. It was determined that 21 workers were exposed to trace levels of radiation. No deaths or serious injuries have been reported, and no one is known to have been exposed to harmful levels of radiation. Pictures from the underground facility show the lid of a drum of waste burst open in a room that is partially filled with containers of radioactive waste. An open drum could release radioactive material into the air flowing through the repository. The cause of the burst lid in an unsealed room is still under investigation at this time.

With this background information in mind, survey respondents were then asked one of two questions [split survey experiment]:

50% of the respondents were asked how the WIPP event affected their support for building regional ISFs:

> On a scale from minus ten to plus ten, where minus ten means the recent experience at the Waste Isolation Pilot Plant (WIPP) in New Mexico *strongly reduces* your support, zero means the WIPP experience has *no effect* on your support, and ten means the WIPP experience *strongly increases* your support, how does the recent release of radiation at WIPP affect your support for building regional interim storage facilities to consolidate used nuclear fuel from more than 100 widely distributed sites in 39 states across the U.S.?

The other 50% of the survey respondents were asked how the WIPP event would affect their support for building more storage and disposal sites for SNF in the US:

> On a scale from minus ten to plus ten, where minus ten means the recent experience at the Waste Isolation Pilot Plant (WIPP) in New Mexico strongly reduces your support, zero means the WIPP experience has no effect on your support, and ten means the WIPP experience strongly increases your support, how does the recent release of radiation at WIPP affect your support for building one or more storage and disposal sites for spent nuclear fuel in the U.S.?

The results of this experiment and these questions are displayed in Figures 6.1. Focusing first on the implications of the WIPP incident for support for an ISF (the blue bars in Figure 6.1), the percentage of respondents who said that the incident had a negative impact on their support for an ISF was 43%,

whereas the percentage of respondents who claimed that the incident had a positive influence was 23%. 34% said the incident had no effect on their support for an ISF.[7]

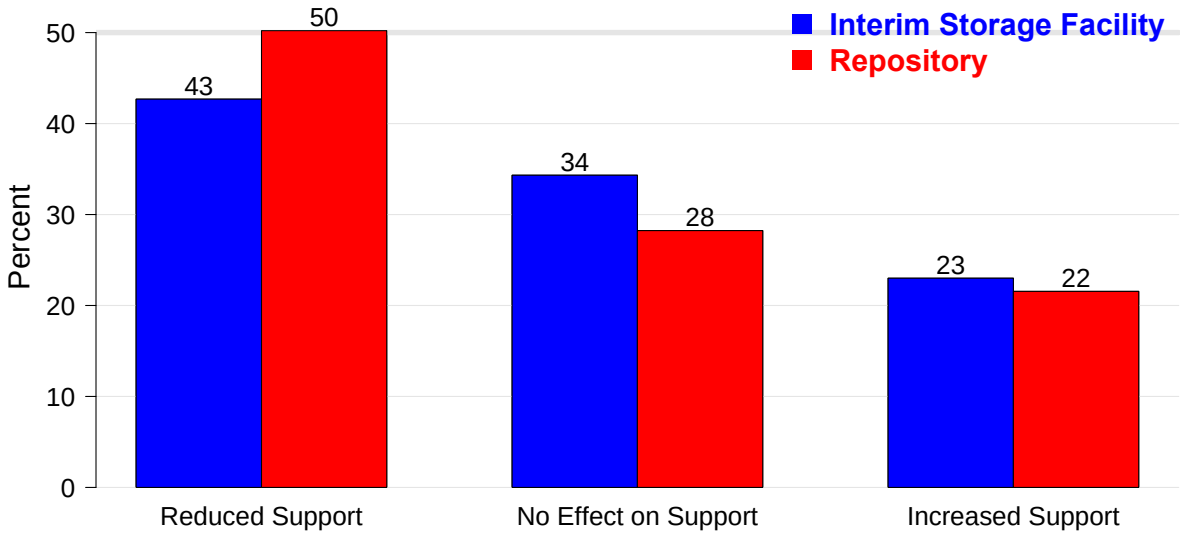

Figure 6.1: Implications of WIPP Incident for Support of Storage and Disposal Site

The effect of the WIPP incident on public support for an ISF – which is a temporary surface storage facility rather than an underground permanent disposal facility – may not be as great is it would be for a permanent deep-geologic disposal facility for SNF. The experimental results in Figure 6.1 bear this out. The red bars show the effect of description of the WIPP incident on self-reported change in support for a permanent deep-geologic disposal facility for SNF. These results indicate that, in the context of an effort to site a permanent SNF repository, a recounting of the (as yet unresolved) story about the WIPP incident is likely to have a negative effect on support for the facility.

[7] We should note that, compared with the EE14 results, the negative effects of the WIPP incident on support for an ISF have attenuated over time. The mean effect in the 2014 survey was -1.87. In 2015 the mean effect was -1.28, a statistically significant reduction in the magnitude of the negative effect on support for an ISF. This may reflect the relative scarcity of continuing reporting and social media content concerning the incident.

7. PUBLIC PERSPECTIVES ON THE INSTITUTIONAL BASIS FOR SNF MANAGEMENT

Any consent-based program must play close attention to institutional credibility and trust because of its potential impact on the design, implementation, and outcome of a nuclear facility siting effort. The BRC was particularly attentive to this aspect of the siting process, as is the recently proposed Nuclear Waste Administration Act of 2015 introduced in the US Senate. In addition to designing a flexible siting process where key concepts like consent and veto authority are not predefined, understanding public expectations about sources of bias in communication and institutional credibility is critical for effective public engagement. This section presents insights into how EE survey respondents view existing institutions/groups involved in the siting process. Additionally, we focus on how variations in the institutional basis for a new independent entity specifically created for leading the siting process for a nuclear waste facility will influence the levels of public trust.

7.1 Institutional Trust and Bias

Complex technical and policy options such as the siting of a nuclear waste facility, coupled with the extant knowledge deficits discussed earlier in the report, highlight the importance of open and transparent communication of benefits and risks. The process is complicated because, when policy choices involve specialized expertise and complex decision making processes, members of the public typically must rely on the expertise of others in deciding whether to support or oppose specific policy options. Nuclear materials management policies, in particular, require the public to rely on information provided by technical experts from a variety of public agencies and non-governmental groups. To evaluate relative levels of public trust in technical information about SNF management and the valence of public expectations about associated risk assessments, we pursue two related inquiries, beginning with the following questions.

