American Views of Nuclear Energy Technologies:

Summary Report on Public Support for Small Modular Reactors

February 2018

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1. Introduction

Production of domestic commercial nuclear energy appears to be at a turning point. The current reactor fleet is aging, and a sustained period of relatively low fossil fuel energy prices challenges the economic viability of existing and proposed new reactors. The combination of well-publicized reactor accidents (Three Mile Island, Chernobyl, and Fukushima) coupled with diminished concern about domestic energy security have driven broad public support for nuclear energy to its lowest level in several decades (Gupta et al. 2017). Public preferences for low-carbon energy, while substantial, have yet to translate into increased support for nuclear energy (Ter Mkrtchyan et al., 2018). Absent significant change in the way the public understands nuclear energy, prospects for broad resurgence of support appear dim.

Proponents of nuclear energy have argued that new technologies – most notably the advent of safer, smaller, and cheaper Small Modular Reactors (SMRs) – offer prospects for increased public support for new reactors to replace aging light-water reactors and retired coal plants. In this report we mobilize evidence from surveys of the American public to evaluate that claim.

Using data from the Center's annual nationwide Environment and Energy (EE) surveys, we explore whether new nuclear technologies have the potential to alter public support for domestic commercial nuclear energy. We begin by briefly describing evidence about how Americans think about current sources of nuclear energy – how is it understood, and how does it compare to perceptions of other energy technologies? We then provide a focused analysis of public views of SMRs (and how they compare to existing reactor technologies) when they are confronted with the kinds of characterizations of the technology that are likely to be made by advocates and opponents. Our findings offer support for the expectation that shifting the focus to new nuclear technologies – even when subject to the kinds of criticisms by nuclear skeptics that we have come to expect – can increase public acceptance of nuclear energy in the US.

2. Background: Public Views on Nuclear Technologies

Popular culture, as well as the news, social media and education, provides the basis for public impressions about nuclear energy. The narratives from *The Simpsons, Spiderman,* and *The Incredible Hulk* jostle with nuclear images of the stricken Fukushima Daiichi power plant in Japan, along with an array of public and private efforts to inform and persuade the public from a diverse range of perspectives. Raw public impressions of nuclear energy are therefore quite mixed – including an amalgam of positive images alongside others drawn from nuclear accidents and war. In a 2015 CES&S study (Jenkins-Smith et al 2015a), a

cross-section of US survey respondents was asked to indicate the first thing that came to mind when they heard the phrase "nuclear energy." The relative frequencies of responses are illustrated in Figure 1, in which the more frequent responses are represented in larger font. When asked to characterize each of their responses as negative or positive, the mixed array of images lean slightly negative (the red images in Figure 1 were rated negative, the grey as neutral, and the green as positive).

Given the underlying imagery of nuclear issues more generally (i.e. nuclear weapons), it is not surprising that public impressions of the technology that makes nuclear energy possible are also mixed. In a 2017 CES&S nationwide survey of 2,412 US residents, respondents were asked to rate a range of technologies as "new or old", "rising or declining" and "necessary or unnecessary" (Jenkins-Smith et al 2017). Surprisingly, half (49%) of our respondents characterized nuclear energy technology as "old"; 38% as "declining", and 34% as "unnecessary." The most similarly rated technology domain, across a wide range of options (including aerospace, nanotech, drones, nuclear weapons, and automotive), was automotive – which 28% characterized as "old", 11% as "declining", and 15% as "unnecessary." In sum, the public impression of nuclear energy when compared to other technologies is relatively unflattering.

Figure 1: Images of "Nuclear Energy"
Acquired from a 2015 nationwide survey of 2,026 respondents.

	Coal	Oil	Nuclear	Natural Gas	Hydro	Wind	Solar
Clean	6.9%	7.5%	31.5%	42.1%	77.4%	85.7%	85.4%
Renewable	11.7	10.2	25.5	21.3	65.3	77.2	73.3
Safe	23.1	24.4	13.8	35.4	64.2	72.9	77.9
Plentiful	31.3	21.9	31.9	41.2	44.3	49.7	52.7
Preferred	9.6	8.8	16.7	31.3	56.9	60.2	64.8

Table 1: Public Impressions for the Attributes of Nuclear Energy
Based on a 2014 nationwide survey of 2,465 respondents.