> *Lead-in:* Managing spent nuclear fuel and other radioactive materials can be technically complex, and getting information you can trust is important. Please indicate your level of trust in information provided by the science and engineering experts from each of the following organizations using a scale from zero to ten, where zero means *no trust* and ten means *complete trust*. (random order)
>
> - The US Nuclear Regulatory Commission
> - The US Environmental Protection Agency
> - US national laboratories for energy and security
> - The National Academy of Sciences
> - State regulatory agencies
> - Environmental advocacy groups, such as the National Resources Defense Council or the Sierra Club
> - The Nuclear Energy Institute, which represents the nuclear power industry
> - Utility companies that own nuclear power plants
> - The US Department of Energy
> - State and local emergency response agencies, such as the police and fire departments

The mean responses, ordered from highest to lowest trust in the scientific and technical information provided by experts from each group, are shown in Figure 7.1.

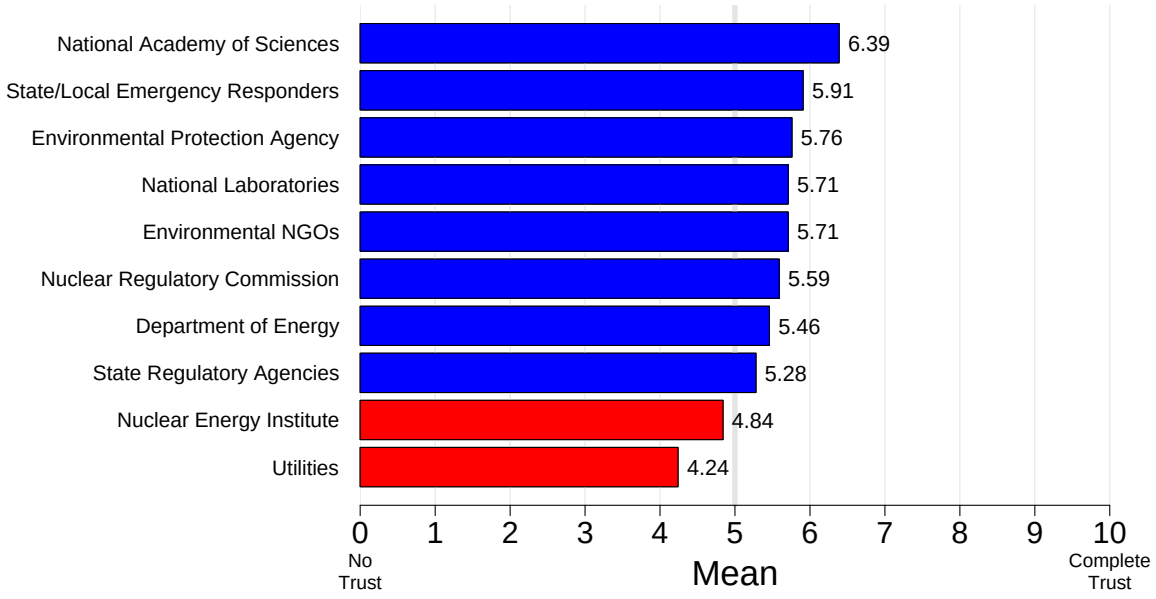

Figure 7.1: Mean Institutional Trust in Information about Spent Nuclear Fuel

Based on results from the EE15 survey, mean levels of trust in information sources vary significantly, with greatest trust accorded to technical experts from the National Academy of Sciences. State and local emergency responders are the second most trusted source of information about spent fuel. The US Environmental Protection Agency (EPA), national laboratories, and environmental NGOs are seen as almost equally trustworthy, close behind the top two entities. The US Nuclear Regulatory Commission (NRC), DOE, as well as state regulatory agencies fall slightly lower on the list. Note that experts from all the above organizations score above midscale for public trust. The two organizations that fall below midscale are the Nuclear Energy Institute (NEI) and the nuclear utilities.

Next we focus on the *valence* of the expected bias in risk assessment by experts in each of the groups listed above. In addition to studying the level of trust accorded in each group, it is important to understand whether members of the public expect to observe a systematic pattern of bias from experts within the various organizations and agencies involved in SNF siting debates. Our interest is in understanding whether some groups are perceived to systematically understate or downplay risks associated with nuclear materials management, while others may be perceived to exaggerate those risks. By the same token, we want to assess whether some entities are more likely to be perceived as accurate assessors and communicators of the risks associated with nuclear energy and facility siting. To understand this issue, we ask the following question:

> Now we want to know more about impressions you may have about how these organizations are likely to assess risks associated with managing spent nuclear fuel. Using a scale from one to seven, where one means the organization is likely to *downplay* risks, four means the organization is likely to *accurately assess* risks, and seven means the organization is likely to *exaggerate* risks, please rate your impressions of how each organization is likely to assess risks.

The mean values for the perceived bias in scientific and technical information provided by technical experts representing each of the groups is shown in Figure 7.2.

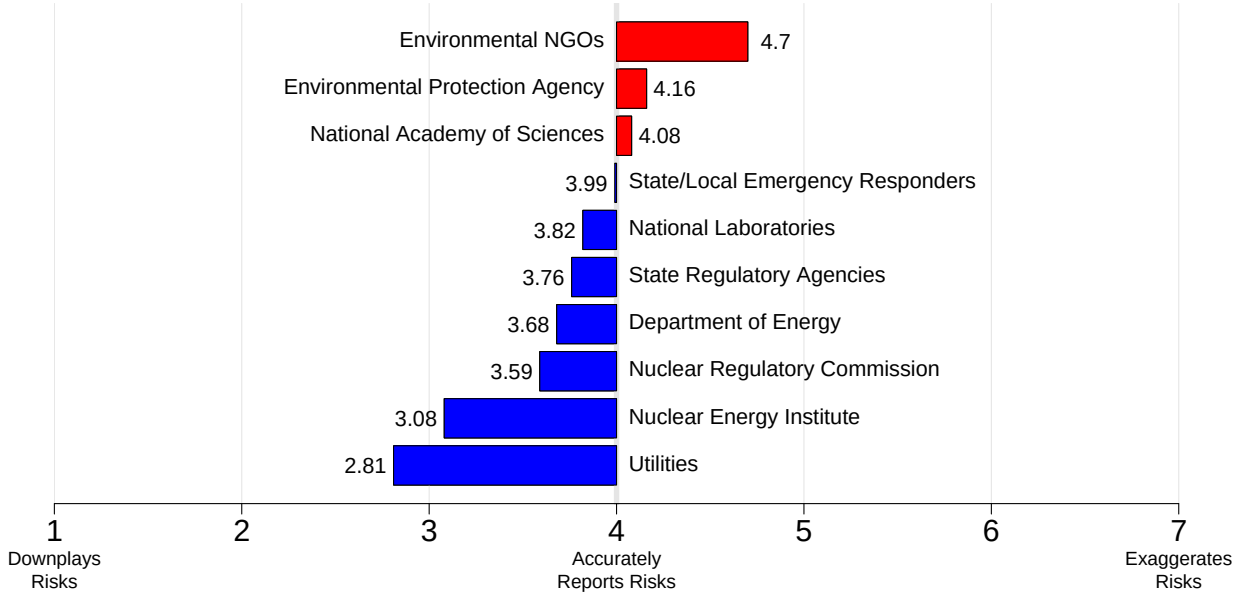

Figure 7.2: Mean Levels of Perceived Bias in Institutional Risk Assessments

In general, the results in Figure 7.2 show that state and local responders are seen as providing the most balanced information about the risks associated with nuclear waste management, followed closely by the National Academy of Sciences. The EPA is perceived to have a slight bias toward exaggerating such risks, while the US national laboratories, state regulators, the DOE and NRC continue to be viewed as reasonably credible, though with a modest propensity to downplay risks. Both industry groups (NEI and utilities) and environmental NGOs are broadly perceived to be more prone to skew the representation of risks (though in opposite directions). These perceptions of bias serve to filter the scientific and technical information and policy recommendations concerning nuclear waste options received by a public that is less than well informed about the particulars of the nuclear waste cycle (as shown in Section 4).

7.2 Public Perspectives on a New Managing Organization for SNF: "Fedcorp"

In addition to highlighting the importance of trust and credibility during the siting process, the BRC report noted an apparent lack of public trust in the DOE. To build trust and garner success during the siting process, the BRC recommended the creation of a new organization "to provide the stability, focus, and credibility that are essential to get the waste program back on track" (BRC, 2012, p. *x*). It was proposed that this new organization be defined as a private company chartered by the government and funded by fees from nuclear energy.[h] The goal was to designate a new organization to wield nuclear waste management authority, one that could elicit greater trust from the public and enhance the legitimacy of SNF management processes. The proposed Nuclear Waste Administration Act of 2015 also discusses the establishment of a new organization to manage nuclear waste that would be in charge of developing and implementing a new consensual process for the siting of nuclear waste management facilities. Such an agency would be established as an independent entity in the executive branch (Nuclear Waste

[h] The BRC recommended the formation of a new single-purpose, government-chartered private company outside DOE to oversee SNF policy management; we call this organization "Fedcorp" for ease of reference.

Administration Act of 2015, S. 201, p. 13). These two descriptions of a new administrative organization that would lead the siting process provide strikingly different institutional designs. It is not clear how the public would view these alternative designs, nor is it clear how public trust would vary based on these alternatives. To address these issues, the EE series has asked questions about different variations of such an entity since 2012. Results from the 2012 EE survey suggested that gaining public trust for a waste management authority modeled on the BRC's recommendation may be more difficult than expected (Jenkins-Smith et. al. 2013a, p. 48). Possible reasons for the low level of expressed trust in the BRC's model include the nascent nature of the concept and its characterization as a private company chartered by the federal government. In short, the *institutional design* of the entity may be influencing the initial levels of trust from the public.

To analyze the relationship between trust and alternative institutional characterizations of the nuclear waste authority, the EE15 survey conducted a split design experiment in which the definition of the "Fedcorp" entity was varied. The descriptions for the three distinct designs for the Fedcorp entity were as follows:

1. A private company chartered by the federal government that is funded by fees from nuclear energy, and that is given responsibility for managing spent nuclear fuel from U.S. nuclear power plants. It would be subject to a Federal Oversight Board.
2. A private company created by the nuclear power industry that is funded by fees from nuclear energy, and that is given responsibility for managing spent nuclear fuel from U.S. nuclear power plants. It would be subject to oversight from federal regulatory agencies.
3. A new independent agency of the federal government, with leadership appointed by the president with the advice and consent of the Senate, that is funded by fees from nuclear energy, and that is given responsibility for managing spent nuclear fuel from U.S. nuclear power plants. It would be subject to a Federal Oversight Board.

Each respondent was randomly assigned to consider one of these three institutional Fedcorp designs.

In the first step of the experiment, respondents were asked to rate their level of trust for the described organization, along with the other actors as discussed previously. The results for the three alternative designs for the Fedcorp, in comparison with the other actors evaluated in Figure 7.1, are shown below in Figure 7.3.