Impressions of the technology naturally bleed over into judgments about the energy produced. Data from a 2014 nationwide survey provide an overview of public impressions of the attributes of a suite of energy sources (Jenkins-Smith et al 2015b). These comparisons are shown in Table 1. Public impressions of nuclear energy are far from positive. It is perceived as the least "safe" energy source, and falls low in rankings as a clean or plentiful source.

In sum, the combination of images and attributes of nuclear energy technologies as perceived by the American public are not positive. The technology itself is broadly seen as old, and nuclear energy production is not believed to be clean or safe. In the face of these impressions, campaigns to increase reliance on nuclear energy are likely to run into stiff public acceptance headwinds.

3. Small Modular Reactors

Social media is a key informational source for the American public, and narratives prevalent on these platforms will likely influence how people think about and respond to new nuclear technologies. CES&S tracks and archives social media messages (on Twitter) about nuclear issues. Figure 2 presents the frequency of messages about small modular technologies on Twitter between January 2013 and February 2018. The overall frequency of messages has gradually increased over time, and the content of these messages suggests that both advocates and opponents of SMRs are actively disseminating their narratives on Twitter.

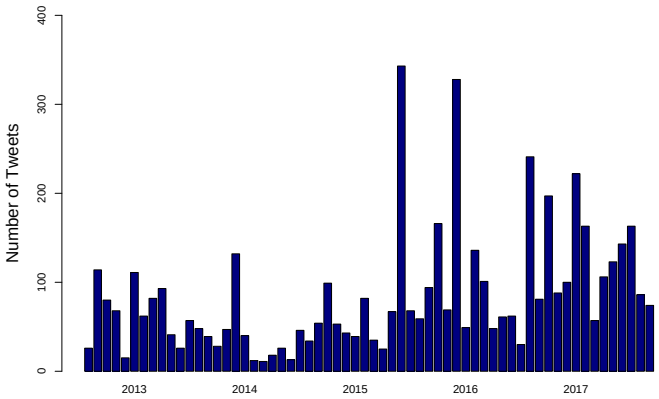

Figure 2: Frequency of Messages Referencing SMRs on Twitter
Based on all Nuclear Energy Tweets 2013-2017

Given perceptions of existing nuclear technology and energy production, how does the public perceive advances in nuclear energy technologies, and how might information about these new technologies influence their acceptance for new reactors? In 2015 the CES&S fielded a nationwide survey to 2,021 US residents to measure perspectives about SMRs (Jenkins-Smith et al 2015c). The challenge is that very few members of the public are knowledgeable about new energy technology developments. In order to obtain a valid and reliable measure of public support for new reactors, respondents were provided with background information about SMRs to familiarize them with the technology. Additionally, respondents were given a brief overview of the kinds of pros and cons surrounding SMRs that are likely to be voiced in the public discussion.[1] Because the background information about SMRs is critical for this analysis, the question was framed as follows:

> 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

[1] These pros and cons were carefully selected and worded to match actual policy debates that members of the public were likely to encounter in the news or social media at the time of the survey.

or shut down. These reactors are still in the development phase, and have not yet been built, licensed, or constructed.

Key arguments that are made FOR small modular reactor technologies include the following:[2]

- 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. The first (worded as shown below) asked respondents to compare the perceived safety of this new technology to that of traditional nuclear reactors.

[2] The ordering of the pro and con arguments was randomized to eliminate "order effects" that could bias responses.

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?

Responses to the question are illustrated in Figure 3, showing that (on average) SMRs would be perceived to be safer than traditional nuclear reactors. Approximately 42% of the respondents said that SMRs would be safer than traditional reactors, whereas only 19% said they would be less safe.