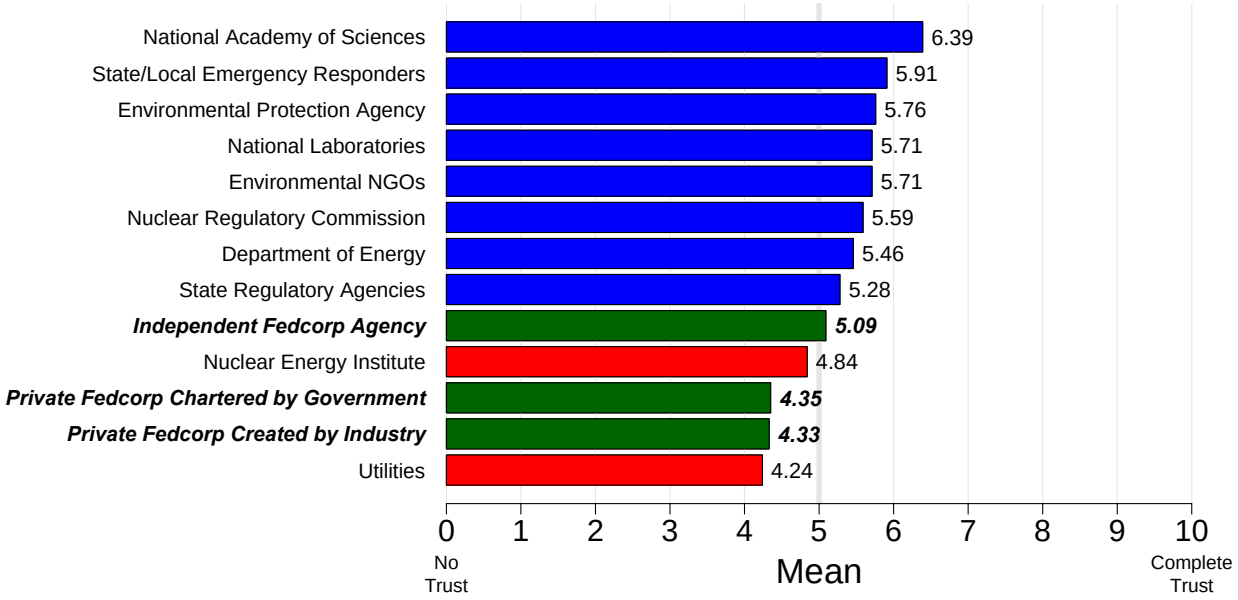

Figure 7.3: Mean Institutional Trust in Information about Spent Nuclear Fuel from 'Fedcorp'

The independent federal agency, which matches the Senate bill description of the Nuclear Waste Administration, is perceived as the most trustworthy of the three institutional characterizations. Trust in the federal version of Fedcorp lies above midscale and is comparable to the perceived trust accorded to state regulators and the DOE. The private versions of Fedcorp, on the other hand, fall below mid-point on the trust scale and are more comparable in trust to the NEI and nuclear utilities.

In the second step of the experiment, respondents were asked to indicate the expected direction and extent of "bias" they thought the Fedcorp entity – in comparison with other key institutional stakeholders in fuel cycle management policy – would display in its assessment of the risks posed by management of SNF. Recall that the question was framed as follows:

> Using a scale from one to seven, where one means the organization is likely to *downplay* risks, four means the organization is likely to *accurately assess* risks, and seven means the organization is likely to *exaggerate* risks, please rate your impressions of how each organization is likely to assess risks.

The distribution of the responses to the three randomly assigned characterizations of Fedcorp, in comparison with the other organizations, are shown below in Figure 7.4. Note that both the federally chartered and industry-backed private corporations tasked with nuclear facility siting are expected to downplay risks, though the privately-backed version of the Fedcorp are expected to be significantly more biased. The independent agency version of Fedcorp is also expected to downplay risks, though to a more moderate extent (comparable to the expected bias by the NRC and DOE).

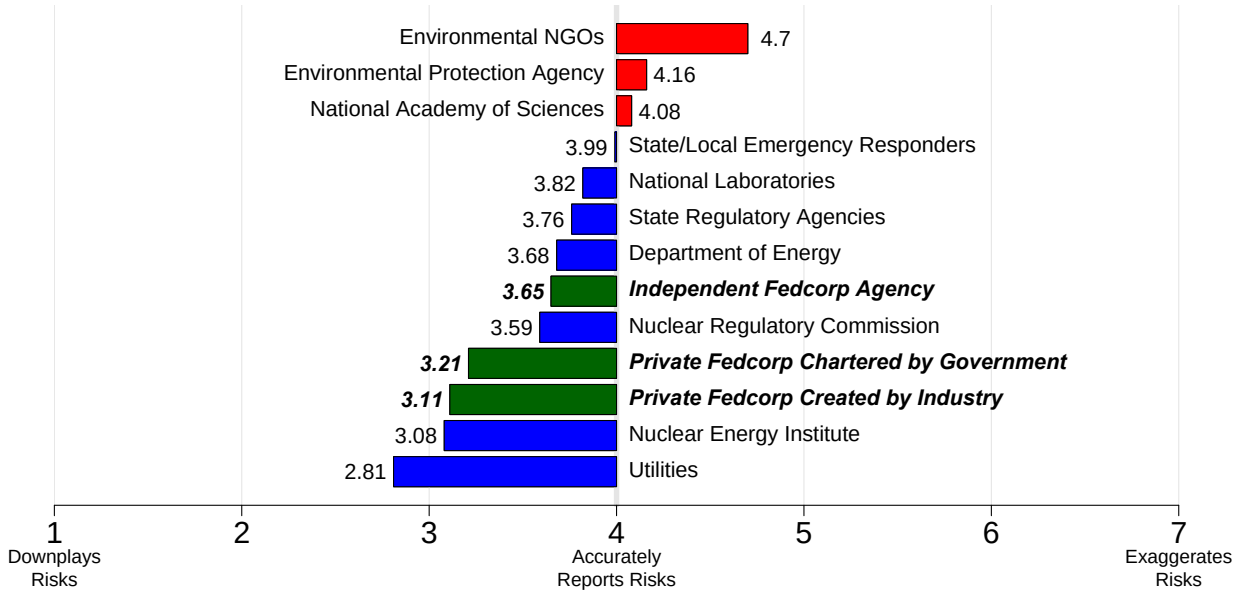

Figure 7.4: Mean Levels of Perceived Bias in Institutional Risk Assessments and 'Fedcorp'

Overall, the results described in this section indicate that respondents expected that an independent federal agency charged with nuclear waste disposal would be more trustworthy, and less biased, than would a private nuclear waste authority. A federally chartered, private organization would be more trustworthy, and less biased, than an organization sponsored by the nuclear industry. Note, however, that these observations concern *a priori* perceptions about bias and trust, based only on the description of the institutional structure of the new nuclear waste authority. Garnering public trust will ultimately be based on a good deal more than the formal institutional structure of a new organization. The new authority will need to persuade the public and stakeholders that it provides balanced information and unbiased risk assessments.

8. PUBLIC PERSPECTIVES ON THE DESIGN OF A CONSENT-BASED SITING PROCESS

In its review of the nation's nuclear waste management policy, the BRC concluded that a successful siting process would be one in which host communities, states, and tribal governments are (a) invited to participate in a consent-based process; (b) have access to the information and resources needed to fully engage in key decisions and advocate effectively for their interests; and (c) retain the right to opt out. In an open and inclusive consent-based siting process, some of the key elements include flexibility, adaptability, and collaboration with the public in characterizing the facility siting process. The BRC's final report provided a broad outline for such a process, including:

- Develop a set of basic initial siting criteria;
- Encourage expressions of interest from a large variety of communities that have potentially suitable sites; and
- Establish initial program milestones.

In line with the BRC recommendations, the US DOE described a consent-based facilities siting process to include key procedural and consensual elements such as agreement at multiple jurisdictional levels (federal, state, tribe, and community levels), open and transparent communication of benefits and risks, and mutually agreed upon off-ramps. Public perceptions about accurate communication of risks and benefits were discussed in the prior section. This section expands on public perspectives of consent, veto authority, and an inclusive decision-making process. For this purpose, the EE15 survey was designed to provide information on broad public preferences regarding (a) what kinds of stakeholders should hold critical "veto" authority within that process; and (b) how much authority should different types of decision-making entities possess during the siting process. Each of these points is addressed below.

8.1 Consent and Veto Authority

In order to understand which stakeholders the public would consider to play the most pivotal roles – and therefore merit the capacity to formally block or veto the selection of a site – survey participants were first asked to assume that "a small community that is about 50 miles from your primary residence … has volunteered to be considered for hosting an interim storage facility for spent nuclear fuel." They were then presented with a randomly ordered list of stakeholders (as shown in Table 8.1) and asked:

> Please select all those on the following list that you think should be allowed to block or veto the construction of a proposed interim storage facility for used nuclear fuel in [insert state]:

Respondents could choose one of three options for each of the stakeholders on the list – "consent not required", "consent required", or "not sure." Table 8.1 shows the percentage of respondents who chose "consent required" for each stakeholder.

Table 8.1: Who Should Have Authority to Block/Veto a Siting Decision?

Who should be allowed to block / veto a siting decision for an ISF?	**%**
A majority of citizens, including those in Native American communities, residing within 50 miles of the facility	**79**
Host state environmental protection agency or equivalent	**75**
A majority of voters in the host state, including affected Native American communities	**73**
US Nuclear Regulatory Commission	**70**
US Environmental Protection Agency	**69**
US Department of Energy	**65**
Tribal Authorities of Affected Native American Communities	**62**
The Governor of host state	**62**
Leaders of the host state's legislature	**56**
US Congressperson representing the host district	**55**
Either of the two US Senators representing the host state	48
Nongovernmental environmental groups in the host state	37

As shown in Table 8.1, the survey respondents identified three sets of actors to have veto authority in the ISF siting process. The first set – chosen by 73-79% of the respondents – include a majority of residents living near the facility, the host state environmental protection agency, and a majority of citizens of the host state. The second group, chosen by 65-70% of the respondents, consists of involved federal agencies (the NRC, the EPA, and the DOE). The third group is made up of political representatives – Tribal authorities, the host state governor, leaders of the host state legislature, and the congressional representative for the host district. This group was chosen by 62-55% of the survey respondents to have veto authority.

Overall, the EE15 survey responses indicate that residents living near a prospective ISF host community would prefer that a wide array of actors have a consequential role in the siting process. This is consistent with the "inclusive" view of consent that the survey respondents have consistently expressed in the EE survey series (Jenkins-Smith et al. 2013b, p. 45). While it may not be feasible to have large numbers of veto-players in the siting process, it is clear that members of the public would prefer a process that provides meaningful engagement with nearby residents, state citizens, oversight agencies, and representatives.

8.2 Perspectives on the Involvement of Different Kinds of Decision-Makers During the Siting Process

A consent-based siting process for SNF management in the US will require the involvement and broad agreement of stakeholders with different backgrounds, expertise, and sources of authority. In addition to measuring the inclusiveness of the siting process using veto authority as the benchmark, the EE15 survey included questions about the potential role of different kinds of decision makers to help design and implement a consent-based process. Siting decisions are often made through iterative stages, providing

the flexibility for both implementers and potential host communities to understand and adapt to contextual changes while assuring sufficient time for development of a competent and fair discourse with the host community and other stakeholders. Throughout this iterative process, technical, political, and social issues need to be considered that require input from policymakers, technical experts, and community members. However, it is unclear how much influence each type of decision-maker should be accorded in the minds of the public.

The EE15 survey included questions about the level of influence that should be assigned to three distinct types of decision makers—elected officials, expert panels, and deliberative citizen panels. The survey briefly described the three types of actors, as shown below:

> Many policy decisions in the U.S. are made by elected officials who are chosen to represent the interests of their constituents and make decisions for the communities they serve. In the case of decisions on technical issues like the transportation and storage of spent nuclear fuel, elected officials may take into account input from citizens, suggestions from technical experts, and guidance from laws and regulations.
>
> In some cases, policy decisions related to scientific and technical issues like how to transport and store spent nuclear fuel, have been based on the recommendation of a "technical expert panel." These expert panels are typically made up of independent scientists and engineers recruited by the federal government. Because these experts have specialized knowledge about the technical aspects of storage and transportation, utilizing expert panels often ensures that the most up-to-date scientific and technical information is considered in making policy decisions.
>
> Recently, there has been interest in getting local citizens to help make decisions about scientific and technical issues like how to transport and store spent nuclear fuel, by assembling a citizen panel that is made up of 10-20 people from the community that is most affected by a given issue.
>
> - Citizen participants would be selected through a process similar to jury selection.
> - Once selected to be on a citizen panel, participants first would be given scientific information in order to learn about and discuss the issue in-depth.
> - The panel would then meet to discuss the issue in the presence of a moderator to ensure fair and respectful discussion among citizens.

Following this information, respondents were asked two questions--

(1) On a scale from zero to ten, where zero means *no trust* and ten means *complete trust*, how much do you trust [insert actor type] to make decisions that are good for society?
(2) On a scale from zero to ten, where zero means *no influence* and ten means *complete influence*, how much influence do you think [insert actor type] should have when deciding whether or not to build an interim storage facility for spent nuclear fuel in that community?

As shown in Figure 8.1, with reference to the level of trust accorded in each type of decision maker, elected officials were accorded significantly less trust to "make decisions that are good for society" (on average) than were expert panels and citizen panels. This finding is consistent both for siting a SNF transportation corridor and an ISF. When asked about the preferred level of influence each type of decision maker should have, survey respondents consistently rated elected officials lower than technical and citizen panels.