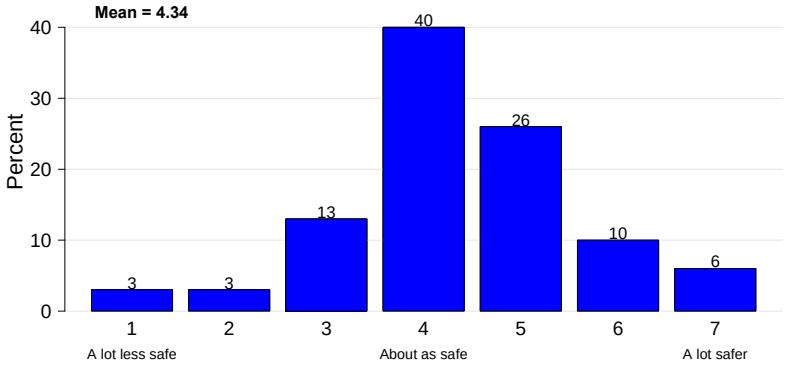

Figure 3: Public Perceptions About the Safety of SMRs and Traditional Nuclear Energy Reactors
Based on a 2015 nationwide survey of 2,021 respondents.

Two follow-up questions asked respondents to indicate their level of support for SMRs in civilian and military settings:

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 4 shows support for the construction and operation of SMRs for civilian or military use, in comparison with that for traditional nuclear reactors in the US.[3] Average support for the use of SMRs is significantly higher than that for traditional nuclear reactors. While pluralities of respondents opposed building new traditional reactors, opposition drops considerably for construction and operation of SMRs. A near majority (47%) support SMRs for civilian use (another 32% are neutral or undecided); a majority of the respondents (51%) registered support for SMRs on military bases. Note that this increased level of support is evident *in spite of* exposure of respondents to both the pro and con arguments that are likely to be prevalent in public policy debates preceding the adoption and construction of new nuclear reactors.

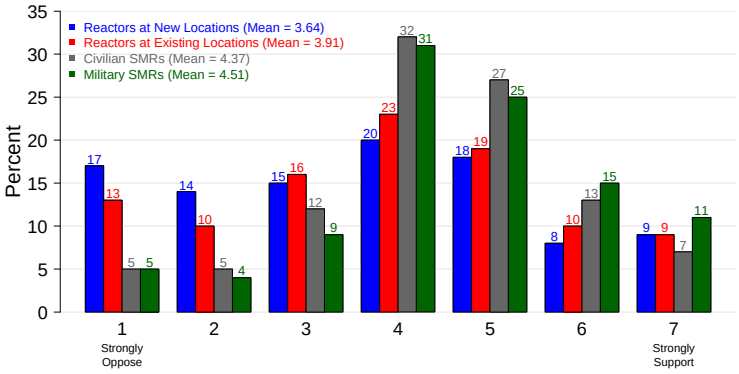

Figure 4: Support for Construction of SMRs vs. Traditional Nuclear Reactors
Based on a 2015 nationwide survey of 2,021 respondents.

5. Conclusions

Do new nuclear energy technologies – such as Small Modular Reactors (SMRs) – offer prospects for increased public support for new reactors to replace aging nuclear reactors and retired coal plants? Our data and analyses indicates that the answer is a qualified yes. For a sizable fraction of the US public, impressions of existing nuclear energy technology are that it is old, dangerous, and unnecessary. When the focus is shifted to SMRs, and respondents hear a balanced account of the characteristics of SMRs along with both positive and negative arguments, support increases substantially.

It is critical to keep in mind that the introduction of a new kinds of nuclear reactors, and the accompanying narratives (e.g., about the potential safety, cost effectiveness, and base load benefits of SMRs), will be but one of multiple narratives competing for public attention and influence. Expectations about public responses should consider the net effect of the expected narratives (that is why, in our analyses, we included both pro- and con-arguments about SMRs). The public discussion will also be affected by the changing nuclear

[3] The questions concerning new conventional reactors used the following wording: "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.?" This was followed by: "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.?"

energy context – including future accidents, changes in the availability of alternative energy sources, and other factors (Gupta et al 2017). Thus while our data show prospects for increased public support with the advent of new kinds of reactors, the nature of the debate (i.e., the stock of pro and con statements) will change over time as proponents and opponents hone their arguments and respond to events. This dynamic context requires systematic tracking of how these evolving narratives connect to public support or opposition toward new nuclear technologies.

6. References

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