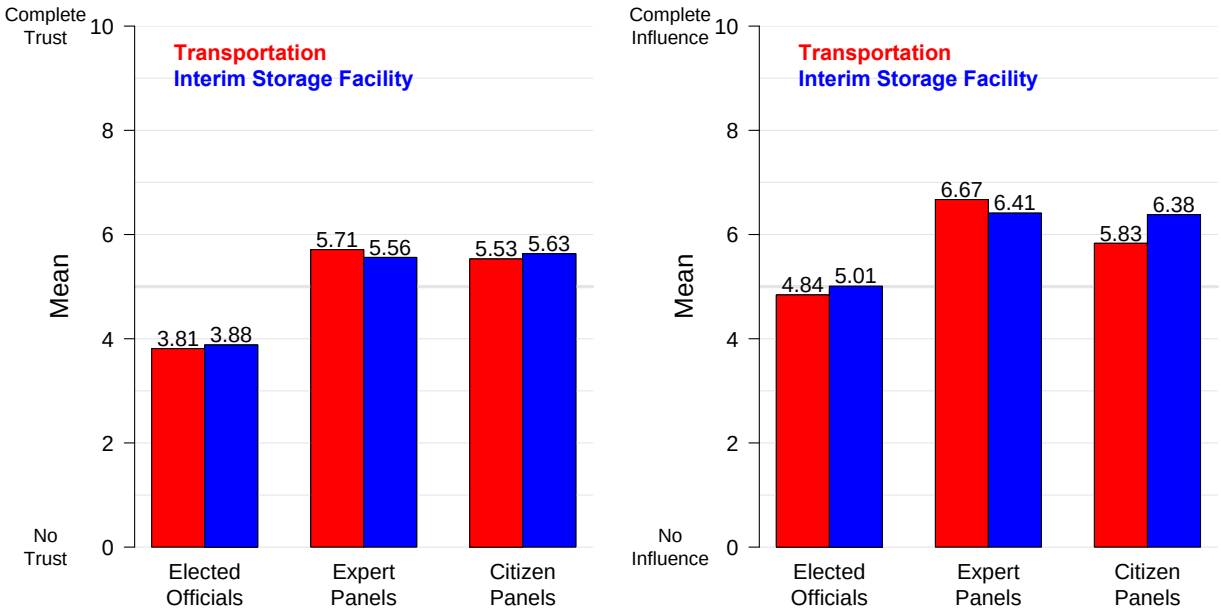

Figure 8.1: Public Trust in and Preferences for Relative Influence of Decision-Making Entities in the Siting Process

The EE15 survey findings also reveal some interesting differences in preferences about the role of citizen and technical panels for siting processes for transport routes versus an ISF. Survey respondents preferred that technical expert panels and local deliberative citizen panels be given roughly equal influence in siting an ISF. By contrast, for transportation routes, respondents preferred that expert panels have greater influence than citizen panels. In both cases, survey respondents preferred to give elected officials less influence than either expert panels or local deliberative citizen panels.

These findings have important implications for policymakers and program managers as they grapple with the task of designing and implementing a successful consent-based siting process. It is clear that the public trust in elected officials is much lower than is trust for technical experts or representative panels of citizens drawn from a potential host community. It is also evident that members of the public would prefer to see a larger role for experts and local citizens during the siting process than for elected officials. Nevertheless, elected representatives necessarily play an integral (and often decisive) role in collective decision making in the US The evident and continuing erosion of trust in elected officials therefore raises significant hurdles for programs – like the siting of SNF routes and storage facilities – that necessarily distribute burdens and benefits across a wide array of American citizens (BRC 2012, p. viii; Pew Research Center 2014).

9. PROSPECTIVE PUBLIC ENGAGEMENT IN SITING ISF AND SNF TRANSPORT CORRIDORS

Mechanisms for engaging with the affected publics will be a crucial element of any consent-based siting process, the importance of which is recognized by policymakers and academics alike. For example, the BRC report argues that "the job of better communicating information and effectively engaging different constituencies must be seen as one of the core missions of a revitalized waste management program" (BRC 2012, p. 8). Doing so, according to the BRC, can help build public trust in the government and increase the legitimacy of the siting process. Similarly, academic studies on public engagement have found that beliefs about inclusiveness and fairness of the policy process are associated with decision favorability and outcome acceptance (Besley 2010).

Furthermore, as shown in Section 8, a large majority of the EE15 respondents believed that the voters and residents of the host state should have veto authority in the consent process. In practice, examples from Sweden and Finland help corroborate these findings (Metlay 2013). Little is known, however, about what to expect about how members of the public will engage in such a process. Who, for example, is most likely to provide input to the process? For that reason, the EE15 survey included a set of questions focusing on respondents' expectations about *how* they might engage, the expected *levels* of engagement, and the *types* of engagement mechanisms they prefer.

9.1 Engagement in an ISF Siting Process

Before asking EE15 survey respondents about the kinds of prospective engagement activities in which they might participate, they were provided the following background information:

> Public engagement in the process of developing interim storage sites will be critical. We want to know how likely it is that you would actively participate in the debate and policy process if construction of an interim storage site for used nuclear fuel was proposed within 50 miles of your residence in [insert state]. We understand that you cannot be sure about your precise level of involvement, but please be as realistic as possible when responding to the following questions using a scale from one to seven, where one means *not at all likely*, and seven means *extremely likely*.

Respondents were then provided, in random order, the following list of activities and asked to indicate their expected likelihood of engaging in each:

- Attend informational meetings held by authorities
- Write or phone your elected representatives
- Express your opinion using social media
- Serve on a citizens' advisory committee
- Help organize public ***support***
- Help organize public ***opposition***
- Speak at a public hearing in your area

For each response, respondents were coded as "likely" to engage if their response was above the midpoint (5 or higher) on the 1 ("not at all likely") to 7 ("extremely likely") scale. The results are shown in the Table 9.1.

Table 9.1: Public Responses to Likelihood of Engagement in the Siting Process

Likely to Engage in… (% with score above scale mid-point)	2014	2015
Attend informational meetings held by authorities	50%	49%
Express your opinion using social media	44%	44%
Serve on a citizens' advisory committee	38%	44%
Write or phone your elected representatives	43%	40%
Help organize public ***opposition***	24%	25%
Speak at a public hearing in your area	25%	24%
Help organize public ***support***	22%	20%

As indicated in Table 9.1, about half of the EE15 respondents said it was more likely than not that they would attend public information meetings on siting an ISF within 50 miles of their homes. The next most likely activities were expressing their opinion using social media platforms (44%), serving on a citizens' advisory committee (44%), and contacting their elected representatives (43%). Note that a relatively small percentage of respondents – only 24% in 2015 – said they would attend and speak at a public hearing if it were held in their area.

Figure 9.1 shows responses to the likelihood of participation for three successive EE surveys (2013 through 2015). Note that the ordering of likelihood of participation has been quite stable over time. Also note that between 38-44% of the survey respondents have consistently said they would be willing to serve on a citizen panel to advise decision-makers. This finding suggests that a reasonable fraction of residents near potential host communities would be willing, if given the opportunity, to serve on a deliberative citizen panel. Somewhat fewer said they would be likely to help organize public opposition (25%) or public support (20%) for a proposed ISF, or speak at a public meeting about the ISF held in their area (24%).

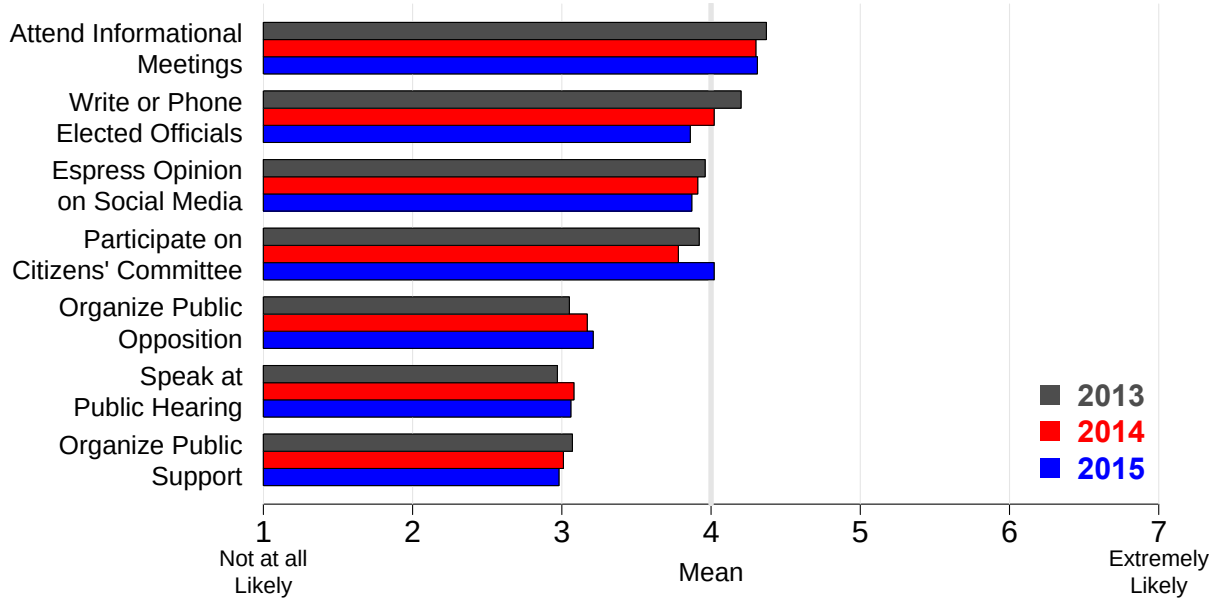

Figure 9.1: Public Preferences for Engagement in the Siting Process

9.2 A Closer Look at Public Hearings: Who is Likely to Speak Up?

The most common engagement mechanism utilized during the process of siting environmentally complex land use facilities such as landfills, factories, and nuclear facilities is open public hearings, wherein citizens have the opportunity to express their concerns and preferences to authorities. Viewed as a way to open communication channels with affected communities, public hearings provide the government an opportunity to raise awareness as well as become informed about community concerns. Therefore, it is useful to understand the kind of people that are most likely to participate in – that is, to speak at – public hearings, and to assess how their underlying policy preferences about nuclear energy and waste management might differ from those who are less likely to express their views at a hearing. Table 9.2 below presents findings from the EE15 survey about some of the policy preferences and perceptions held by people who were most and least likely to express their views at public hearings about an ISF.

Table 9.2: Policy Characteristics of People Who Are Most and Least Likely to Express Their Views at a Public Hearing about an ISF

Variable (Range)	Least Likely to Speak at Public Hearing (47% of EE15 respondents)	Most Likely to Speak at Public Hearing (12% of EE15 respondents)
Risk of a Transportation Accident (0-10)	5.90	6.97*
Risk of a Storage Accident (0-10)	5.87	7.64*
Nuclear Power Benefit Index (0-10)	6.93	7.39*
Trust in Dept. of Energy (0-10)	5.37	6.05*
Help organize opposition (1 - 7)	2.03	5.31*
Help organize support (1 - 7)	2.03	4.66*

* Difference of means is statistically significant ($p < 0.05$)

Respondents were coded as "least" likely to speak at a public hearing about siting an ISF if their response was 1 or 2 on the seven-point scale described in section 9.1. 47% of the EE15 respondents fell into this category. Respondents were coded as "most" likely if their response was 6 or 7 on the same seven-point scale. Only 12% of the EE15 respondents were in this category.

The first three rows of Table 9.2 show the variations in the underlying risk and benefit perceptions of these two groups. The findings indicate that there is a positive relationship between *both* risk and benefit perceptions and the likelihood of expressing those views at a public hearing. For instance, as shown in the first row in Table 9.2, respondents who were most likely to speak at a hearing were, on average, more concerned about the risk of a transportation or storage accident (6.97 on the 0-10 scale) than respondents who were least likely to speak at the hearing (5.90 on the same scale). Similarly, respondents who said that they were likely to speak during the hearing were more cognizant of the benefits of nuclear energy than respondents who said that they would not speak, though this gap was substantially smaller than that for the risks. These results suggest that perceptions about the risks and benefits of nuclear energy are likely to influence expression of views in future hearings—people who have strong beliefs (about risks *or* benefits) are more likely to express their views in this kind of setting than are people who do not. It is important to note, however, that risk perceptions appear to provide a larger motivation to speak at hearings than do benefit perceptions.

We also look at how trust in key agencies might influence decisions to express one's views in public hearings. The US DOE is likely to play a major role in any public hearings held about the siting of an ISF, and the findings listed above indicate that, on average, the people who were most likely to speak at public hearings have somewhat greater trust in the DOE than do the respondents who were least likely to speak.

It is possible that trust in the DOE is intertwined with perceptions about the success and utility of public hearings more generally. Lower trust for the DOE may lead respondents to be skeptical about the utility of expressing their views in hearings, and therefore might undermine incentives for them to participate.

Finally, Table 9.2 (in rows 5 and 6) illustrates the relationship between likely participation in organizing support or opposition for an ISF and speaking at public hearings. These results indicate that propensities to express views and preferences in hearings are strongly correlated with propensities for other types of engagement. Respondents who said that they would speak at public hearings were more likely to say that they would be likely to consider engaging in organizing public support for *or* opposition to an ISF than did respondents who said that they would not speak at public hearings. Similar patterns hold for other kinds of engagement.[i]

The challenge posed by these results is twofold: first, those who are most likely to attend open public hearings and express their views perceived strikingly different patterns of risks/benefits from nuclear materials management than did those who are least likely to express their views. They also hold somewhat different levels of trust in those agencies likely to play a key role in the engagement process. Second, these patterns are compounded by correlations in propensities to participate across the different kinds of engagement. That means that, due to differences in risk perceptions and trust, open public hearings are likely to evoke a skewed expression of public concerns and preferences, and that this skew will be compounded by its correlation across multiple formal and informal mechanisms for engagement on ISF siting.

These issues are not unique to nuclear facility siting; regardless of the engagement mechanism, incentives to participate in voluntary processes are not uniformly distributed across all stakeholders and citizens. As illustrated by the EE15 survey results, the challenge for nuclear facility siting is heightened by the perceived nature and distribution of the burdens of hosting a nuclear waste management facility. As filtered through differential propensities to participate, the expression of public opinion through traditional voluntary engagement mechanisms such as hearings may well provide a distorted picture of public concerns, beliefs, and preferences. For that reason, it is likely that recognizing and engaging with the full distribution of citizen concerns and perceptions will require mobilizing engagement mechanisms, such as the citizen deliberation panels described earlier. This aspect of "better communicating information and effectively engaging different constituencies" is likely a necessary step in accomplishing one of the BRC's "core missions of a revitalized waste management program" (BRC 2012, p. 8).

[i] For more information on the predictors of likely engagement, see Trousset et al. 2015.

REFERENCES

Besley, John C. 2010. "Public Engagement and the Impact of Fairness Perceptions on Decision Favorability and Acceptance." *Science Communication* 32(2): 256–80.

BRC (Blue Ribbon Commission on America's Nuclear Future). 2012. Report to the Secretary of Energy. Washington, DC: Blue Ribbon Commission on America's Nuclear Future. www.brc.gov.

Brumfiel, Geoff, and Ichiko Fuyuno. 2012. "Japan's Nuclear Crisis: Fukushima's Legacy of Fear." *Nature* 483(7388): 138–40.

Coleman, Neil, Lee Abramson and Fiona Coleman. 2012. "Estimated Lag Time in Global Carbon Emissions and CO_2 Concentrations Produced by Commercial Nuclear Power Through 2009 With Projections Through 2030." *Health Physics*, 102(3): 326-334.

DOE (US Department of Energy). 2013. Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste. Available at www.doe.gov.

Dunlap, Riley E., Michael E. Kraft, and Eugene A. Rosa, eds. 1993. xvi *Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting*. Durham, NC, US: Duke University Press.

J. Flynn, and Paul Slovic. 1995. Yucca Mountain: A Crisis for Policy: Prospects for America′ s High-Level Nuclear Waste Program. In *Annual Review of Energy and the Environment*, Vol. 20, pp. 83-118. Palo Alto, CA: Annual Reviews Inc.

Jenkins-Smith, Hank, and Carol Silva. 1998. "The Role of Risk Perception and Technical I nformation in Scientific Debates Over Nuclear Waste Storage," Journal of Reliability Engineering and System Safety . 59: 107-122.

Jenkins-Smith, Hank, Carol L. Silva, Matthew Nowlin, and deLozier. 2011. Reversing Nuclear Opposition: Evolving Public Acceptance of a Permanent Nuclear Waste Disposal Facility. *Risk Analysis*, 31(4): 629-644.

Jenkins-Smith, Hank C., Carol L. Silva, Kerry G. Herron, Kuhika Gupta, Matthew Nowlin, Joseph Ripberger, Evaristo Bonano, and Rob P. Rechard. 2013a. Public Preferences Related to Consent-Based Siting of Radioactive Waste Management Facilities for Storage and Disposal: Analyzing Variations over Time, Events, and Program Designs, FCRDNFST-2013-000076, SAND2013-0032P, Idaho Falls, ID: Nuclear Fuel Storage and Transportation Planning Project, US Department of Energy.

Jenkins-Smith, Hank C., Kuhika Gupta, Carol L. Silva, Kerry G. Herron, Joseph Ripberger, and Rob P. Rechard. 2013b. Guidance for Conducting Consent-Based Siting of Radioactive Waste Management Facilities: Evidence from a Nationwide Survey of US Residents, FCRD-NFST-2013-000280, SAND2013-0032P, Idaho Falls, ID: Nuclear Fuel Storage and Transportation Planning Project, US Department of Energy.

Jenkins-Smith, Hank C., Kuhika Gupta, Carol L. Silva, Evaristo Bonano, and Rob P. Rechard. (2015). Public Preferences Related to Radioactive Waste Management, Nuclear Energy, and Environment: Methodology and Response Reference Report for the 2015 Environment and Energy Survey. Albuquerque, NM: Sandia National Laboratories.

Medvedev, Zhores. 1992. *The Legacy of Chernobyl*. New York: W. W. Norton & Company.

Metlay, Daniel. 2013. "Consent-Based Siting: What Have We Learned?" *Radwaste Solutions* 20(3): 28–36.

Nuclear Waste Administration Act of 2015, 114th Congress. 2012. Retrieved from ProQuest congressional Database.

Pew Research Center. 2014. "Public Trust in Government: 1958-2014." *Pew Research Center for the People and the Press*. http://www.people-press.org/2014/11/13/public-trust-in-government/ (October 12, 2015).

Trousset, Sarah et al. 2015. "Degrees of Engagement: Using Cultural Worldviews to Explain Variations in Public Preferences for Engagement in the Policy Process." *Policy Studies Journal* 43(1): 44–69.